IOSR Journal of Applied Physics (IOSR-JAP)
e-ISSN: 2278-4861.Volume 10, Issue 6 Ver. I (Nov. – Dec. 2018), 17-20
www.iosrjournals.org

Measurements of K- shell X-ray production cross-sections and fluorescence yield for 31Ga element

Rafet Yılmaz[1], Y. Emre Aksöz[2]
1Department of Physics, Faculty of Sciences, Yüzüncü Yıl University, Van, Turkey,
Corresponding Author: Rafet Yılmaz
2Institute of Sciences, Yüzüncü Yıl University, Van, Turkey,
Corresponding Author: Rafet Yılmaz

Abstract: *K shell X- ray production cross-sections ($\sigma_{K\alpha}$ and $\sigma_{K\beta}$) were measured for 31Ga element. Measurements were carried out at 11.372 keV using secondary excitation method. The results obtained for K X- ray production cross-sections were compared the theoretically calculated .In addition, measurement of K X-ray fluorescence yield for 31Ga at the same excitation energy were carried out, and compared with semiempirical fits values.*

Keywords: *X-ray, cross- sections, fluorescence yields.*

Date of Submission: 10-11-2018 Date of acceptance: 25-11-2018

I. Introduction

Atomic parametres such as cross-section , subshell X-ray production yields (ω_K) form a data base that is important in many applications. Some of these areas are atomic physics, molecular physics, X-ray fluorescence analysis, medical research and environmental protection. Also, these measurements provide an indirect check on theoretical physical parameters , such as K X-ray fluorescence yields, cross-sections.

K X-ray production cross-sections and fluorescence yields for different elements have been investigated for many years. [1-5]. Bambynek et al. [6] in review article have fitted their collection of selected most reliable experimental values in the $13\leq Z\leq92$ range. Krause [7] present a table of ω_K adopted values for elements $5\leq Z\leq 110$ by using all theoretical and experimental data on the parameter contributing to the K-shell fluorescence yields. Hubbel et al. [8] have compiled more next experimental values.

In the present study, the K X- production cross-sections for 31Ga element have measured at 11.372 keV . K shell is excited by the K X-rays of the secondary source excited by 59.5 keV photons emitted by the primary source. K - shell fluorescence yield was deduced from the measured cross-sections by using the theoretical photoionization cross-sections and fractional X-ray emission rates.

II. Experimental

The experimental arrangement used in the present study has been shown in Fig.1. The sample was excited by the K X-ray of secondary source excited at 59.5 keV γ- rays from a 241Am point source. Fluorescent X-rays spectra were recorded by a calibrated Si(Li) X-ray spectrometer (FWHM =160 eV at 5.96 keV, active area = 12.5 mm2, sensitivity depth = 3.5 cm, Be window thickness = 12.5μm) coupled to a Nuclear Data MCA system (ND66B) consisting of a 4096- channel analyzer and spectroscopy amplifier. The secondary excitation source was pure 34Se (99.99%). The excitation energy was taken as average of K_α and K_β X-ray energies. For 34Se, weighted averages of K_α, K_β, $K_{\alpha\beta}$ energies are 11.210, 12.503 and 11.372 keV, respectively [12].

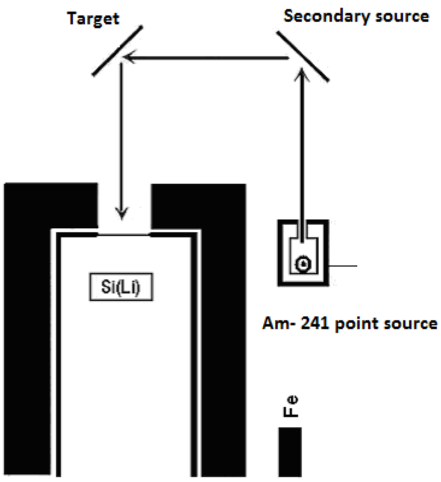


Figure 1. Experimental set-up.

2.1.Data analysis

The experimental K X-ray production cross-sections have been measured using the relation[3].

$$\sigma_{Ki} = \frac{N_{Ki}}{I_0 G \varepsilon_{Ki} \beta t} \qquad (1)$$

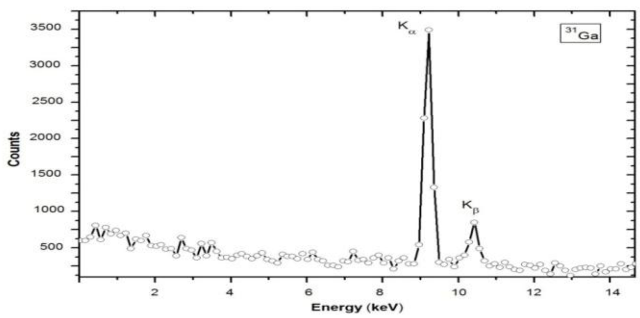
where N_{Ki} $((i = \alpha, \beta)$ is the number of counts per unit time under the corresponding photopeak. A typical K X-ray spectrum for Ga is shown in Fig.2. K_α and K_β X-rays emitting energies of 31Ga are 9.243, 10.263 keV, respectively. I_0 is the intensity of exciting radiation , G is the geometrical factor, ε_{Ki} is the detector efficiency for the Ki X-rays, t is the mass of the sample in g /cm2 and β is the self-absorption correction factor for the incident photons and emitted K X-ray photons. β is the calculated by using the relation [3].

$$\beta = \frac{1 - \exp(-1)(\mu_1 / \cos\theta + \mu_2 / \cos\theta)t}{(\mu_1 / \cos\theta + \mu_2 / \cos\theta)t} \qquad (2)$$

where μ1 and μ2 are the absorption coefficients (cm2/g) of incident photons and emitted characteristic X-Rays, respectively [9]. The angle of incident photons and emitted X-rays, with respect to the normal at the surface of the sample, θ was equal to 450 in the present set-up in the present study. As shown in Fig. 3, the values of the factors I0εG, which contain terms related to the incident photon flux, geometrical factor and the efficiency of the X-ray detector, were determined by collecting the K X-ray spectra of samples of 22Ti, 25Mn, 29Cu, 32Ge and 35Br in the same geometry in which the K X- ray fluorescence cross-sections were measured and using the equation,

$$I_0 G \varepsilon_{Ki} = \frac{N_{Ki}}{\sigma_{Ki} \beta t} \qquad (3)$$

where NKi , β and t are as in Eq.(1). I0GεKi value for the target element (31Ga) is obtained from the graph in Fig.3.



.

Figure. 2. K X-ray spectrum of Ga .

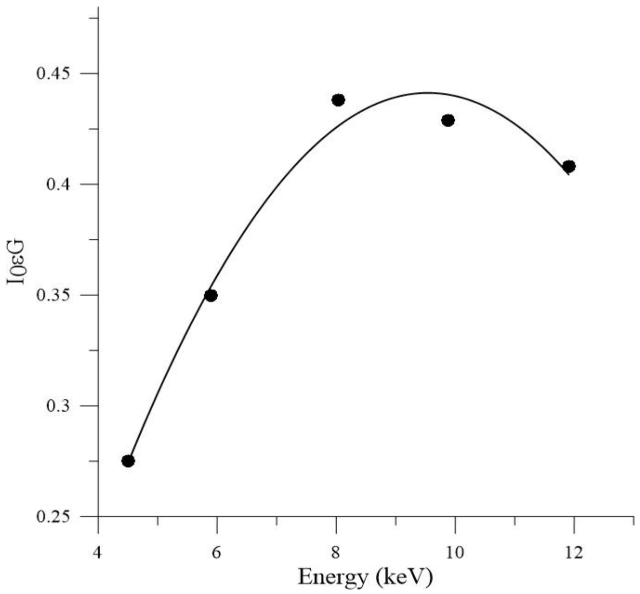


Figure. 3. Plot of the factor I0εG vs. K X-ray energy.

III.Theoretical method

The theoretical values of K X-ray production cross-sections have been calculated using the following equations,[4].

$$\sigma_{K\alpha} = \sigma_K^p(E)\omega_K f_{K\alpha} \qquad (4)$$

$$\sigma_{K\beta} = \sigma_K^p(E)\omega_K f_{K\beta} \qquad (5)$$

Where $\sigma_K^P(E)$ is the K-shell photoionization cross-section for the given element at excitation energy E, ω_K is the K-shell fluorescence yield and $f_{K\alpha}$ and $f_{K\beta}$ are fractional X-ray emission rates for Kα and Kβ ;

$$f_{K\alpha} = (1 + I_{K\beta} / I_{K\alpha})^{-1} \qquad (6)$$

$$f_{K\beta} = (1 + I_{K\alpha} / I_{K\beta})^{-1} , \qquad (7)$$

where $I_{K\beta} / I_{K\alpha}$ is the Kβ to Kα X-ray intensity ratio. $I_{K\beta} / I_{K\alpha}$ values based on relativitic Hartree-Slater potential theory were used for the evaluation of theoretical K X-ray cross-sections [11]. In the this calculations, the values of σ_K^P(E) were taken from Scofield [10] based on Hartree-Slater potential theory, and the values of ω_K were taken from the tables of Krause[7].

IV. Conslusion

The experimental values of K shell X-ray production cross-sections for 31Ga element at 11.372 keV are listed in Table 1. together with the theoeretical values obtained using Eq.(4 and 5). The overall error in the present measurements is estimated to be <7%. This error is the quadrature **s**um of the uncertainties in the different parameters(evaluation of photopeak area, the uncertainty of absorbtion coefficient, geometric effect, dedector efficiency etc.). In order to reduce the statistical error, experimental conditions and geometry were maintained during the experimental process. The agreement between the presently measured K shell X-ray production cross-sections and theoretical predictions agree to 2.4%, 2%, respectively, Table 1.

Table 1. Experimental and theoretical K-shell X-ray cross-sections (barns/atom) for 31Ga.

Element	**Excitation energy (keV)**	**Present Work**		**Theoretical**	
		σ_α	σ_β	σ_α	σ_β
31Ga	11.372	7687±542	979±64	7874.763	998.875

Table 2. Present Experimental result and semiemperical fits values of (ω_K) for 31Ga.

Element	Present Work	Krause[7]	Bambynek[6]	Hubbel[8]
31Ga	0.498±0.032	0.507	0.516	0517

K-shell fluoresans yield for 31Ga is compared with the semiempirical fits, in Tables 2, [7,6,8]. In this study, the present measurement is in good agreement with the semiempirical fit value deduced by Krause[7].This agreement is within <1.8% for 31Ga. The experimental results agree to 3.6%, 3.8% with the K-shell fluorescence yields obtained using a semiempirical fits by Bamnynek[6] and Hubbel[8],respectively**.**

Finally, the comparison between the experimental results and the theoretical values leads to the conclusion that both the experimental and the calculated cross-sections can be used with confidence for analytical purpose and satisfactory for many other appilications employing the fundemental parameter approach.

References

[1]. L. Garg, D. Mehta, S. Kumar, P.C. Mangal, P.N. Trehan,. Energy dependence of photon-induced K_α and Kβ X-ray fluorescence crosss-sections for some elements with 20≤Z≤56. X-ray Spectrom. 14, 1985,165-169.

[2]. D. V. Rao, R. Cesereo, and G. E. Gigante, Photon-excited K X ray fluorescence cross-sections for some light elements in the range 20-60 keV. X-ray Spectrom, 22, 1993d, 406.

[3]. S.K. Arora, K.L. Allawadhi, B.S. Sood, Measurement of K-shell fluorescence in elements 28≤Z≤53. Physica B, C 111C, 1981, 71-75.

[4]. R. Durak, Y. Özdemir, Measurement of K-shell fluorescence cross-sections and yields of 14 elements in the atomic number range 25≤Z≤47 using photoionization. Radiation Physics and Chemistry.61, 2001,19-25.

[5]. R. Yılmaz, Measurements of K shell X-ray production cross-sections and fluorescence yields for Cr, Mn, Fe and Co elements. Radiation Physics and Chemistry, 81, 2012, 1539-1542.

[6]. W. Bambynek, B, Crasemann, R. W. Fink, H.U. Freund, H. Mark, C.D. Swift, R.E. Price, P.V. Rao, X-ray fluorescence yields, Auger and Coster-Kronig transitions probabilities. Rev. Mod.phys, 44, 1972,716-813.

[7]. M.O. Krause, Atomic radiative and radiationless yields for K and L shell. J.Phys.Chem. Ref.Data 8, 1979, 307-327.

[8]. J.H. Hubbell, P.N. Trehan, N. Singh, B. Chand, D.Mehta, M.L. Garg, R.R. Garg, S. Singh, S. Puri, A review, bibliography, and tabulation of K, L, and hinger atomic Shell X-ray fluorescence yields. J. Phys. Chem. Ref. Data 23, 1994,339–364..

[9]. J.H. Hubbell, and S. M. Seltzer, Tables of X-ray mass attenuation coefficients and mass energy absorption coefficients 1 keV to 20 MeV for elements Z=1 to 92 and 48 additional substance of dosimetric interest. NISTIR 1995. 5632.

[10]. J.H. Scofield, Theoretical photoionisation cross-sections from 1 to 1500 keV. Report UCRL 51326, Lawrence Livermore Laboratory, Livermore, CA. 1973.

[11]. J.H. Scofield, Relativistic Hartree-Slater values for K and L X-ray emission rates. Atom. Data Nucl. Data Tables 14, 1974, 121-137.

[12]. E. Storm, I. Israel, Photons cross-sections from 1 keV to 100 MeV for elements Z=1 to Z=100. Nuclear Data Tables A 7, 1970. 565-681.

IOSR Journal of Applied Physics (IOSR-JAP) is UGC approved Journal with Sl. No. 5010, Journal no. 49054.

Rafet Yılmaz" Measurements of K- shell X-ray production cross-sections and fluorescence yield for 31Ga element." IOSR Journal of Applied Physics (IOSR-JAP) , vol. 10, no. 6, 2018, pp. 17-20.