5. X-ray Energies and Intensities

Tables 7a, 7b, 7c, and 7d list energies and intensities for x-rays with intensities greater than 0.001 per 100 primary vacancies in the K, L_1, L_2, and L_3 atomic shells, respectively. The first column shows the Siegbahn notations for the x-ray transitions (the associations with initial and final atomic-shell vacancies are given in Table 6). The following columns give, for each element, the x-ray energies in *keV* (boldface) rounded to the nearest *eV*, and their corresponding intensities directly below. Intensities for the L x-rays are totals from both primary and secondary atomic-shell vacancies.

X-ray energies have been determined from differences between the corresponding atomic-shell binding energies reported by Larkins.[1] Energies of complex x-ray transitions, e.g., $L_{\beta_{2,15}}$, are unweighted averages of those for the single-line components.

X-ray intensities have been determined from the experimental relative emission probabilities of Salem, *et al*,[2] and the atomic yields of Krause.[3] The theoretical emission probabilities of Scofield[4] were occasionally used whenever experimental values were not available.

The relative intensities of x-rays from the same initial atomic shells are independent of the processes creating the shell vacancies. Tables 7a-7d may, therefore, be used to separate experimentally unresolved or complex x-ray intensities from the photon tables of the *Table of Isotopes*. Table 5 shows the initial atomic shells and their associated x-rays, and the procedure below illustrates the separation of an x-ray peak.

Table 5

Atomic Shell	Associated x-rays
K	K_{α_1}, K_{α_2}, K_{α_3}, K_{β_1}, K_{β_2}, K_{β_3}, K_{β_4}, K_{β_5}, $KO_{2,3}$, $KP_{2,3}$
L_1	L_{β_3}, L_{β_4}, L_{γ_2}, L_{γ_3}
L_2	L_{β_1}, L_η, L_{γ_1}, L_{γ_6}
L_3	L_{α_1}, L_{α_2}, $L_{\beta_{2,15}}$, L_{β_5}, L_{β_6}, L_l

The single-line x-ray intensity of a specific transition *i* from an initial atomic shell *j* is

$$I(ji)=\frac{I}{I^0}I^0(ji) \tag{1}$$

where *I* is the measured (or photon-table) intensity value of a single or complex x-ray transition from atomic-shell *j*, I^0 is the intensity of the same x-ray transition from Tables 7a-7d, and $I(ji)^0$ is the intensity of the specific *i* x-ray transition from atomic-shell *j*, also from Tables 7a-7d. As an example, the uranium K_{β_1} intensity per 100 disintegrations of ^{235}Np is[5]

$$I(K_{\beta_1}) = \frac{I(K_{\alpha_1})}{I(K^0_{\alpha_1})} I(K^0_{\beta_1}) = \frac{0.957}{45.1} 10.70 = 0.227\% \; . \tag{2}$$

$I(K_{\alpha_1})$ is from the photons table for ^{235}Np, and $I(K^0_{\alpha_1})$, and $I(K^0_{\beta_1})$ are from Table 7a. Calculations for the L_1 atomic shell may be more complex, because none of the x-ray transitions in the photon tables of reference 5 is associated exclusively with this shell.

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[1]F.B. Larkins, *At. Data and Nucl. Data Tables* **20**, 313 (1977).

[2]S.I. Salem, S.L. Panossian, and R.A. Krause, *Atomic Data and Nucl. Data Tables* **14**, 91 (1974).

[3]M.O. Krause, *J. Phys. Chem. Ref. Data* **8**, 307 (1979).

[4]J.H. Scofield, *Atomic Data and Nucl. Data Tables* **14**, 121 (1974).

[5] E. Browne and R.B. Firestone, *Table of Radioactive Isotopes*, John Wiley & Sons, Inc. (1986).

Table 6. Notations for X-ray Transitions

Classical designation (Siegbahn notation)	Associated initial - final shell vacancies
K_{α_1}	$K - L_3$
K_{α_2}	$K - L_2$
K_{α_3}	$K - L_1$
K_{β_1}	$K - M_3$
K_{β_2}	$K - N_2N_3$
K_{β_3}	$K - M_2$
K_{β_4}	$K - N_4N_5$
K_{β_5}	$K - M_4M_5$
$KO_{2,3}$	$K - O_2O_3$
$KP_{2,3}$	$K - P_2P_3$
L_{α_1}	$L_3 - M_5$
L_{α_2}	$L_3 - M_4$
L_{β_1}	$L_2 - M_4$
$L_{\beta_{2,15}}$	$L_3 - N_4N_5$
L_{β_3}	$L_1 - M_3$
L_{β_4}	$L_1 - M_2$
L_{β_5}	$L_3 - O_4O_5$
L_{β_6}	$L_3 - N_1$
L_{γ_1}	$L_2 - N_4$
L_{γ_2}	$L_1 - N_2$
L_{γ_3}	$L_1 - N_3$
L_{γ_6}	$L_2 - O_4$
L_{ν}	$L_2 - M_1$
L_{l}	$L_3 - M_1$
Group designation	**Associated transitions**
K'_{β_1}	$K_{\beta 1} + K_{\beta 3} + K_{\beta 5}$
K_{β_2}	$K_{\beta 2} + K_{\beta 4} + ...$
L_{α}	$L_{\alpha_1} + L_{\alpha_2}$
L_{β}	$L_{\beta_1} + L_{\beta_{2,15}} + L_{\beta_3} + L_{\beta_4} + L_{\beta_5} + L_{\beta_6}$
L_{γ}	$L_{\gamma_1} + L_{\gamma_2} + L_{\gamma_3} + L_{\gamma_6}$