K-Shell Fluorescence Yields of Low , Medium And High Z Elements

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ABSTRACT

➢K-shell fluorescence yields of low , medium and high Z elements were determined using a Si(PIN) and HPGe detector employing reflection geometry set up. Target atoms were excited using 59.5 keV gamma rays emerging from Am-241 source of strength 300 mCi. Background radiation and multiple scattering effects were minimized by properly shielding the detector. The elemental foils of uniform thickness and 99.9% purity were used in the present investigation. The fluorescent spectra were recorded in an 8K and 16 K multi channel analyzer. The data were carefully analyzed and total K-shell fluorescence yields were calculated. The resulting yield values are compared with the available experimental and theoretical values.

1.INTRODUCTION

➢K-shell fluorescence yield is one of the important parameters that play a vital role in experimental XRF studies. They connect X-ray production cross sections with the theoretically calculated ionization cross sections and hence are important whenever comparing theory with experiment. The knowledge of fluorescence yields is also required in the solution of many practical problems, such as standardization of radio isotopes, design of many radiation detecting devices and in the design of minimum weight graded or stacked shields for various engineering applications. They are also found extensively useful in non destructive testing, trace element analysis, analyses of geological samples and in medical research. A detailed knowledge of fluorescence yields is necessary for the interpretation of a large variety of measurements in atomic and nuclear physics. Some of these measurements include the transition energy in nuclear electron capture decay, the multi polarity of internally converted nuclear gamma transitions, internal ionization and atomic collision cross sections for processes in which inner shells are excited.

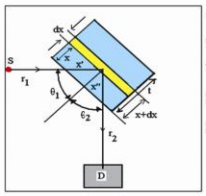
➢A literature survey on the K-shell fluorescence yields reveals the fact that there have been a number of theoretical estimations, semi empirical fits (Mc Guire 1969; Walters et al 1971; Kostrum et al 1971; Bambynek et al 1972; Krause 1979; Hubbel et al 1994) and some experimental investigations to measure these values in all atomic number region in the periodic table (Arora et al 1987; Al-Naser et al 1987; Siddu et al 1988; Pious et al 1991; Balakrishna et al 1994; Yashoda et al., 2002). With the advent of super computers and sophisticated computing methods, more and more accurate theoretical data are now available which are to be tested experimentally. Advances made in the field of semi conductors and radiation detection technology culminated in the development of sophisticated and high resolution solid state detectors like Si(Li), Ge(Li) and HPGe . These detectors might enhance the accuracy of the experimental data quite considerably. In the minds of many experimentalists, this rekindled the hope of getting more accurate experimental values with these high resolution and high efficiency detectors. The experimental work embodies the present paper is an attempt in this direction. In the present work a Si(PIN) detector and an HP(Ge) detector are used to detect the fluorescent X-rays coming out from different target materials when they are irradiated with 59.5 keV gamma rays of Am-241 source. Fluorescence Yields corresponding to K shell were measured for elements of atomic number ranging from 26 to 70. The present work also serves as a comparative study of the performance of different detectors to detect photons of different energies coming out from absorbers of different atomic numbers.

➢2. EXPERIMENT

➢Source used in the experiment Am^{241} giving mono - energetic gamma rays of energy 59.54 keV Source Strength --- 300mCi

Detector s used.... HPGe Detector And Si (PIN) Diode Detector

Geometrical Representation



S-source,

D-Detector,

T-Target,

r1 – Source to Target Distance

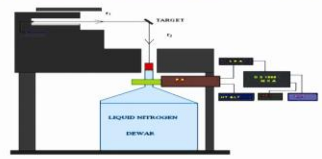
r2– Target to Detector Distance

Fluorescence Yield is calculated using the formula...

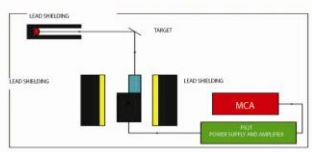
$$\omega_K = \frac{16\pi^2 N_K r_1^2 r_2^2 [1 + \frac{\mu_K}{\mu}]}{S \varepsilon_D f_K A A_D \{1 - Exp[-(\mu + \mu_K)t\sqrt{2}]\}}$$

where N_K is the total number of counts under the K-peak
r_1 is the distance between the source and the target; r_2 is the distance between the target and the detector; S is the source strength, E_D is the detector efficiency
f_k is the fraction of the incident gamma ray flux that ionizes the K shell of the target fluorescer , A is the area of the target, A_D is the area of the detector, t is the thickness of the target.
The attenuation coefficients μ and μ_K were taken from the literature (Hubbell 1982).
The fraction of the incident gamma ray flux that ionizes the K shell of the target fluorescer is given by $f_k = (\mu^+ - \mu^-)/\mu^+$
where μ^+ and μ^- are the attenuation coefficients immediately above and below the K- edge respectively.

Experimental arrangement with HPGe Detector



Experimental arrangement with Si(PIN) Detector

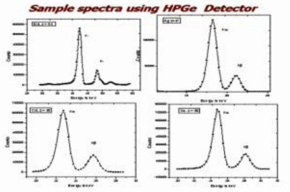


➢3. RESULTS

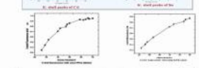
K-shell fluorescence yields with other experimental and theoretical results

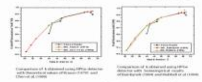
ELEMENT	ω_K (Present Value ...)	ω_K (Other Experimental value)	ω_K (Theory)
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

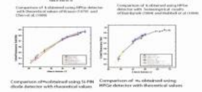
Sample spectra using HPGe Detector

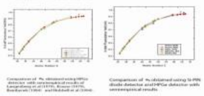


Sample spectra using Si(PIN)Detector









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