K-shell photoelectric cross sections for intermediate-Z elements at 26 keV

Suresh Kumar, N. Singh, K. L. Allawadhi, and B. S. Sood
Nuclear Science Laboratories, Department of Physics, Punjabi University, Patiala 147002, Punjab, India
(Received 5 February 1986)

Our earlier measurements of K-shell photoelectric cross sections for intermediate Z elements at 74 and 37 keV have been extended to 26 keV using external conversion x rays in Sn. The experimental results are found to show fairly good agreement with the theoretical values of Scofield.

In order to fill the existing void,[1] we have extended our earlier measurements[2] at 74 and 37 keV to 26 keV for Se, Br, Rb, Y, Zr, Nb, Mo, and Pd and report the results in this paper. In the earlier measurements the cross sections at 74 and 37 keV in various elements were determined by comparing the intensity of the K-shell fluorescent x rays emitted from a target of the element under investigation with that of a composite beam of γ rays and internal-conversion x rays (obtained from strong ^{203}Hg and ^{141}Ce sources, respectively) incident on the target. In the present measurements composite beams of 59.57-keV γ rays[3] and 25.77-keV external conversion Sn K x rays ($K\langle\alpha,\beta\rangle$) are obtained by covering a $\sim$1-C ^{241}Am source with a thin Sn foil, since a suitable radioactive source emitting monoenergetic γ rays and internal-conversion Sn x rays is not available. The experiment is performed in a standard 90° reflection geometrical setup described earlier.[2] The targets of elements under investigation are irradiated, in turn, with a composite beam of external conversion Sn x rays and transmitted γ rays and a beam of γ rays only obtained after removing the Sn-foil covering from the source. An NaI(Tl) scintillation counter of size 2×0.04 in.^{2} with a Be window of thickness 0.005 in. (BICRON Model 2XM 040/2 BP) coupled to a ND 600 analyzer system is used to compare the intensities of the K-shell x rays emitted from and the photons incident on the target. The energy resolution of the spectrometer is sufficient to isolate the K-shell fluorescent x rays from the radiations scattered from the target. However, it provides greater target detector solid angle and is thus more efficient than Si (Li) detectors for the present measurements. The K-shell photoelectric cross sections, $\sigma(x)$ at Sn K x ray energy are determined from the following relation as explained earlier:

$$\sigma(x)=\frac{s(\gamma)a(\gamma)}{s(x)a(x)}\left[\frac{N(\gamma+x)}{N'(\gamma)}\frac{s'(\gamma)}{s(\gamma)}\right]\frac{\beta(\gamma)}{\beta(x)}\sigma(\gamma)\ .$$

TABLE I. Measured values of K-shell photoelectric cross sections at 25.77 keV are compared with theoretical values of Scofield (Ref. 4).

Sample No.	Element	Z	Cross sections (b/atoms) Experimental	Theoretical
1	Se	34	2810±200	2709
2	Br	35	3140±220	3001
3	Rb	37	3550±250	3653
4	Y	39	4580±300	4367
5	Zr	40	4600±320	4748
6	Nb	41	5190±360	5162
7	Mo	42	5750±400	5584
8	Pd	46	7290±510	7499

The ratio $N(\gamma+x)/N'(\gamma)$ is determined by measuring the ratio of the areas under the K x ray photopeaks of the spectra taken when the target is irradiated with photons from the source with and without Sn-foil covering. The values of the ratios $S(\gamma)a(\gamma)/S(x)a(x)$ and $S(\gamma)/S'(\gamma)$ are measured in a separate experiment by measuring the intensities of 59.57-keV γ rays and Sn K x rays with and without Sn-foil covering of the source at the target position. The measured values of the K-shell photoelectric cross sections in elements Se, Br, Rb, Y, Zr, Nb, Mo, and Pd are compared with theoretical values of Scofield[4] in Table I. No other experimental data are available for comparison. The overall error in the measurements is estimated to be $\sim$7–8% and is due to counting statistics and other parameters needed for determination of the cross sections as detailed earlier.[2] A fairly good agreement between experiment and theory shows that the present method can be used to measure photoelectric cross sections in various elements in the characteristic x-ray energy region.

[1]R. H. Pratt, Indian J. Phys. **58A**, 1 (1984).
[2]K. L. Allawadhi and B. S. Sood, Phys. Rev. A **11**, 1928 (1975).
[3]S. K. Arora, K. L. Allawadhi, and B. S. Sood, Phys. Rev. A **23**, 1147 (1981).
[4]J. H. Scofield, Lawrence Livermore Laboratory Report No. UCRL-51326, 1973 (unpublished).

 ©1986 The American Physical Society