Energies of the $K\alpha_1$, $K\alpha_2$, $K\beta_1$, and $K\beta_3$ X Rays and the K-shell Binding Energies in Np, Pu, and Am*

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The energies of the $K\alpha_1$, $K\alpha_2$, $K\beta_1$, and $K\beta_3$ X rays in Np, Pu, and Am have been measured with a Cauchois-type bent-crystal spectrometer. The K-shell binding energies have been determined by combining the measured $K\alpha$ and $K\beta$ X-ray energies with the previously determined $L_{11}$, $L_{111}$, $M_{11}$, and $M_{111}$ binding energies. The $L_{11}-L_{111}$ and $M_{11}-M_{111}$ binding energy differences obtained from the $K\alpha_1-K\alpha_2$ and $K\beta_1-K\beta_3$ X-ray energies agree, within the experimental error, with the differences obtained from the $L_{11}$, $L_{111}$, $M_{11}$, and $M_{111}$ binding energies previously reported.

Introduction

Accurate data on X-ray energies and binding energies are needed in beta and gamma decay studies. Knowing the binding energy permits internal conversion electron data to be correlated with gamma ray data. X-ray energies are of use for unambiguously identifying a given element, as for example following electron capture or internal conversion.

X-ray and binding energies have been measured for most elements through uranium. See for example the tables of Bearden\textsuperscript{1} and Bearden and Burr\textsuperscript{2}. However, little work has been done on the transuranic elements, and most of this has been concentrated on $L$ or higher shells.

In this paper we present the results of measurements of the $K\alpha_1$, $K\alpha_2$, $K\beta_1$, and $K\beta_3$ X-ray energies of Np, Pu, and Am. The $K\alpha_1$ and $K\alpha_2$ X-ray energies were reported earlier\textsuperscript{3}. The present values are within the experimental error but differ slightly from those we reported in Ref.\textsuperscript{3} due to a reevaluation of the calibration lines and the fundamental constants\textsuperscript{4}. From these energies and the previously reported $L$ and $M$ binding energies\textsuperscript{2,5} we have deduced the $K$ binding energies for Np, Pu, and Am.

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Experimental Procedure

The present measurements were carried out with a 2 m Cauchois-type transmission bent-crystal spectrometer. This instrument has been described in detail in Refs. 3, 6, 7. Fig. 1 is a schematic drawing of the spectrometer, which consists basically of an extended X-ray source, a diffraction crystal, and a traveling slit and detector. The X rays are produced by fluorescing samples of the elements with a $^{182}$Ta source approximately 80 Ci in strength. Our samples were 4 g of $^{237}$Np, 51 g of $^{239}$Pu, and 1 g of $^{241}$AmO$_2$, sealed in aluminum cans to prevent radioactive contamination. The fluoresced X rays pass through a Pb precollimator and are diffracted by the (310) planes of a quartz crystal 2 mm thick, bent to a radius of 2 m. The diffracted X rays are scanned by the 0.17-mm-wide traveling slit and recorded in a 2 cc Ge(Li) detector. A single-channel analyzer is used to select the region of interest. The scanning consists of discrete steps 0.01 mm each. The counting time per step varies from 4 to 25 min depending on the intensity of the line being studied.

The peak position was determined from a nonlinear least-squares fit of a peak-shape function to the experimental data points. The peak-shape function consists of a fold of a Lorentzian, which represents the natural shape of the X ray, with a Gaussian, which represents the instrumental response. The resulting function is folded into the detector slit. Least-squares fits to the Pb$K\alpha_1$ calibration line and the Pu$K\beta_1$