Vacancy transfer probability parameters: database and a new empirical value for elements in the atomic number range 16 ≤ Z ≤ 92

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Abstract:

In the present work, we offer a collection of documented values for vacancy transfer probabilities $(\eta_{XY}, X = \mathrm{K}, \mathrm{L}i;\ \ Y = \mathrm{L}, \mathrm{M}, \mathrm{N}, \mathrm{L}i, \mathrm{M}j, \mathrm{N}p, \mathrm{O}p;\ \ i = 1,2,3;\ j = 1,2,3,4,5;\ p = 1,4,5)$ sourced from published technical literature spanning 1993 to 2023 for elements in the atomic range $16 \le Z \le 92$. We found 1200 experimental vacancy transfer probability values from 68 scientific papers, during the specified period. These have been compiled and summarized in tables, encompassing various parameters and elements. This data is also comprehensively analysed, including tables that display weighted average vacancy transfer probability (η_{XY}) values along with the combined standard deviation and the average z-score. We also recommend a new collection of empirical values for the atomic parameters $\eta_{\mathrm{KL}}(T), \eta_{\mathrm{KL2}}(R),\ \eta_{\mathrm{KL3}}(R), and\ \eta_{\mathrm{KM}}(R)$ of vacancy transfer probabilities. This compilation offers an overview of the present state of atomic data for vacancy transfer probabilities. It is a valuable resource to guide future experimental and theoretical studies in this area.

Keywords: X-rays, fundamental atomic parameters, vacancy transfer probabilities, weighted average values.

Introduction

X-ray production cross-sections, intensity ratios, fluorescence yields, and vacancy transfer probabilities are critical parameters of high importance due to their use in an extensive range of applications across various domains. These fundamental atomic parameters, whether derived through theoretical calculations, experimental studies, or analytical methods, are essential in fields encompassing physical chemistry, medical research (including cancer therapy), analytical methods with X rays (e.g., in nuclear safeguards, safety and security applications), radiation dosimetry, characterization of plasmas, radiation protection, and industrial radiation processing. In recent times, there has been a growing focus on the determination of vacancy transfer probabilities (η_{XY}) between different atomic shells or subshells. Precise vacancy transfer probability (η_{XY}) values play a crucial role in the computation of nuclear phenomena like electron capture, internal conversion of gamma rays, the photoelectric effect, and characteristic X-ray production, etc. (Demir and Şahin, 2007; Turşucu *et al.*, 2012). For example, in medical research, accurate determination of vacancy transfer probabilities is essential for optimizing radiation therapy techniques used in cancer treatment. By understanding how electrons transition between different atomic shells or subshells, clinicians can precisely target tumor tissues while minimizing damage to surrounding healthy cells, thereby enhancing the effectiveness and safety of cancer therapies. In analytical methods involving X-rays, vacancy transfer probabilities are utilized to identify and quantify trace elements in various materials. This capability can be valuable in nuclear safeguards and security applications, where precise detection of radioactive materials is critical for ensuring national security and preventing illicit trafficking of nuclear materials. Moreover, in industrial applications such as radiation processing, knowledge of vacancy transfer probabilities informs the design and optimization of processes for materials synthesis, sterilization, and quality control. By controlling vacancy transfer processes, manufacturers can tailor the properties of materials and optimize production processes to meet specific performance requirements and regulatory standards. Understanding and accurately determining vacancy transfer probabilities are essential for advancing research, innovation, and practical applications across diverse scientific and technological disciplines. Vacancy transfer may occur when photons interact with matter through various mechanisms, which are closely linked to the energy of the incident photons. This interaction hinges on the process of photoionization, where a bound electron departs, creating a vacancy that is subsequently filled by another electron from a higher energy shell. The nature of this transition, whether radiative or nonradiative, is governed by quantum mechanical guidelines, the so-called selection rules. dictating permissible transitions, depending on their multipolarity. When they violate the rules for electric dipole transitions, they are called "forbidden transitions", which means that although they may occur in practice they do so, in general, with low probabilities (Turşucu *et al.*, 2012).

This paper is the first to present a comprehensive summary of experimental data concerning vacancy transfer probabilities. The data has been directly extracted from a wide range of publications (68 papers) spanning the timeframe from April 1993 (Puri *et al.*, 1993) to June 2023 (Gudennavar and Bubbly, 2023). In this study, a total of 1200 experimental values were collected from these 68 papers, further enriching the understanding of vacancy transfer probabilities within the specified period, especially with respect to the present state of experimental capability and data coverage. These values belong to 25 atomic parameters of η_{XY} vacancy transfer probabilities from X shell/sub-shell to Y shell/sub-shell. The compiled values include 413 values from 49 papers for $\eta_{\mathrm{KL}}(T)$ spanning April 1993 (Puri *et al.*, 1993) to June 2023 (Gudennavar and Bubbly, 2023), 16 values from 4 papers for $\eta_{\mathrm{KL1}}(A)$ from between January 2002 (Ertuğrul, 2002d) and October 2007 (Han *et al.*, 2007), 10 values from 3 papers each for $\eta_{\mathrm{KL2}}(A)$ and $\eta_{\mathrm{KL3}}(A)$ appearing between January 2002 (Ertuğrul, 2002d) and June

2003 (Ertuğrul, 2003), 138 values from 20 papers each for $\eta_{\mathrm{KL2}}(R)$ and $\eta_{\mathrm{KL3}}(R)$ published between February 1997 (Ertuğrul *et al*., 1997b) and December 2017 (Turhan *et al*., 2017), 14 values from 4 papers each for $\eta_{\mathrm{KL2}}(T)$ and $\eta_{\mathrm{KL3}}(T)$ reported between January 2002 (Ertuğrul, 2002d) and October 2007 (Han *et al*., 2007), 103 values from 10 papers for $\eta_{\mathrm{KM}}(R)$ from between February 1997 (Ertuğrul *et al*., 1997b) and July 2016 (Akman, 2016a), 8 values from 2 papers each for $\eta_{\mathrm{KM2}}(A)$ and $\eta_{\mathrm{KM3}}(R)$ in August 2012 (Durak *et al*., 2012) and December 2017 (Turhan *et al*., 2017), 30 values from 5 paper for $\eta_{\mathrm{L3M}}(R)$ available between February 2002 (Şimşek, 2002) and August 2016 (Krishnananda *et al.*, 2016), 9 values from 1 paper each for $\eta_{\mathrm{L1M}}(R)$, $\eta_{\mathrm{L2M}}(R)$, $\eta_{\mathrm{L1N}}(R)$ and $\eta_{\mathrm{L2N}}(R)$ in December 2005 (Sharma *et al*., 2005) , 30 values from 5 papers each for ($\eta_{\mathrm{L3Y}}(R),\ Y = \mathrm{M}i, \mathrm{N}i\ and\ i = 1{,}4{,}5$), between January 2004 (Dogan and Ertuğrul, 2004) and January 2019 (Hiremath *et al*., 2019), 26 values from 4 papers for $\eta_{\mathrm{L3N}}(R)$ between February 2002 (Şimşek, 2002) and September 2008 (Tuzluca *et al*., 2008), 28 values from 4 papers each for $\eta_{\mathrm{L3O1}}(T)$ and $\eta_{\mathrm{L3O4,5}}(T)$ between January 2004 (Dogan and Ertuğrul, 2004) and January 2019 (Hiremath *et al*., 2019). After collecting, scrutinizing, and summarizing the data, we organized them into a series of tables. The tables include both the weighted average values and standard deviation values. We then identified the atomic parameters of interest and analyzed them using these statistical measures. Finally, based on the coherent review of all available experimental information, we suggest a set of new empirical values for the atomic parameters $\eta_{\mathrm{KL}}(T), \eta_{\mathrm{KL2}}(R), \eta_{\mathrm{KL3}}(R), and\ \ \eta_{\mathrm{KM}}(R)$ of vacancy transfer probabilities, derived from the experimental values. These values are analytical in nature and are obtained through a computer program designed to fit polynomials to trending data values.

1. Survey of the experimental works

Table 1 presents an overview of the vacancy transfer probabilities (η_{XY}) published between 1993 and 2023, using a variety of experimental methods and under various experimental conditions. The table lists the atomic parameters for elements from $_{16}$S to $_{92}$U, as well as the references from where they were obtained, the excitation sources used, the target samples involved, and the X-ray spectrometers deployed to record the emitted photons.

The excitation sources can be charged particles or photons. Charged particles include proton beams with different energies, alpha particles, deuterons, and electrons. Photon sources include the 59.5 keV gamma rays emitted from a ^{241}Am radioactive source, the 122 keV gamma rays emitted from a ^{57}Co radioactive source, and the 22.69 keV X-rays emitted from a ^{109}Cd radioactive source. Other radioactive sources have also been used. Target samples can be pure elements, alloys, or chemical compounds. They can be found in the form of powders, foils, pellets, or circular discs. A variety of detector types and configurations have been used to measure the resulting X-ray emissions. The most widely used are single crystal semiconductors, such as Si(Li) detectors or Ge(Li) detectors. Ge(Li) spectrometers have been largely superseded in later studies by high purity germanium (HPGe) detectors which have much better energy resolution. More recently still, the Ultra-LEGe detector has been developed, which additionally offers reduced attenuation correction and hence potentially improved accuracy because of lower systematic error.

It is important to note that some of the papers cited in Table 1 (Ertuğrul, 2002b; Ertuğrul, 2002c; Ertuğrul, 2002d; Ertuğrul, 2003) did not directly report the values of the K- to L-shell total vacancy transfer probabilities $\eta_{\mathrm{KL}}(T)$. Therefore, we calculated these values using the following equations:

$$\eta_{\mathrm{KL}}(T) = \eta_{\mathrm{KL1}}(T) + \eta_{\mathrm{KL2}}(T) + \eta_{\mathrm{KL3}}(T) \qquad (1)$$

with

$$\Delta\eta_{\mathrm{KL}}(T) = \Delta\eta_{\mathrm{KL1}}(T) + \Delta\eta_{\mathrm{KL2}}(T) + \Delta\eta_{\mathrm{KL3}}(T) \tag{2}$$

or

$$\eta_{\mathrm{KL1}}(A) = \eta_{\mathrm{KL1}}(T) \tag{3}$$

$$\eta_{\mathrm{KL2}}(A) = \eta_{\mathrm{KL2}}(T) - \eta_{\mathrm{KL2}}(R) \tag{4}$$

$$\eta_{\mathrm{KL3}}(A) = \eta_{\mathrm{KL3}}(T) - \eta_{\mathrm{KL3}}(R) \tag{5}$$

and

$$\Delta\eta_{\mathrm{KL1}}(T) = \Delta\eta_{\mathrm{KL1}}(A) \tag{6}$$

$$\Delta\eta_{\mathrm{KL2}}(T) = \Delta\eta_{\mathrm{KL2}}(A) + \Delta\eta_{\mathrm{KL2}}(R) \tag{7}$$

$$\Delta\eta_{\mathrm{KL3}}(T) = \Delta\eta_{\mathrm{KL3}}(A) + \Delta\eta_{\mathrm{KL3}}(R)\ . \tag{8}$$

$\eta_{\mathrm{KL}i}(T)$ represents the probability of total vacancy transfer between the K shell and the L_i subshell, with $\Delta\eta_{\mathrm{KL}i}(T)$ signifying the associated uncertainty.

$\eta_{\mathrm{KL}i}(R)$ represents the probability of radiative vacancy transfer between the K shell and the L_i subshell, with $\Delta\eta_{\mathrm{KL}i}(R)$ signifying the associated uncertainty.

$\eta_{\mathrm{KL}i}(A)$ represents the probability of radiationless (Auger) vacancy transfer between the K shell and the L_i subshell, with $\Delta\eta_{KLi}(A)$ signifying the associated uncertainty.

2. Data analysis

All the experimental vacancy transfer probability values $(\eta_{XY}, X = \mathrm{K}, \mathrm{L}i;\ \ Y = \mathrm{L}, \mathrm{M}, \mathrm{N}, \mathrm{L}i, \mathrm{M}j, \mathrm{N}p, \mathrm{O}p;\ \ i = 1,2,3;\ \ j = 1,2,3,4,5;\ \ p = 1,4,5)$ were taken from the referenced papers. The reported values were in a three- to four-digit format, with their associated errors. However, the experimental values for the parameters (η_{L3N1}, η_{L3N4}, η_{L3O1}, and $\eta_{\mathrm{L3O4.5}}$) were taken in a four- to five-digit format. Tables 2–21 gives a summary of the compiled database of vacancy transfer probabilities for various elements from $_{16}S$ to $_{92}U$ for η_{KL}, from $_{55}Cs$ to $_{68}Er$ for ($\eta_{\mathrm{KL1}}(A)$, $\eta_{\mathrm{KL2}}(A)$, $\eta_{\mathrm{KL2}}(T)$, $\eta_{\mathrm{KL3}}(A)$, and $\eta_{\mathrm{KL3}}(T)$), from $_{23}V$ to $_{92}U$ for ($\eta_{\mathrm{KL2}}(R)$ and $\eta_{\mathrm{KL3}}(R)$), from $_{24}Cr$ to $_{92}U$ for $\eta_{\mathrm{KM}}(R)$, from $_{64}Gd$ to $_{92}U$ for $\eta_{\mathrm{L3M}}(R)$, from $_{62}Sm$ to $_{92}U$ for ($\eta_{\mathrm{L3}Y}(R)$, $Y = \mathrm{M}i, N\mathrm{i}$ and $i = 1,4,5$), and from $_{72}Hf$ to $_{92}U$ for $\eta_{\mathrm{L3N}}(R)$, $\eta_{\mathrm{L3O1}}(R)$, and $\eta_{\mathrm{L3O4,5}}(R)$).The same tables present the references from which they were obtained, as well as the weighted average values, which are given by the following formula:

$$(\eta_{XY})_W \pm \varepsilon = \frac{1}{\sum_{i=1}^{N}\frac{1}{\left(\Delta(\eta_{XY})_{EXP-i}\right)^2}} \cdot \sum_{i=1}^{N}\frac{(\eta_{XY})_{EXP-i}}{(\Delta(\eta_{XY})_{EXP-i})^2} \pm \frac{1}{\left(\sum_{i=1}^{N}\frac{1}{\left(\Delta(\eta_{XY})_{EXP-i}\right)^2}\right)^{\frac{1}{2}}} \quad (9)$$

In Eq. (9), $(\eta_{XY})_{EXP-i}$ denotes the i^{th} experimental value, $\Delta(\eta_{XY})_{EXP-i}$ signifies the assigned uncertainty (standard deviation) for the i^{th} experimental value, and *N* represents the number of experimental data points of the element.

The combined standard deviation is defined by the following equation (and is reported in a two-digit format) (Hamidani *et al.*, 2023):

$$z_i = \frac{(\eta_{XY})_{EXP-i} - (\eta_{XY})_W}{\sqrt{(\Delta(\eta_{XY})_{\mathrm{EXP}-i})^2 + (\Delta(\eta_{XY})_W)^2}} \ , \quad (10)$$

where $(\eta_{XY})_{EXP-i}$ and $(\eta_{XY})_W$, respectively, represent the i^{th} experimental value and the weighted average for each (η_{XY}) vacancy transfer probabilities parameter. Similarly, $\Delta(\eta_{XY})_{EXP-i}$ and $\Delta(\eta_{XY})_W$ correspond to the related assigned standard deviations.

The average *z*-score (presented in a two-digit format) is defined by:

$$\bar{z} = \frac{\sum_{i=1}^{n} z_i}{n} \ , \quad (11)$$

where n indicates the number of experimental points for each element.

It is important to highlight that the experimental values of K-L total vacancy transfer probabilities ($\eta_{\mathrm{KL}}(T)$) reported without uncertainties were omitted from the computation of the weighted average values $(\eta_{XY})_W$. In addition, for atomic elements that have only one experimental value, their weighted average value is equates to their experimental value, and both the combined standard deviation and average z-score are null so we do not include these statistical values in Table 11. Furthermore, certain values of K-L total vacancy transfer probabilities ($\eta_{\mathrm{KL}}(T)$) are reported in the literature accompanied by their estimated fractional standard deviation, expressed as a percentage (p%) as in (Puri *et al.*, 1993; Cengiz *et al.*, 2008; Han and Demir, 2010; Cengiz *et al.*, 2011; Onde *et al.*, 2013; Alim *et al.*, 2017b). In such situations, the absolute standard deviation $\Delta(\eta_{KL}(T))$ is computed using the following expression (Hamidani *et al.*, 2023):

$$\Delta(\eta_{\mathrm{KL}}(\mathrm{T})) = 0.01 \times (p\%) \times \eta_{\mathrm{KL}}(\mathrm{T}). \quad (12)$$

It is important to remember that the majority of figures that we are dealing with in this work are for the atomic parameters ($\eta_{\mathrm{KL}}(T), \eta_{\mathrm{KL2}}(R), \eta_{\mathrm{KL3}}(R)$ *and* $\eta_{\mathrm{KM}}(R)$) and because there are typically multiple determinations, they may be considered using statistical methods. However, it is also important to note that the lack of a large database for a given parameter does not necessarily mean that the parameter is not important or that it cannot be measured. It simply means that it is more difficult to obtain data for this parameter than for others. In the case of the rest of the atomic parameters of vacancy transfer probabilities, the lack of a large database is due to a combination of factors. It could be that the process is difficult to measure, is not a high priority for many applications, requires use of radioactive targets, or that the underlying physics is not fully understood, meaning that data interpretation is not clear-cut. However, the experimental data that is available and has been assembled here is still invaluable for understanding the dynamics of atomic collisions and for developing models of atomic structure.

Fig. 1(a) illustrates the distribution of the experimental $\eta_{\mathrm{KL}}(T)$ values according to the target atomic number *Z*. Notably, the atomic parameter K-L total vacancy transfer probabilities

$\eta_{\mathrm{KL}}(T)$ holds the largest proportion of data in terms of the number of values, some 413 values, roughly 35% of the complete database. This atomic parameter spans a wide range of elements, ranging from $_{16}$S to $_{92}$U. Analysis of this figure leads to the following conclusions:

- Except for twelve elements namely $_{18}$Ar, $_{36}$Kr, $_{43}$Tc, $_{54}$Xe, $_{61}$Pm, $_{84}$Po, $_{85}$At, $_{86}$Rn, $_{87}$Fr, $_{88}$Ra, $_{89}$Ac, and $_{91}$Pa, the vast majority of elements from $_{16}$S to $_{92}$U are present in the database. The absence of data for these specific elements is likely attributed to challenges in their handling.
- For certain elements, only one value is available, namely ($_{16}$S, $_{17}$Cl, $_{69}$Tm, $_{70}$Yb and $_{71}$Lu), while for others, there are merely two value, ($_{19}$K, $_{35}$Br, $_{53}$I, $_{72}$Hf, $_{76}$Os and $_{77}$Ir). These elements are either relatively rare or difficult to study experimentally.
- The most exploited targets are in the region $22 \leq Z \leq 50$. The elements in this region include $_{24}$Cr, $_{25}$Mn, $_{26}$Fe, $_{28}$Ni, $_{30}$Zn, $_{40}$Zr, $_{42}$Mo, $_{48}$Cd, and $_{50}$Sn. Additionally, it's noteworthy that two elements, $_{42}$Mo and $_{47}$Ag, have the highest number of data points, each boasting 16 values across approximately 17 publications.
- The number of measurements for the following elements ranges from eleven to fifteen: $_{24}$Cr, $_{25}$Mn, $_{26}$Fe, $_{27}$Co, $_{28}$Ni, $_{29}$Cu, $_{30}$Zn, $_{40}$Zr, $_{41}$Nb, $_{46}$Pd, and $_{48}$Cd. These elements are all transition metals, which are located in the middle of the periodic table.
- For the rest of elements, between three and ten experimental values of the K-L total vacancy transfer probability ($\eta_{KL}(T)$) are available.

Fig. 1(b) and (c) show the distribution of the 138 experimental values of the radiative vacancy transfer probabilities for each of $\eta_{\mathrm{KL2}}(R)$ and $\eta_{\mathrm{KL3}}(R)$ for atoms with atomic number $23 \leq Z \leq 92$ displayed as a function of Z. Examination and analysis of this figures shows:

- The radiative vacancy transfer probabilities (RVTP) $\eta_{\mathrm{KL2}}(R)$ and $\eta_{\mathrm{KL2}}(R)$ for almost all elements from $_{23}$V to $_{92}$U are covered, with the exceptions of $_{25}$Mn, $_{29}$Cu, $_{31}$Ga, $_{32}$Ge,

$_{35}$Br, $_{36}$Kr, $_{43}$Tc, $_{44}$Ru, $_{45}$Rh, $_{54}$Xe, $_{61}$Pm, $_{72}$Hf, $_{76}$Os, $_{77}$Ir, $_{84}$Po, $_{85}$At, $_{86}$Rn, $_{87}$Fr, $_{88}$Ra, $_{89}$Ac, and $_{91}$Pa. The absence of RVTP data for these specific elements is likely because they are either rare, radioactive, or difficult to study experimentally.

- There are some elements with only one value: $_{23}$V, $_{24}$Cr, $_{26}$Fe, $_{27}$Co, $_{28}$Ni, $_{33}$As, $_{34}$Se, $_{37}$Rb, $_{38}$Sr, $_{39}$Y, $_{40}$Zr, $_{41}$Nb, $_{49}$In, $_{50}$Sn, $_{51}$Sb, $_{52}$Te, $_{53}$I, $_{69}$Tm, $_{71}$Lu, $_{75}$Re, $_{83}$Bi, $_{90}$Th, and $_{92}$U.
- The elements with the largest number of measured data are all lanthanides, namely $_{60}$Nd, $_{64}$Gd, $_{66}$Dy, $_{67}$Ho, and $_{68}$Er, with 9, 10, 10, 10, and 8 data values, respectively.
- The RVTP $\eta_{\mathrm{KL2}}(R)$ and $\eta_{\mathrm{KL3}}(R)$ values for the rest of elements are between two and seven experimental values.

Fig. 1(d) shows the distribution of 103 experimental values of K-M radiative vacancy transfer probabilities ($\eta_{\mathrm{KM}}(R)$) as a function of the atomic number Z (for $24 \leq Z \leq 92$), obtained from 10 referenced papers. The analysis of these figures allows us to make the following comments:

- Only 46 elements have published values for the K-M radiative vacancy transfer probabilities, and almost half of them (24 elements) have only one value each. These elements are $_{24}$Cr, $_{28}$Ni, $_{30}$Zn, $_{33}$As, $_{34}$Se, $_{37}$Rb, $_{38}$Sr, $_{39}$Y, $_{40}$Zr, $_{41}$Nb, $_{46}$Pd, $_{47}$Ag, $_{48}$Cd, $_{49}$In, $_{50}$Sn, $_{51}$Sb, $_{52}$Te, $_{53}$I, $_{69}$Tm, $_{71}$Lu, $_{75}$Re, $_{83}$Bi, $_{90}$Th, and $_{92}$U.
- The elements $_{55}$Cs, $_{56}$Ba, $_{57}$La, $_{58}$Ce, $_{60}$Nd, $_{62}$Sm, $_{63}$Eu, $_{64}$Gd, $_{65}$Tb, $_{66}$Dy, $_{67}$Ho, $_{68}$Er, $_{70}$Yb, $_{73}$Ta, $_{74}$W, $_{75}$Re, $_{78}$Pt, $_{79}$Au, $_{80}$Hg, $_{81}$Tl, and $_{82}$Pb have been documented in several experimental reports each with two and seven entries. The listed elements are all lanthanides and actinides, which are relatively rare and difficult to study experimentally. As a result, there is a limited number of available experimental data values for these elements.

- The K-M radiative vacancy transfer probabilities have a smaller database than the K-L vacancy transfer probabilities because they are more difficult to measure and the underlying physics of the K-M process is not fully understood, meaning that a clear interpretation of an experiment is lacking.

The various atomic parameters, specifically the vacancy transfer probabilities, were experimentally determined using a range of excitation sources, including X-ray tubes and radioactive materials, as described in the referenced articles. These measurements differ in quality based on the experimental design. They are usually reported with an estimated uncertainty but sometimes the overall uncertainty must be assembled from the partial error contributions.

One effective method to graphically represent how each experimental data point differs from the weighted mean for the element is by creating a plot that shows the signed deviation in units of the combined standard deviation, as defined in equation (10).

The distribution of equations (10) and (11) with respect to the atomic number Z is presented in Fig. 6 (a) (for the $\eta_{\mathrm{KL}}(T)$), (b) (for the $\eta_{\mathrm{KL2}}(R)$), (c) (for the $\eta_{\mathrm{KL3}}(R)$), and (d) (for the $\eta_{\mathrm{KM}}(R)$). An analysis of these figures enables us to draw the following observations:

- A careful examination of Fig. 6(a) reveals that the experimentally reported uncertainties for the atomic elements do not exhibit significant dispersion. For most atomic elements, the z value falls within the range of -2 to 2. This suggests that the experimenters likely used a consistent approach when estimating and reporting uncertainties, thus increasing the credibility of these values. It implies that most experimenters followed a similar experimental methodology for determining their results. However, it is worth noting some quite large deviations, as reported in the works of Bennal *et al*. (2010), Anand *et al*. (2013), and Ertuğral *et al*. (2005). Among these deviations, the two most distant points are approximately 4.16 (corresponding to $_{83}$Bi) as reported in Ertuğral *et al.* (2005), and 4.1 (for $_{48}$Cd) as reported in Bennal *et al.* (2010).

- In Fig. 2(b), (c), and (d), we observe that the *z*-scores for the parameters $\eta_{\mathrm{KL2}}(R)$, $\eta_{\mathrm{KL3}}(R)$), and $\eta_{\mathrm{KM}}(R)$, calculated based on the experimentally reported uncertainties of the atomic elements, span the interval from -1.09 (Bennal and Badiger, 2006) to 1.17 (Reyes-Herrera and Miranda, 2009) for $\eta_{\mathrm{KL2}}(R)$, from -0.83 (Bennal and Badiger, 2006) to 0.83 (Reyes-Herrera and Miranda, 2009) for $\eta_{\mathrm{KL3}}(R)$, and from -1.04 (Çalişkan *et al.*, 2002) to 1.27 (Demir and Şahin, 2007) for $\eta_{\mathrm{KM}}(R)$. Notably, the dispersion of these values is less prominent when compared to the parameter $\eta_{\mathrm{KL}}(T)$. This observation underscores the proximity of the experimental values reported by the researchers and their adeptness in effectively estimating uncertainties, thereby enhancing the overall reliability of these results.

In brief, Fig. 2(a), (b), (c), and (d) demonstrate that the presented vacancy transfer probability experimental data exhibit a high level of quality when compared to the K_{β}/K_{α} intensity ratios, as indicated in the sources by Hamidani *et al.* (2023) and Daoudi *et al.* (2020). Future experimental data must maintain a similarly high standard and be accompanied by thorough descriptions and meticulous uncertainty analyses. These endeavors are crucial for resolving discrepancies and elevating the overall quality of practical guidance. This study represents an initial stride toward enabling a comprehensive assessment. For those interested in specific details or in planning new experimental campaigns, the references provided to the original papers can serve as a valuable resource on experimental technique and good practice.

4. Empirical calculation.

In our quest for a deeper understanding of vacancy transfer probabilities and to assist in the production of missing data points (shown in bold in Tables 23-26) for various atomic elements across multiple parameters, we generated plots showing the experimental values of the $\eta_{\mathrm{KL}}(T), \eta_{\mathrm{KL2}}(R),\ \eta_{\mathrm{KL3}}(R), and\ \eta_{\mathrm{KM}}(R)$ vacancy transfer probabilities. These parameters encompass the atomic range of 16 ≤ Z ≤ 92 (for $\eta_{KL}(T)$), 23 ≤ Z ≤92 (for $\eta_{KL2}(R)$ and $\eta_{KL3}(R)$), and 24 ≤ Z ≤92 (for $\eta_{KM}(R)$) all plotted against the atomic number *Z*. Harnessing the available experimental database (the second column of Tables 2, 5, 8, and 10), we subsequently performed fitting procedures to compute updated empirical values for these parameters. The results of this fitting process are visually represented in Figs. 3 and 4. The mentioned experimental values, which were reported without specific uncertainties, have also been included in computing the updated empirical values. Notably, the analytical function utilized for the fitting process is as follows:

$$(\eta_{XY})_{Exp} = A_0 + \sum_{r=1}^{4} A_r Z^r \qquad (13)$$

$X = \mathrm{K}; Y = \mathrm{L, M, L}i;\ \ i = 2,3.$

The fitting coefficients A_r are listed in Table 22.

A computer program has been designed to fit polynomials with degrees up to the 9th degree to the provided input data. This program employs a selection process to determine the most suitable polynomial (smoothly representing the data without overfitting), primarily based on the correlation coefficient. The empirical values calculated by these selected polynomials have been organized and are available in Tables 23 to 26.

The deviation between the calculated empirical values ($\eta_{XY}(emp)$) and their associated experimental values ($\eta_{XY}(\exp)$) for vacancy transfer probabilities is represented through the root-mean-square error (ε_{RMS}). This error is determined by the formula:

$$\varepsilon_{RMS} = \left[\frac{1}{N}\sum_{j=1}^{N}\left(\frac{\eta_{XY}(\text{exp})_j - \eta_{XY}(\text{emp})}{\eta_{XY}(\text{emp})}\right)^2\right]^{1/2}, \quad (14)$$

$X = \text{K}; Y = \text{L}, \text{M}, \text{L}i;\ i = 2{,}3$. Here, N represents the total number of experimental data for each element, and the equation evaluates the average square difference between the experimental and empirical values for each point, normalized by the empirical value.

5. Results and discussion.

The current assessment of empirical vacancy transfer probabilities, encompassing $\eta_{\text{KL}}(T), \eta_{\text{KL2}}(R), \eta_{\text{KL3}}(R), and\ \eta_{\text{KM}}(R)$, is documented in Tables 23, 24, 25, and 26. Table 23 includes theoretical values from Roa *et al*. (1972), fitting outcome from Schönfeld and JanBen (1996), and experimental data from Öz (2006), Ertuğral et al. (2005), and Ertuğral *et al*. (2006) as well. In Tables 24, 25, and 26, you'll find theoretical values from Roa *et al*. (1972) alongside experimental measurements from Ertuğrul (2002a), Çalilskan *et al*. (2002), Durak and Özdemir (1998), and Ertuğrul *et al*. (1997b). Additionally, the tables present the root-mean-square error (ε_{RMS}) for the empirical results. Because the experimental data (shown in bold in Tables 23-26) are not yet reported, the values of (ε_{RMS}) for these elements are not added.

To thoroughly assess our empirical vacancy transfer probabilities alongside theoretical, fitted, and experimental values, all values of $\eta_{\text{KL}}(T), \eta_{\text{KL2}}(R),\ \eta_{\text{KL3}}(R), and\ \eta_{\text{KM}}(R)$, have been plotted in Fig. 5 against the atomic number *Z*. Generally, our present empirical calculations, derived from formula (13), exhibit consistency with the theoretical, fitted, and experimental values across the atomic range of $16 \leq Z \leq 92$ (for $\eta_{\text{KL}}(T)$,), $23 \leq Z \leq 92$ (for $\eta_{\text{KL2}}(R)$, and $\eta_{\text{KL3}}(R)$,), and $24 \leq Z \leq 92$ (for $\eta_{\text{KM}}(R)$,). Specifically, for $\eta_{\text{KL}}(T)$, marginal differences are observed, ranging from 0.07% to 6.93% concerning Rao *et al*. (1972). Additionally, in comparison with the semi-empirical values of Schönfeld and JanBen. (1996), variations range from 0.05% to 2.50%, except for the last eight elements, where a deviation span from 2.92% to

7.07%. Regarding comparisons with the experimental values, our empirical results align closely with Ertuğral *et al*. (2006) within 0.01% to 2.50%, Öz. (2006) within 0.09% to 0.84%, and Ertuğral *et al*. (2005) within 0.05% to 3.83%. These relative differences ($RD\%$) were computed using the expression $(RD\%) = \frac{|\eta_{XY}-\eta_{XY}(\text{emp})|}{\eta_{XY}(\text{emp})} \times 100$. Regarding $\eta_{\text{KL2}}(R)$, $\eta_{\text{KL3}}(R)$ and, $\eta_{\text{KM}}(R)$, depicted in Fig. 5, our empirical findings demonstrate strong alignment with the theoretical outcomes of Roa *et al*. (1972), showcasing relative differences ranging from 0.05% to 2.74% for $\eta_{\text{KL2}}(R)$, 0.18% to 2.54% for $\eta_{\text{KL3}}(R)$, and 0.14% to 5.76% for $\eta_{\text{KM}}(R)$, excluding elements $_{26}$Fr and $_{30}$Zn, with deviations of 41.06% and 9.01%, respectively. Our comparison with experimental measurements also indicates a high level of agreement, displaying deviations from 0.09% to 4.43%, 0.64% to 3.40%, and 0.31% to 2.54% for Ertuğrul (2002a); 0.23% to 1.70%, 0.19% to 2.50%, and 0.08% to 3.04% for Çalilskan *et al*. (2002); 0.08% to 0.96%, 0.06% to 1.37%, and 0.36% to 2.43% for Durak and Özdemir (1998); and 0.18% to 1.44%, 0.00% to 1.19%, and 0.26% to 2.09% for Ertuğrul *et al*. (1997b). These deviations correspond to $\eta_{\text{KL2}}(R)$, $\eta_{\text{KL3}}(R), and\ \eta_{\text{KM}}(R)$, respectively. Finally, Fig. 6 illustrates an examination of the root mean square error (ε_{RMS}) between empirical and experimental values of the vacancy transfer probability atomic parameters ($\eta_{\text{KL}}(T), \eta_{\text{KL2}}(R), \eta_{\text{KL3}}(R), and\ \eta_{\text{KM}}(R)$) for various atomic elements in relation to their atomic numbers *Z*. Notably, the ε_{RMS} values for most elements reside within a narrow range of 0% to 5%, indicating strong agreement between calculated results and experimental data. However, exceptions exist for certain elements: $_{38}$Sr, $_{41}$Nb, $_{44}$Ru, $_{45}$Rh, $_{46}$Pd, $_{77}$Ir, $_{83}$Bi, $_{90}$Th, and $_{92}$U for $\eta_{\text{KL}}(T)$; $_{23}$V, $_{24}$Cr, $_{27}$Co, and $_{28}$Ni for$\eta_{\text{KL2}}(R)$ and $\eta_{\text{KL3}}(R)$; and $_{24}$Cr, $_{28}$Ni, $_{56}$Ba, and $_{66}$Dy for $\eta_{\text{KM}}(R)$. These deviations likely stem from data heterogeneity, as values were sourced from diverse references with varying experimental conditions. Despite these exceptions, the overall consistency of the ε_{RMS} values for most elements supports the credibility of our results. Furthermore, our findings exhibit consistency with various theoretical, experimental, empirical, and semi-empirical studies, strengthening their validity.

6. Conclusion

A total of 1200 experimental data points for 25 parameters concerning vacancy transfer probabilities in elements with atomic numbers from 16 to 92 were compiled from diverse reference sources spanning the years 1993 to 2023 (68 distinct papers). These data points have been meticulously organized and are presented in tabular format. Notably, this database includes 413 data points for $\eta_{\mathrm{KL}}(T)$, 138 data points for each of $\eta_{\mathrm{KL2}}(R)$ and $\eta_{\mathrm{KL3}}(R)$, and 103 data points for $\eta_{\mathrm{KM}}(R)$, all of which were subjected to thorough review and analysis.

Furthermore, the weighted average value for each element was meticulously computed. A new set of vacancy transfer probabilities has been derived through analytical methods covering elements within specific atomic regions: $16 \leq Z \leq 92$ (for $\eta_{\mathrm{KL}}(T)$), $23 \leq Z \leq 92$ (for $\eta_{\mathrm{KL2}}(R)$ and $\eta_{\mathrm{KL3}}(R)$), and $24 \leq Z \leq 92$ (for $\eta_{\mathrm{KM}}(R)$). These derived empirical values demonstrated a relatively strong alignment with findings from other research groups across the entire range of atomic numbers. To the best of our knowledge, this work represents the first attempt to consolidate and present experimental data values for a range of parameters concerning vacancy transfer probabilities. However, there is still room for further refinement and expansion. We encourage future researchers to utilize our database as a foundation for deriving new empirical and semi-empirical models, as well as for informing new experimental efforts aimed at improving and extending the dataset. To analyze vacancy transfer effects more effectively, we recommend employing a combination of experimental, theoretical, and computational approaches. Experimental techniques such as spectroscopic measurements can provide valuable insights into the behavior of atoms and the dynamics of vacancy transfer processes. Meanwhile, theoretical frameworks and computational simulations can offer predictive capabilities and deeper insights into the underlying mechanisms governing vacancy transfer phenomena. By integrating these approaches, researchers can gain a comprehensive understanding of vacancy transfer effects and their implications across various scientific and technological domains. Ultimately, we believe that continued research in this area will not only advance our understanding of atomic inner shell ionization processes but also lead progress and innovations across various fields ranging from medical imagining to materials science.

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Figures caption:

Fig. 1. Distribution of the experimental $\eta_{\mathrm{KL}}(T)$ (a), $\eta_{\mathrm{KL2}}(R)$ (b), $\eta_{\mathrm{KL3}}(R)$ (c), and $\eta_{\mathrm{KM}}(R)$ (d) values according to the atomic number *Z*.

Fig. 2. Distribution of Eqs. (10) and (11) of $\eta_{\mathrm{KL}}(T)$ (a), $\eta_{\mathrm{KL2}}(R)$ (b), $\eta_{\mathrm{KL3}}(R)$ (c), and $\eta_{\mathrm{KM}}(R)$ (d) according to the atomic number *Z*.

Fig. 3. The distribution of experimental values $\eta_{\mathrm{KL}}(T)$ with respect to atomic number *Z*, within the range of $16 \leq Z \leq 70$ (a) and from $71 \leq Z \leq 92$ (b) is shown. The curve is the fitting according to the Eq. (13).

Fig. 4. The distribution of experimental values $\eta_{\mathrm{KL2}}(R)$ and $\eta_{\mathrm{KL3}}(R)$ in the range $23 \leq Z \leq 92$, and $\eta_{\mathrm{KM}}(R)$ from $24 \leq Z \leq 92$ with respect to atomic number *Z* is shown. The curve is the fitting according to the Eq. (13).

Fig. 5. Comparison of current empirical vacancy transfer probabilities with theoretical, fitted, and experimental values for $\eta_{\mathrm{KL}}(T)$, $\eta_{\mathrm{KL2}}(R)$, $\eta_{\mathrm{KL3}}(R)$, and $\eta_{\mathrm{KM}}(R)$ as a function of atomic number *Z*.

Fig. 6. Root-mean-square error ($\varepsilon_{\mathrm{RMS}}$) for for $\eta_{\mathrm{KL}}(T)$, $\eta_{\mathrm{KL2}}(R)$, $\eta_{\mathrm{KL3}}(R)$, and $\eta_{\mathrm{KM}}(R)$ as a function of atomic number *Z*.

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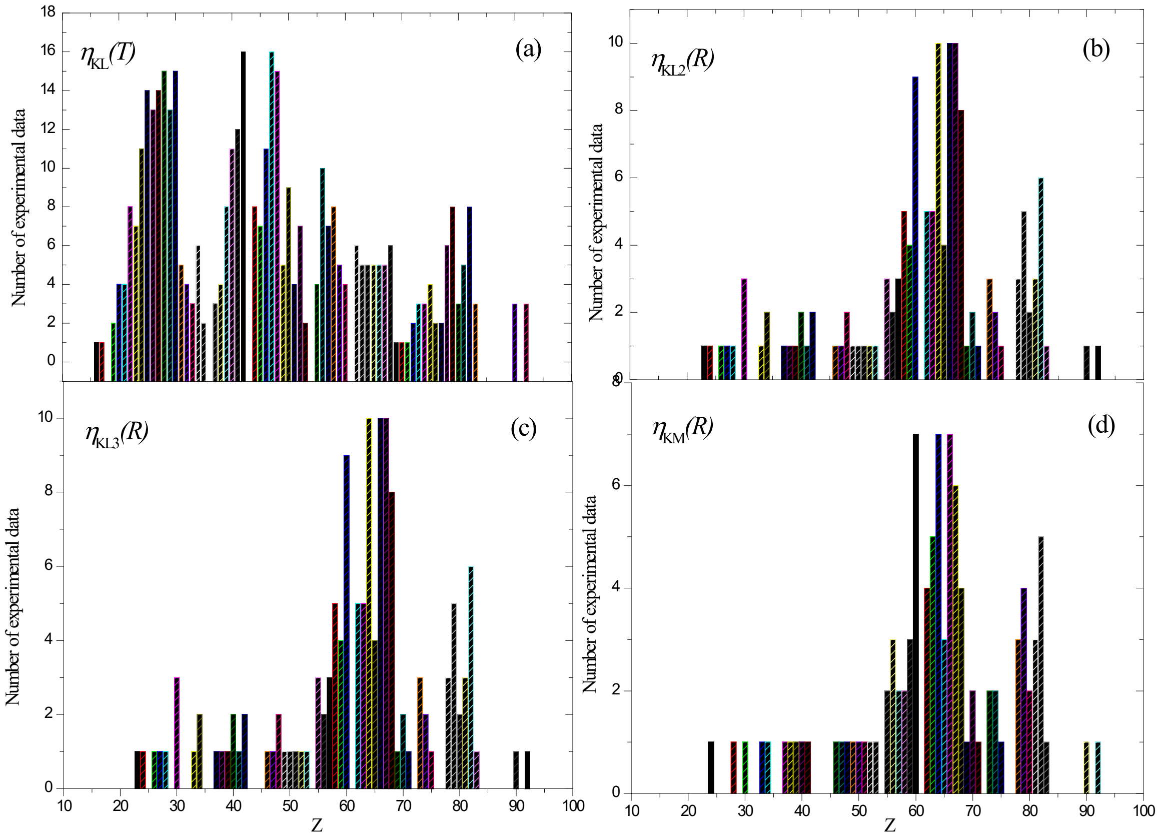


(a)
$\eta_{KL}(T)$
(b)
$\eta_{KL2}(R)$
(c)
$\eta_{KL3}(R)$
(d)
$\eta_{KM}(R)$
Number of experimental data
Z

Fig. 1

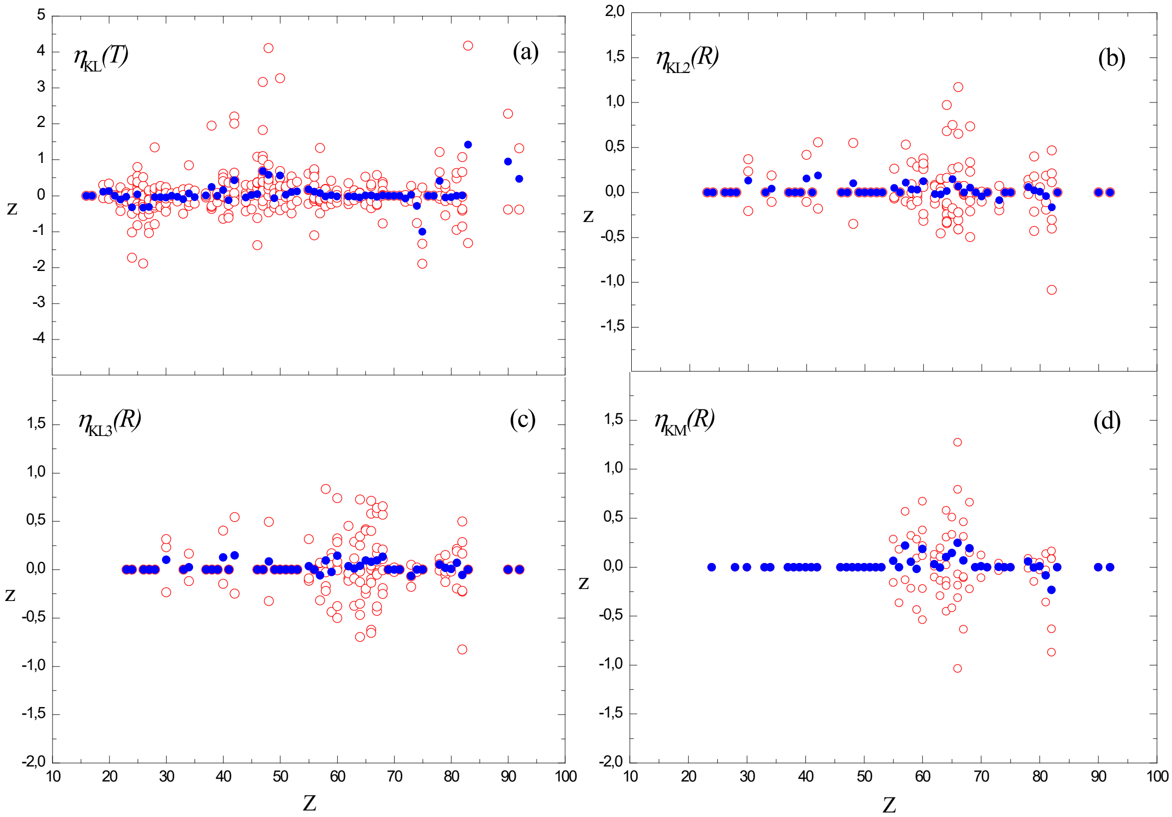


Fig. 2

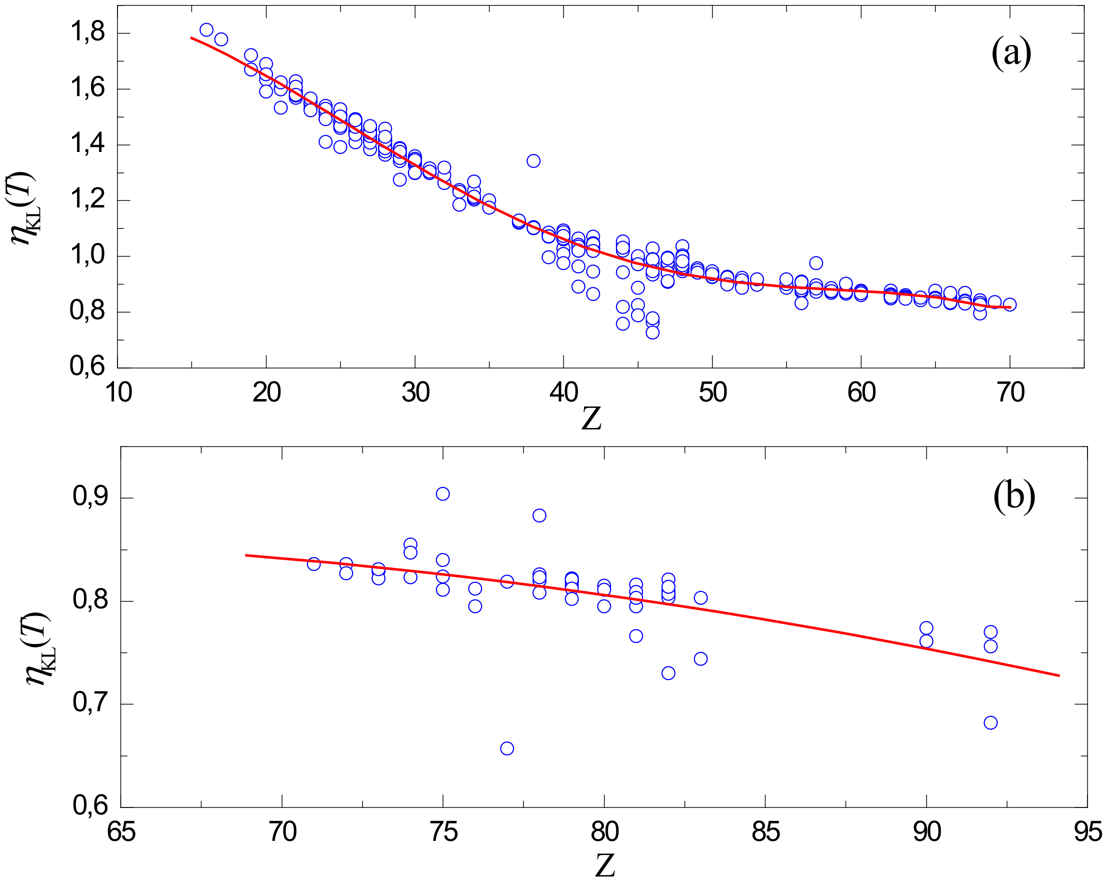
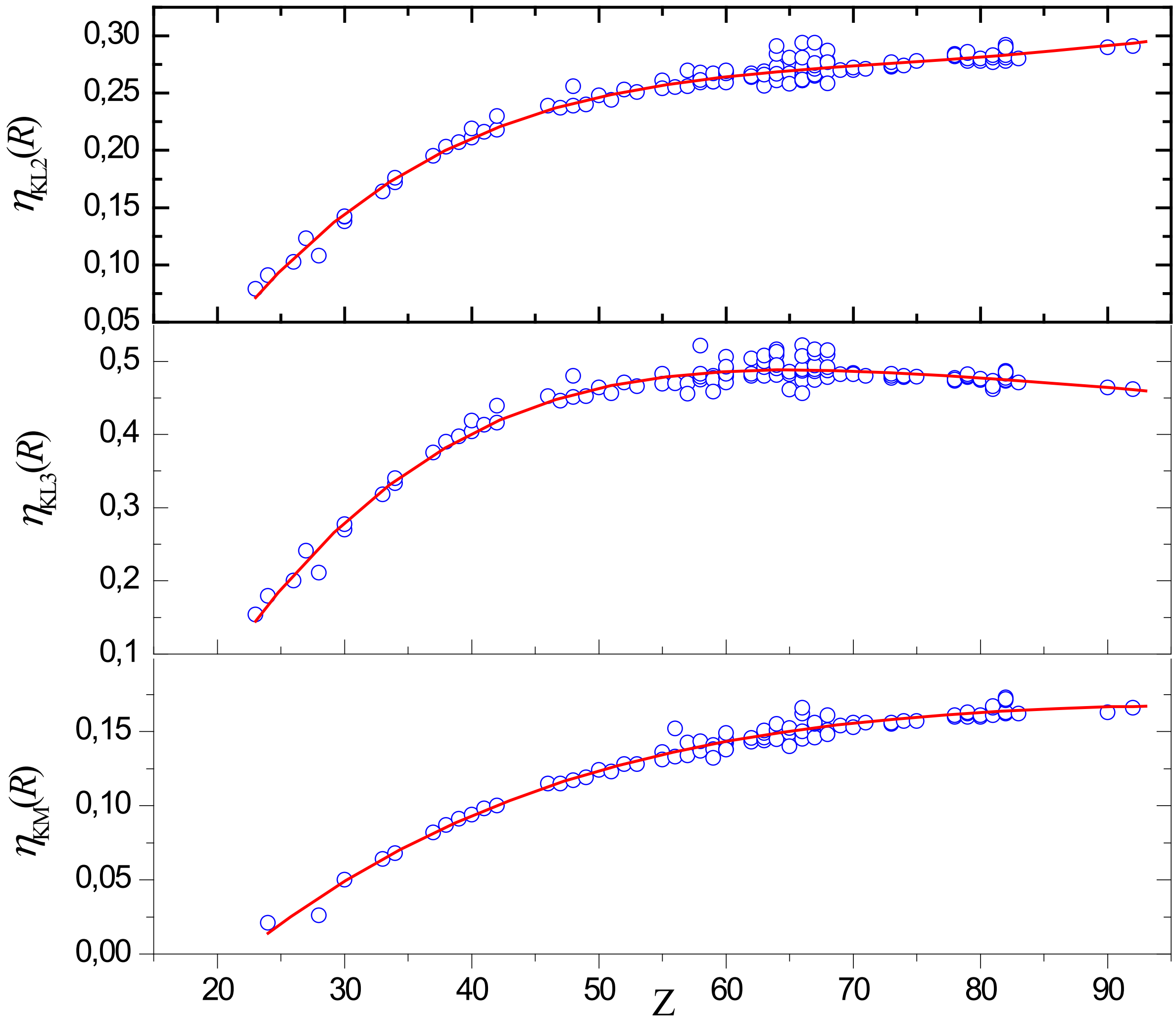

(a)
1,8
1,6
1,4
1,2
1,0
0,8
0,6
$\eta_{KL}(T)$
10
20
30
40
50
60
70
Z
(b)
0,9
0,8
0,7
0,6
$\eta_{KL}(T)$
65
70
75
80
85
90
95
Z

Fig. 3



0,30
0,25
0,20
0,15
0,10
0,05
$\eta_{KL2}(R)$
0,5
0,4
0,3
0,2
0,1
$\eta_{KL3}(R)$
0,15
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0,00
$\eta_{KM}(R)$
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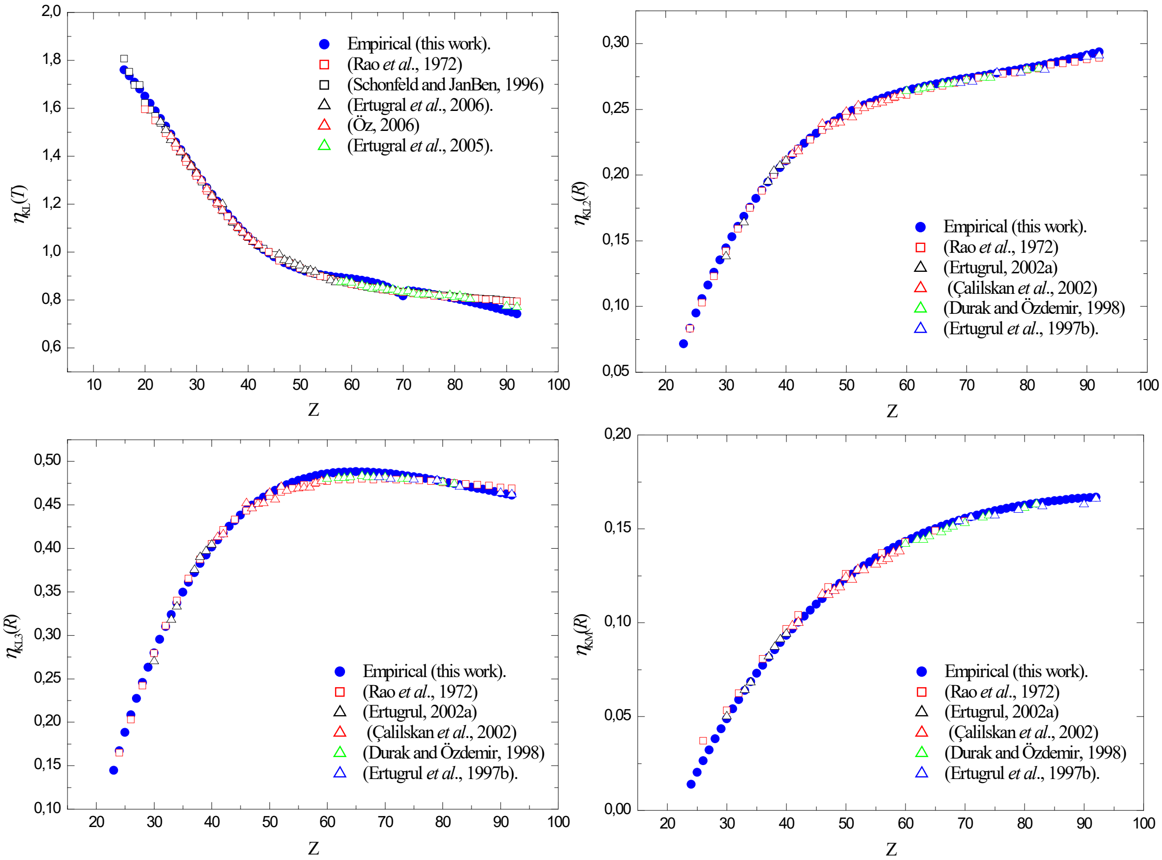
30
40
50
60
70
80
90
Z

Fig. 4


Empirical (this work).
(Rao et al., 1972)
(Schonfeld and JanBen, 1996)
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(Öz, 2006)
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Empirical (this work).
(Rao et al., 1972)
(Ertugrul, 2002a)
(Çalilskan et al., 2002)
(Durak and Özdemir, 1998)
(Ertugrul et al., 1997b).
Z

Fig. 5

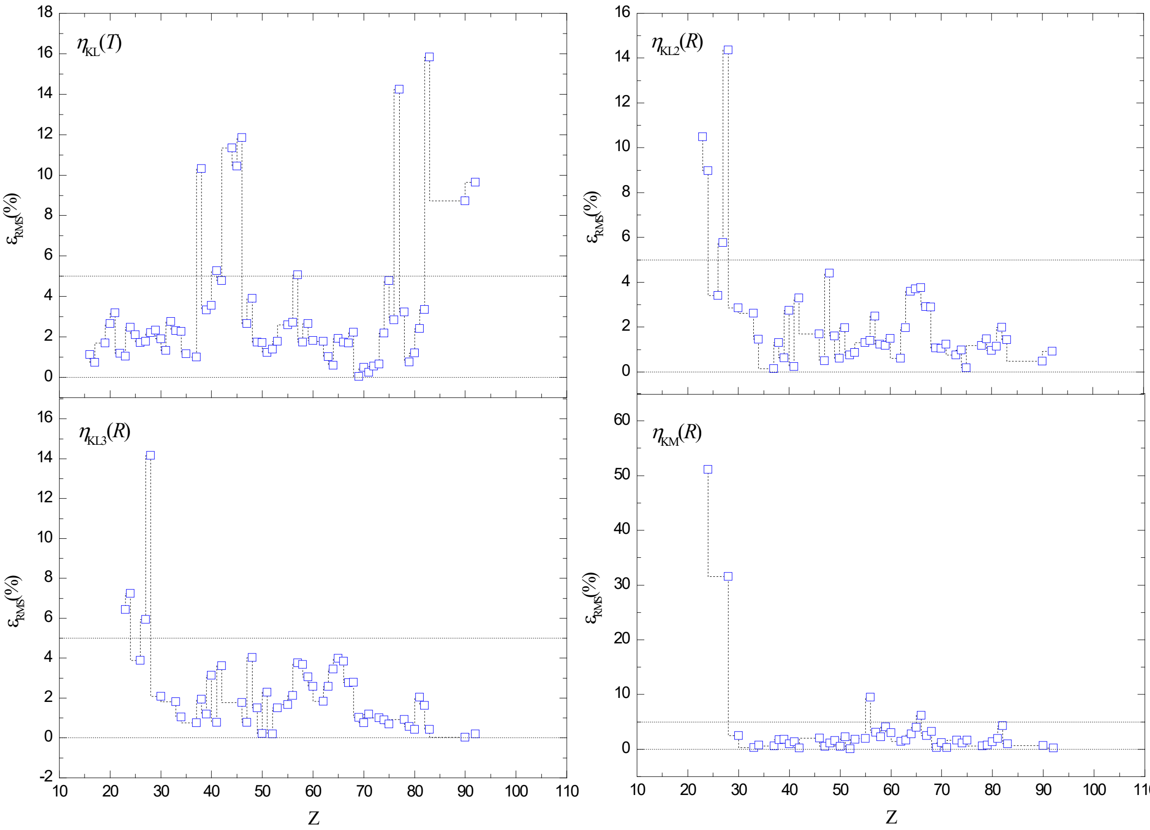

Fig. 6

Table 1. Summary of atomic parameters for elements ranging from $_{16}$S to $_{92}$U, including excitation sources, target samples, detectors, and references.

References	Atomic parameters	Excitation sources	Target samples	Detectors
(Puri *et al.*, 1993)	$\eta_{KL}(T)$	5.96 and 22.6 keV photons produced from a ^{55}Fe(25 mCi) and ^{109}Cd (20 mCi).	$_{37}$Rb, $_{38}$Sr, $_{39}$Y, $_{40}$Zr, $_{41}$Nb, $_{42}$Mo.	Si(Li) detector with a resolution of 170 eV FWHM at 5.96 keV.
(Ertuğrul *et al.*, 1997a)	$\eta_{KL}(T)$	59.5 and 122 keV photons produced from a ^{241}Am (100mCi) and ^{57}Co (100 mCi).	$_{73}$Ta, $_{74}$W, $_{75}$Re, $_{79}$Au, $_{80}$Hg, $_{81}$Tl, $_{82}$Pb, $_{83}$Bi, $_{90}$Th and $_{92}$U.	Si(Li) detector with a resolution of 160 eV FWHM at 5.96 keV.
(Ertuğrul *et al.*, 1997b)	$\eta_{KL2}(R)$ $\eta_{KL3}(R)$ $\eta_{KM}(R)$	122 keV photons produced from a ^{57}Co radioactive source.	$_{69}$Tm, $_{70}$Yb, $_{71}$Lu, $_{73}$Ta, $_{74}$W, $_{75}$Re, $_{79}$Au, $_{80}$Hg, $_{81}$Tl, $_{82}$Pb, $_{83}$Bi, $_{90}$Th and $_{92}$U.	Ge(Li) detector with 190 eV resolution at 5.96 keV.
(Durak and Özdemir, 1998)	$\eta_{KL2}(R)$ $\eta_{KL3}(R)$ $\eta_{KM}(R)$	123.6 keV photons produced from a ^{57}Co radioactive source of 100 mCi activity.	$_{60}$Nd, $_{62}$Sm, $_{63}$Eu, $_{64}$Gd, $_{66}$Dy, $_{67}$Ho, $_{68}$Er, $_{70}$Yb, $_{73}$Ta, $_{74}$W, $_{80}$Hg and $_{82}$Pb (pure circular disc samples).	Collimated Ge(Li) detector having 190 eV FWHM resolution at 5.9 keV.
(Durak and Özdemir, 2000)	$\eta_{KL2}(R)$ $\eta_{KL3}(R)$ $\eta_{KM}(R)$	59.5 keV photons produced from a ^{241}Am radioactive source of 100 mCi activity.	$_{55}$Cs, $_{59}$Pr, $_{60}$Nd, $_{62}$Sm, $_{64}$Gd, $_{65}$Tb, $_{66}$Dy, $_{67}$Ho, and $_{68}$Er	Si(Li) detector having 188 eV FWHM at 5.9 keV
(Simsek, 2002)	$\eta_{L3M}(R)$ $\eta_{L3N}(R)$	59.5 keV photons produced from a ^{241}Am radioactive source of 100 mCi activity.	$_{37}$Rb, $_{41}$Nb and $_{42}$Mo.	Si(Li) X-ray detector with a resolution of 160 eV at 5.96 keV.
(Ertuğrul, 2002a)	$\eta_{KL2}(R)$ $\eta_{KL3}(R)$ $\eta_{KM}(R)$	59.5 keV gamma rays produced from a ^{241}Am radioactive source.	$_{30}$Zn, $_{33}$As, $_{34}$Se, $_{37}$Rb, $_{38}$Sr, $_{39}$Y and $_{40}$Zr.	Ge(Li) detector having 190 eV resolution at 5.96 keV.
(Ertuğrul, 2002b)	$\eta_{KL}(T)$ $\eta_{KL1}(T)$ $\eta_{KL2}(T)$ $\eta_{KL3}(T)$ $\eta_{KL1}(A)$ $\eta_{KL2}(A)$ $\eta_{KL3}(A)$ $\eta_{KL2}(R)$ $\eta_{KL3}(R)$	59.5 keV gamma rays produced from a ^{241}Am radioactive source of 100 mCi activity.	$_{67}$Ho and $_{68}$Er (high purity samples).	Si(Li) detector having 160 eV resolution at 5.96 keV.
(Ertuğrul, 2002c)	$\eta_{KL}(T)$ $\eta_{KL1}(T)$ $\eta_{KL2}(T)$ $\eta_{KL3}(T)$ $\eta_{KL1}(A)$ $\eta_{KL2}(A)$ $\eta_{KL3}(A)$ $\eta_{KL2}(R)$ $\eta_{KL3}(R)$	59.5 keV gamma rays produced from a ^{241}Am radioactive source of 100 mCi activity.	$_{62}$Sm and $_{65}$Tb (high purity samples).	Si(Li) detector having 160 eV resolution at 5.96 keV.

(Ertuğrul, 2002d)	$\eta_{KL}(T)$ $\eta_{KL1}(T)$ $\eta_{KL2}(T)$ $\eta_{KL3}(T)$ $\eta_{KL1}(A)$ $\eta_{KL2}(A)$ $\eta_{KL3}(A)$ $\eta_{KL2}(R)$ $\eta_{KL3}(R)$	59.5 keV photons produced from a ^{241}Am radioactive source of 100 mCi activity.	$_{55}$Cs, $_{56}$Ba and $_{57}$La.	Si(Li) detector.
(Çalilskan *et al.*, 2002)	$\eta_{KL2}(R)$ $\eta_{KL3}(R)$ $\eta_{KM}(R)$	59.5 keV gamma rays produced from a ^{241}Am radioactive source.	$_{41}$Nb, $_{42}$Mo, $_{46}$Pd, $_{47}$Ag, $_{48}$Cd, $_{49}$In, $_{50}$Sn, $_{51}$Sb, $_{52}$Te, $_{53}$I, $_{55}$Cs, $_{56}$Ba, $_{57}$La, $_{58}$Ce, $_{59}$Pr, $_{60}$Nd, $_{62}$Sm, $_{64}$Gd, $_{65}$Tb, $_{66}$Dy, $_{67}$Ho, and $_{68}$Er (pure targets).	Si(Li) detector having 160 eV resolution at 5.96 keV.
(Şimşek *et al.*, 2003)	$\eta_{KL}(T)$	59.5 keV gamma rays produced from a ^{241}Am radioactive source of 100 mCi activity.	$_{46}$Pd, $_{47}$Ag, $_{48}$Cd, $_{49}$In, $_{50}$Sn, $_{51}$Sb, $_{52}$Te, $_{53}$I, and $_{55}$Cs.	Ultra-LEGe detector having 145 eV resolution at 5.96 keV.
(Ertugral *et al.*, 2003)	$\eta_{KL}(T)$	59.5 keV produced from a ^{241}Am radioactive source of 50 mCi activity.	$_{52}$Te, $_{56}$Ba, $_{57}$La, $_{58}$Ce, $_{59}$Pr, $_{60}$Nd, $_{62}$Sm, $_{63}$Eu, $_{64}$Gd, $_{65}$Tb, $_{66}$Dy, $_{67}$Ho and $_{68}$Er.	Si(Li) detector having 147 eV resolution at 5.96 keV.
(Ertuğrul, 2003)	$\eta_{KL}(T)$ $\eta_{KL1}(T)$ $\eta_{KL2}(T)$ $\eta_{KL3}(T)$ $\eta_{KL1}(A)$ $\eta_{KL2}(A)$ $\eta_{KL3}(A)$ $\eta_{KL2}(R)$ $\eta_{KL3}(R)$	59.5 keV gamma rays produced from a ^{241}Am radioactive source of 100 mCi activity.	$_{58}$Ce, $_{59}$Pr and $_{60}$Nd.	Si(Li) detector having 160 eV resolution at 5.96 keV.
(Dogan and Ertuğrul, 2004)	$\eta_{L3M1}(R)$ $\eta_{L3M4}(R)$ $\eta_{L3M5}(R)$ $\eta_{L3N1}(R)$ $\eta_{L3N4}(R)$ $\eta_{L3N5}(R)$ $\eta_{L3O1}(R)$ $\eta_{L3O4.5}(R)$	59.5 keV gamma rays produced from a ^{241}Am radioactive source of 100 mCi activity.	$_{73}$Ta, $_{74}$W, $_{75}$Re, $_{79}$Au, $_{80}$Hg, $_{81}$Tl, $_{82}$Pb, $_{90}$Th and $_{92}$U.	Si(Li) detector with a resolution of 160 eV FWHM at 5.96 keV.
(Santra *et al.*, 2005)	$\eta_{KL}(T)$	59.5 keV gamma rays produced from a ^{241}Am radioactive source.	$_{42}$Mo, $_{46}$Pd, and $_{48}$Cd.	Si(Li) detector with a resolution of 140 eV at 5.9 keV.
(Baydaş, 2005)	$\eta_{KL}(T)$	59.5 keV gamma rays produced from a ^{241}Am radioactive point-source.	$_{47}$Ag, $_{48}$Cd, $_{50}$Sn, $_{51}$Sb, $_{55}$Cs, $_{56}$Ba, $_{57}$La, $_{58}$Ce, $_{59}$Pr, $_{62}$Sm, $_{63}$Eu, $_{64}$Gd, $_{65}$Tb, $_{66}$Dy, $_{67}$Ho and $_{68}$Er (circular samples).	Si(Li) detector with a resolution of 160 eV FWHM at 5.96 keV.

(Sharma *et al*., 2005)	$\eta_{L1M}(R)$ $\eta_{L2M}(R)$ $\eta_{L3M}(R)$ $\eta_{L1N}(R)$ $\eta_{L2N}(R)$ $\eta_{L3N}(R)$	59.5 keV gamma rays produced from a ^{241}Am annular source.	$_{77}$Ir, $_{78}$Pt, $_{79}$Au, $_{80}$Hg, $_{81}$Tl, $_{82}$Pb, $_{83}$Bi, $_{90}$Th and $_{92}$U.	Si(Li) detector.
(Ertuğral *et al*., 2005)	$\eta_{KL}(T)$	^{57}Co radioisotope source at 123.6 keV photons with strength of approximately 25 mCi.	$_{58}$Ce, $_{59}$Pr, $_{60}$Nd, $_{62}$Sm, $_{63}$Eu, $_{64}$Gd, $_{65}$Tb, $_{66}$Dy, $_{67}$Ho, $_{68}$Er, $_{69}$Tm, $_{70}$Yb, $_{71}$Lu, $_{72}$Hf, $_{73}$Ta, $_{74}$W, $_{75}$Re, $_{77}$Ir, $_{79}$Au, $_{80}$Hg, $_{81}$Tl, $_{82}$Pb, $_{83}$Bi, $_{90}$Th and $_{92}$U.	Si(Li) detector with a resolution of 160 eV FWHM at 5.9 keV.
(Bonzi, 2006)	$\eta_{L3M}(R)$ $\eta_{L3N}(R)$	Silicon (111) channel-cut double crystal monochromator, which can tune energies between 3 and 30 keV. The energy resolution is 3–4×10^{-4} between 7 and 10 keV.	$_{74}$W, $_{75}$Re and $_{82}$Pb.	Si(Li) detector with a resolution of 170 eV at 5.9 keV.
(Ertuğral *et al*., 2006)	$\eta_{KL}(T)$	59.543 keV gamma rays emitted from 1.85 GBq ^{241}Am radioisotope source.	$_{23}$V, $_{24}$Cr, $_{25}$Mn, $_{26}$Fe, $_{27}$Co, $_{28}$Ni, $_{29}$Cu, $_{30}$Zn, $_{33}$As, $_{34}$Se, $_{35}$Br, $_{37}$Rb, $_{38}$Sr, $_{39}$Y, $_{40}$Zr, $_{41}$Nb, $_{42}$Mo, $_{47}$Ag, $_{48}$Cd, $_{49}$In, $_{50}$Sn, $_{51}$Sb, $_{52}$Te, $_{53}$I, $_{56}$Ba and $_{57}$La (high purity samples).	Si(Li) detector with a resolution of 160 eV at 5.96 keV.
(Sögüt, 2006)	$\eta_{KL}(T)$ $\eta_{KL2}(R)$ $\eta_{KL3}(R)$ $\eta_{KM}(R)$	59.5 keV gamma rays produced from a ^{241}Am radioactive source of 100 mCi activity.	$_{24}$Cr, $_{28}$Ni and Cr_xNi_{1-x}, Cr_xAl_{1-x} alloys (pure samples and alloys were in the form of powders).	Si(Li) detector with a resolution of 160 eV at 5.9 keV.
(Öz, 2006)	$\eta_{KL}(T)$	59.54 keV gamma rays produced from a ^{241}Am radioactive point-source.	$_{25}$Mn, $_{26}$Fe, $_{27}$Co, $_{28}$Ni, $_{29}$Cu, $_{30}$Zn, $_{31}$Ga, $_{32}$Ge, , $_{33}$As, $_{34}$Se, $_{35}$Br, $_{37}$Rb, $_{38}$Sr, $_{39}$Y, $_{40}$Zr, $_{41}$Nb, and $_{42}$Mo (circular samples of various thickness).	Si(Li) detector having 160 eV FWHM resolution at 5.9 keV.
(Bennal and Badiger, 2006)	$\eta_{KL2}(R)$ $\eta_{KL3}(R)$	10^4 Bq ^{57}Co gamma source that produces photons with energies of 122 keV 136 keV.	$_{73}$Ta, $_{79}$Au and $_{82}$Pb (thin foils of pure targets).	ORTEC HPGe detector with 700 eV resolution at 122 keV.

Demir and Şahin, 2007)	$\eta_{KL2}(R)$ $\eta_{KL3}(R)$ $\eta_{KM}(R)$	59.5 keV gamma rays produced from a ^{241}Am radioactive source of 100 mCi activity.	$_{60}$Nd, $_{63}$Eu, $_{64}$Gd, $_{66}$Dy and $_{67}$Ho (pure foils of $_{64}$Gd and $_{66}$Dy, and $_{60}$Nd, $_{63}$Eu and $_{67}$Ho in powder form).	Si(Li) detector having 180 eV resolution at 5.9 keV.
(Han *et al*., 2007)	$\eta_{KL}(T)$ $\eta_{KL1}(T)$ $\eta_{KL2}(T)$ $\eta_{KL3}(T)$	59.5 keV gamma rays produced from a ^{241}Am point source.	$_{62}$Sm, $_{63}$Eu, $_{64}$Gd, $_{66}$Dy, $_{67}$Ho, $_{68}$Er, $_{78}$Pt, $_{79}$Au, $_{81}$Tl, $_{82}$Pb and $_{83}$Bi (pure targets of thickness ranging from 0.02 to 0.4 g/cm^2).	Si(Li) detector having 160 eV FWHM resolution at 5.9 keV.
(Tuzluca *et al*., 2008)	$\eta_{L3M}(R)$ $\eta_{L3N}(R)$ $\eta_{L3M1}(R)$ $\eta_{L3M4}(R)$ $\eta_{L3M5}(R)$ $\eta_{L3N1}(R)$ $\eta_{L3N4}(R)$ $\eta_{L3N5}(R)$ $\eta_{L3O1}(R)$ $\eta_{L3O4.5}(R)$	59.5 keV gamma photons produced from a ^{241}Am radioactive source of 75mCi activity.	$_{72}$Hf, $_{73}$Ta, $_{74}$W, $_{75}$Re, $_{78}$Pt, $_{79}$Au, $_{80}$Hg, $_{81}$Tl, $_{82}$Pb, $_{83}$Bi, $_{90}$Th and $_{92}$U of thickness ranging 37×10^{-3}-553×10^{-3} g/cm^2.	Si(Li) detector having 155 eV FWHM resolution at 5.96 keV.
(Reyes-Herrera and Miranda, 2008)	$\eta_{KL2}(R)$ $\eta_{KL3}(R)$	proton beams having energies between 3 and 4 MeV produced from a ^{241}Am point-source.	$_{58}$Ce, $_{60}$Nd, $_{64}$Gd, $_{66}$Dy and $_{67}$Ho (pure elements).	LEGe detector having 145 eV resolution at 5.9 keV.
(Cengiz *et al.,* 2008)	$\eta_{KL}(T)$	5.96 and 59.5 keV photons produced from annular ^{55}Fe and ^{241}Am radioactive sources, respectively.	$_{41}$Nb (powder samples of pure element and its compounds: $NbCl_5$, $NbBr_5$, Nb_2O_5, NbC and NbN).	Ultra-LEGe detector having 150 eV resolution at 5.9 keV.
(Sögüt *et al*., 2009)	$\eta_{KL}(T)$	59.5 keV gamma rays produced from a ^{241}Am radioisotope source of 75 mCi activity and ^{241}Am annular radioactive source of 100 mCi activity.	$_{19}$K, $_{20}$Ca, $_{22}$Ti, $_{23}$V, $_{24}$Cr, $_{25}$Mn, $_{26}$Fe, $_{27}$Co, $_{28}$Ni, $_{29}$Cu, $_{30}$Zn, $_{33}$As, $_{34}$Se, $_{38}$Sr, $_{42}$Mo, $_{47}$Ag, $_{48}$Cd, $_{56}$Ba, $_{57}$La and $_{58}$Ce. High purity samples of thickness 2-4×10^{-2} g/cm^2).	Si(Li) detector having 155 eV FWHM resolution at 5.96 keV.
(Sögüt, 2009)	$\eta_{KL}(T)$ $\eta_{KL2}(R)$ $\eta_{KL3}(R)$	59.5 keV photons produced from a ^{241}Am radioactive source of 50mCi activity.	Fe_xZn_{1-x} thin film alloys.	Ultra-LEGe detector having 150 eV FWHM resolution at 5.9 keV.
(Ertuğral *et al*., 2010)	$\eta_{KL}(T)$	59.5 keV photons produced from a ^{55}Fe annular radioactive source of 1.85GBq activity.	$_{16}$S, $_{17}$Cl, $_{19}$K, $_{20}$Ca, $_{21}$Sc and $_{22}$Ti (Powder samples).	Si(Li) detector having 160 eV FWHM resolution at 5.96 keV.
(Han and Demir, 2010)	$\eta_{KL}(T)$	22.69 keV X-rays produced from a ^{109}Cd radioactive point source of 10mCi activity.	$_{22}$Ti, $_{24}$Cr, $_{26}$Fe, $_{27}$Co, $_{28}$Ni, $_{29}$Cu (pure elements and high purity alloys	Si(Li) detector having 160 eV FWHM resolution at 5.96 keV.

			of Fe_xNi_{1-x}, Fe_xCr_{1x}, Ni_xCr1_{1-x}, $Fe_xCr_yNi_{1-(x+y)}$, Ti_xNi_{1-x}, Ti_xCo_{1-x}, and Co_xCu_{1-x}).	
(Bennal *et al*., 2010)	$\eta_{KL}(T)$	123.6 keV gamma rays emitted by a weak ^{57}Co source.	Z = 42 − 82 (thin elemental target)	ORTEC HPGe detector having 700 eV resolution at 88 keV.
(Cengiz *et al*., 2010a)	$\eta_{KL}(T)$	^{241}Am and ^{57}Co annular radioactive sources producing 59.5 and 123.6 keV gamma rays.	$_{79}$Au (powder samples of pure elements and its compounds: AuCl, Au_2O_3 and $AuBr_3$).	Ultra-LEGe detector having 150 eV resolution at 5.9 keV.
(Cengiz *et al*., 2010b)	$\eta_{L3M1}(R)$ $\eta_{L3M4}(R)$ $\eta_{L3M5}(R)$ $\eta_{L3N1}(R)$ $\eta_{L3N4}(R)$ $\eta_{L3N5}(R)$ $\eta_{L3O1}(R)$ $\eta_{L3O4.5}(R)$	59.5 keV photons produced from a ^{241}Am radioactive source of 50mCi activity.	$_{74}$W, $_{75}$Re, $_{76}$Os, and $_{78}$Pt (powder samples of pure elements and their compounds).	Ultra-LEGe detector.
(Cengiz *et al*., 2011)	$\eta_{KL}(T)$	123.6 keV gamma rays emitted by a weak ^{57}Co source of 925 MBq activity.	$_{74}$W, $_{75}$Re, $_{76}$Os, and $_{78}$Pt (powder samples of pure elements and their compounds).	Ultra-LEGe detector having 150 eV resolution at 5.96 keV.
(Anand *et al*., 2012)	$\eta_{KL}(T)$ $\eta_{KL2}(R)$ $\eta_{KL3}(R)$ $\eta_{KM}(R)$	123.6 keV gamma and X-rays emitted by a ^{57}Co source.	$_{78}$Pt and $_{82}$Pb.	HPGe detector having 200 eV resolution at 5.9 keV.
(Apaydin and Tirasoğlu, 2012)	$\eta_{KL}(T)$	123.6 keV photons emitted by an annular 925 MBq ^{57}Co radioisotope source.	($_{75}$Re, $_{76}$Os, $_{77}$Ir, $_{78}$Pt, $_{79}$Au, $_{80}$Hg, $_{81}$Tl, $_{82}$Pb, $_{83}$Bi, $_{90}$Th and $_{92}$U).	Si(Li) detector.
(Turşucu *et al*., 2012)	$\eta_{KL}(T)$	5.66 µCi ^{133}Ba gamma source at 80.997 keV of excitation energy.	$_{40}$Zr, $_{41}$Nb, $_{42}$Mo,$_{44}$Ru, $_{45}$Rh, $_{46}$Pd, $_{47}$Ag, $_{48}$Cd, and $_{50}$Sn. (Solid).	CdTe semiconductor detector having a resolution lower than 1.2 keV at 122 keV.
(Durak *et al*., 2012)	$\eta_{KL2}(R)$ $\eta_{KL3}(R)$ $\eta_{KM2}(R)$ $\eta_{KM3}(R)$	Photons of 0.0208 nm wavelength.	$_{23}$V, $_{27}$Co, $_{30}$Zn and $_{34}$Se.	Si(Li) detector.
(Turşucu *et al*., 2013)	$\eta_{KL}(T)$	59.537 keV gamma rays produced from a ^{241}Am radioactive point source.	$_{40}$Zr, $_{41}$Nb, $_{42}$Mo, $_{44}$Ru, $_{45}$Rh, $_{46}$Pd, $_{47}$Ag, $_{48}$Cd and $_{50}$Sn (spectroscopically pure targets with various thicknesses, except for Ru which is in powder form).	Si(Li) detector having 180 eV FWHM resolution at 5.9 keV.
(Onder *et al*., 2013)	$\eta_{KL}(T)$	80.998 keV gamma rays emitted by a ^{133}Ba radioactive source of 10 mCi activity.	$_{40}$Zr, $_{41}$Nb, $_{42}$Mo,$_{44}$Ru, $_{45}$Rh, $_{46}$Pd, $_{47}$Ag, $_{48}$Cd,	CdTe detector.

			and $_{50}$Sn (thin samples).	
(Anand *et al*., 2013)	$\eta_{KL}(T)$	32.86 keV Ba K X-rays that led to the internal conversion of Cs^{137}.	$_{42}$Mo and $_{47}$Ag (thin foils of pure elements).	Si(Li) detector having 140 eV resolution at 5.9 keV.
(Turşucu and Demir, 2013)	$\eta_{KL}(T)$	59.54 keV gamma rays produced from a ^{241}Am annular radioactive source of 5Ci activity.	$_{58}$Ce (samples with various thicknesses of pure element and its compounds: $CeCl_3$, CeF_3, Ce $(NO_3)_3$, $Ce_2(SO_4)_3$ and Ce_2O_3) Samples were then turned into cylindrical pellets.	HPGe detector having 182 eV resolution at 5.9 keV.
(George *et al*., 2014)	$\eta_{KL}(T)$	EC dacay of ~ 2 μCi ^{57}Co (emission of γ-rays of 122, 136, and 14.39 keV), ^{109} Cd (emission of γ-ray of 88.04 keV), and ^{125}I (emission of γ-ray of 35.49 keV).	$_{26}$Fe, $_{47}$Ag and $_{52}$Te.	Si(Li) detector having 140 eV resolution at 5.9 keV.
(Kaya *et al*., 2014)	$\eta_{KL}(T)$	59.54 keV gamma photons produced from a ^{241}Am radioactive source of 50mCi activity.	$_{24}$Cr, $_{26}$Fe, $_{27}$Co, $_{29}$Cu, $_{30}$Zn, $_{31}$Ga, $_{34}$Se, $_{39}$Y, $_{42}$Mo, $_{48}$Cd, $_{49}$In, $_{50}$Sn, $_{52}$Te and $_{56}$Ba (Pure metals).	Si(Li) detector having 150 eV resolution at 5.96 keV.
(Sreevidya *et al.,* 2014)	$\eta_{KL}(T)$ $\eta_{KL2}(R)$ $\eta_{KL3}(R)$ $\eta_{KM}(R)$	IC decay of ~ 2 μCi ^{137}Cs (emission of γ-ray of 662 keV) and ^{203}Hg (emission of γ-ray of 279.19 keV)	$_{56}$Ba and $_{81}$Tl.	Si(Li) detector having 140 eV resolution at 5.9 keV.
(Anand *et al*., 2014)	$\eta_{KL}(T)$ $\eta_{KL2}(R)$ $\eta_{KL3}(R)$ $\eta_{KM}(R)$	123.6 keV photons produced from a weak ^{57}Co radioactive source of ~10^4 Bq activity.	$_{78}$Pt, $_{79}$Au and $_{82}$Pb (thin foils of pure elements).	HPGe detector having 200 eV resolution at 5.9 keV.
(Mirji *et al*., 2015a)	$\eta_{KL}(T)$	6.5, 10 and 11 keV synchrotron radiation.	3d atoms such as $_{24}$Cr, $_{29}$Cu and $_{30}$Zn and their compounds.	Silicon drift detector with 130 eV resolution at 5.9 keV.
(Mirji *et al*., 2015b)	$\eta_{KL}(T)$	6.5, 10 and 11 keV synchrotron radiation.	$_{24}$Cr, $_{29}$Cu and $_{30}$Zn (pure 3d elements).	Silicon drift detector with 130 eV resolution at 5.9 keV.
(Aylikci *et al*., 2015)	$\eta_{KL}(T)$	59.5 keV gamma rays produced from a ^{241}Am annular radioactive source.	$_{21}$Sc, $_{22}$Ti, $_{23}$V, $_{24}$Cr, $_{25}$Mn, $_{26}$Fe, $_{27}$Co, $_{28}$Ni, $_{29}$Cu, and $_{30}$Zn (3d transition elements).	Ultra-LEGe detector having 150 eV resolution at 5.9 keV.
(Anand *et al*., 2015)	$\eta_{KL}(T)$	32.86 KeV Ba K X-rays from a 10^4 Bq ^{137}Cs source.	$_{27}$Co, $_{28}$Ni, $_{29}$Cu, and $_{30}$Zn (high purity thin foils).	Low energy HPGe detector having 200 eV resolution at 5.9 keV.
(Akman, 2016a)	$\eta_{KL}(T)$ $\eta_{KL2}(R)$ $\eta_{KL3}(R)$	59.5 keV γ-rays from a 100 mCi ^{241}Am annular radioactive source.	$_{57}$La, $_{58}$Ce, $_{59}$Pr, $_{60}$Nd, $_{62}$Sm, $_{63}$Eu, $_{64}$Gd, $_{65}$Tb, $_{66}$Dy	Si(Li) detector having 160 eV FWHM resolution at 5.96 keV.

	$\eta_{KM}(R)$		and $_{68}$Er (spectroscopically pure targets with various thicknesses).	
(Akman, 2016b)	$\eta_{KL}(T)$	59.5 keV gamma rays produced from a ^{241}Am annular radioactive source of 100 mCi activity.	$_{30}$Zn, $_{31}$Ga, $_{32}$Ge, $_{34}$Se, $_{39}$Y, $_{40}$Zr, $_{41}$Nb, $_{42}$Mo, $_{44}$Ru, $_{46}$Pd, $_{47}$Ag, $_{48}$Cd, $_{49}$In, $_{50}$Sn, $_{51}$Sb, $_{52}$Te, $_{55}$Cs, $_{56}$Ba, $_{57}$La, and $_{58}$Ce (powder samples of pure elements and their compounds).	Si(Li) detector having 160 eV FWHM resolution at 5.96 keV.
(Krishnananda *et al.*, 2016)	$\eta_{L3M}(R)$	10 and 11 keV synchrotron radiation.	$_{64}$Gd, $_{65}$Tb and $_{67}$Ho.	silicon drift detector with energy resolution of 130 eV at 5.9 keV.
(Alim *et al.*, 2017a)	$\eta_{KL}(T)$	22.69 keV X-rays from a 10 mCi ^{109}Cd radioactive point source.	$_{26}$Fe, $_{27}$Co and $_{28}$Ni (3d transition metals).	Si(Li) detector.
(Alim *et al.*, 2017b)	$\eta_{KL}(T)$	22.69 keV X-rays from a 10 mCi ^{109}Cd radioactive point source.	high-purity $_{22}$Ti, $_{23}$V, $_{26}$Fe, $_{27}$Co, $_{28}$Ni pure metals and PERMENDUR49, KOVAR and Ti-Co alloys.	Si(Li) solid-state detector having 160 eV FWHM resolution at 5.9 keV.
(Turhan *et al.*, 2017)	$\eta_{KL2}(R)$ $\eta_{KL3}(R)$ $\eta_{KM2}(R)$ $\eta_{KM3}(R)$	photons of 59.54 keV emitted from a 100 mCi ^{241}Am point source.	$_{40}$Zr, $_{42}$Mo, $_{48}$Cd and $_{68}$Er of thicknesses ranging from 0.26 to 0.33 g/cm^2.	Si(Li) detector having 185 eV resolution at 5.9 keV.
(Anand *et al.*, 2018)	$\eta_{KL}(T)$	32.86 keV Ba K X-rays from a 10^4 Bq ^{137}Cs source.	$_{27}$Co, $_{28}$Ni, $_{29}$Cu and $_{30}$Zn (pure thin foils).	Low energy HPGe detector.
(Durdu, 2018)	$\eta_{L3M1}(R)$ $\eta_{L3M4}(R)$ $\eta_{L3M5}(R)$ $\eta_{L3N1}(R)$ $\eta_{L3N4}(R)$ $\eta_{L3N5}(R)$	59.543 keV X-rays from a 75 mCi ^{241}Am radioisotope source.	$_{62}$Sm and $_{63}$Eu.	Si(Li) detector having 155 eV FWHM resolution at 5.9 keV.
(Hiremath *et al.,* 2018)	$\eta_{L3M1}(R)$ $\eta_{L3M4}(R)$ $\eta_{L3M5}(R)$ $\eta_{L3N1}(R)$ $\eta_{L3N4}(R)$ $\eta_{L3N5}(R)$ $\eta_{L3O1}(R)$ $\eta_{L3O4.5}(R)$	Indus-2 third generation synchrotron radiation. 15, 16, and 17 keV is used to excite Hg, Pb, and Bi respectively.	$_{80}$Hg, $_{82}$Pb and $_{83}$Bi.	silicon drift detector with energy resolution of 138 eV at 5.9 keV.
(Turhan *et al.*, 2020)	$\eta_{KL}(T)$	59.5 keV γ-photon from a 100 mCi ^{241}Am annular radioactive source.	$_{25}$Mn, MnF_2, $MnCl_2$, $_{28}$Ni, $NiCl_2$ and NiS_2	Si(Li) semiconductor detector having 160 eV resolution at 5.9 keV.
(Uğurlu *et al.*, 2020)	$\eta_{KL}(T)$	γ-rays produced from a ^{241}Am radioactive source.	$_{39}$Y, $_{40}$Zr, $_{41}$Nb, $_{42}$Mo, $_{44}$Ru, $_{45}$Rh, $_{46}$Pd, $_{47}$Ag, and $_{48}$Cd	Si(Li) detector.

			(powder) in various magnetic fields (B= 0, 0.4, 0.8 T)).	
(Uğurlu and Demir, 2020)	$\eta_{\mathrm{KL}}(T)$	59.54 keV gamma rays produced from a ^{241}Am radioactive point source.	$_{20}Ca$, $_{21}Sc$, $_{22}Ti$, $_{23}V$, $_{24}Cr$, $_{25}Mn$, $_{26}Fe$, $_{27}Co$, $_{28}Ni$, $_{29}Cu$, $_{30}Zn$, $_{31}Ga$, $_{32}Ge$ (Powder form).	Si(Li) detector having 160 eV resolution at 5.96 keV.
(Durdu *et al.*, 2022)	$\eta_{\mathrm{KL}}(T)$	59.54 keV gamma rays produced from a 75mCi ^{241}Am radioisotope source.	Pure $_{56}Ba$ and BaF_2, $Ba(ClO_3)_2$, $BaCl_2$, $BaSO_4$, BaO, $Ba(OH)_2$, $Ba(NO_3)_2$, $BaCO_3$ compounds.	Si(Li) detector having 155 eV FWHM resolution at 5.9 keV.
(Gudennavar and Bubbly, 2023)	$\eta_{\mathrm{KL}}(T)$	Weak ^{55}Fe (emission of X-rays of 5.899, 5.888 and 6.490 keV) radioactive source of strength of the order of ~2 µCi was procured from Board of Radiation and Isotopes Technology.	$_{25}Mn$.	Amptek XR-100T-CdTe detector having 1.5 KeV resolution at 122 keV.
(Turhan and Akman, 2023)	$\eta_{\mathrm{KL}}(T)$	59.5 keV γ-photons from a 100 mCi ^{241}Am annular radioactive source.	$_{22}Ti$, $_{23}V$, $_{24}Cr$, $_{25}Mn$, $_{27}Co$, $_{28}Ni$, $_{30}Zn$, $_{34}Se$, $_{39}Y$, $_{40}Zr$, $_{41}Nb$, $_{42}Mo$, $_{44}Ru$, $_{45}Rh$, $_{46}Pd$, $_{47}Ag$ and $_{48}Cd$ (Powder samples)	Si(Li) detector having 160 eV FWHM resolution at 5.9 keV.

Table 2. Summary of the experimental $\eta_{\mathrm{KL}}(\mathrm{T})$ total vacancy transfer probabilities from $_{16}$S to $_{92}$U according to their target atomic numbers. The references from which the databases are extracted, the weighted average values $((\eta_{\mathrm{KL}}(\mathrm{T}))_{\mathrm{W}}$, the combined standard deviation and the average z-score were also listed.

Z, Symbol	$(\eta_{\mathrm{KL}}(T))_{EXP-i} \pm \Delta(\eta_{\mathrm{KL}}(T))_{EXP-i}$	References	$(\eta_{\mathrm{KL}}(T))_W \pm \varepsilon$	z_i	$\bar{z}$
Z=16, S	1.812 ±0.054	(Ertuğral *et al*., 2010)	1.812 ±0.054	0	0
Z=17, Cl	1.777 ± 0.053	(Ertuğral *et al*., 2010)	1.777 ± 0.053	0	0
Z=19, K	1.721 ±0.153 1.669 ± 0.050	(Söğűt *et al*.,2009) (Ertuğral *et al*., 2010)	1.6740 ± 0.0475	0.29 -0.07	0.11
Z=20, Ca	1.689 ± 0.143 1.632 ±0.049 1.653 1.591	(Söğűt *et al*., 2009) (Ertuğral *et al*., 2010) (Uğurlu and Demir, 2020) (Uğurlu and Demir, 2020)	1.6380 ± 0.0464	0.34 -0.09	0.13
Z=21, Sc	1.602 ± 0.048 1.5986 ± 0.0815 1.623 1.533	(Ertuğral *et al*., 2010) (Aylikci *et al*., 2015) (Uğurlu and Demir, 2020) (Uğurlu and Demir, 2020)	1.6011 ± 0.0414	0.01 -0.03	-0.01
Z=22, Ti	1.586 ± 0.127 1.574 ± 0.047 1.568 ± 0.078 1.5763 ± 0.0804 1.6274 ± 0.040 1.592 ± 0.111 1.608 1.578	(Söğűt *et al*., 2009) (Ertuğral *et al*., 2010) (Han and L. Demir, 2010) (Aylikci *et al*., 2015) (Alim *et al*., 2017b) (Turhan and Akman, 2023) (Uğurlu and Demir, 2020) (Uğurlu and Demir, 2020)	1.5967 ± 0.0255	-0.08 -0.42 -0.19 -0.14 0.23 -0.03	-0.11
Z=23, V	1.544 ± 0.061 1.528 ± 0.122 1.5459 ± 0.0788 1. 5529 ± 0.038 1.553 ± 0.103 1.565 1.523	(Ertuğral *et al*., 2006) (Söğűt *et al*., 2009) (Aylikci *et al*., 2015) (Alim *et al*., 2017b) (Turhan and Akman, 2023) (Uğurlu and Demir, 2020) (Uğurlu and Demir, 2020)	1.5489 ± 0.0279	-0.07 -0.17 -0.04 0.09 0.04	-0.03
Z=24, Cr	1.493 ± 0.037 1.509 ± 0.044 1.538 ± 0.123 1.410 ± 0.070 1.523 ± 0.044 1.539 ± 0.014 1.539 ± 0.014 1.5161 ± 0.0773 1.516 ± 0.098 1.528 1.492	(Söğüt, 2006) (Ertuğral *et al*., 2006) (Söğűt *et al*., 2009) (Han and Demir, 2010) (Kaya *et al*., 2014) (Mirji *et al*., 2015a) (Mirji *et al*., 2015b) (Aylikci *et al*., 2015) (Turhan and Akman, 2023) (Uğurlu and Demir, 2020) (Uğurlu and Demir, 2020)	1.53181 ± 0.0089	-1.02 -0.51 0.05 -1.73 -0.2 0.43 0.43 -0.2 -0.16	-0.32
Z=25, Mn	1.467 ± 0.044 1.483 ± 0.12 1.505 ± 0.120 1.4793 ± 0.0754 1.507 ± 0.084 1.527 ± 0.092 1.4599 ± 0.0511 1.4879 ± 0.0129 1.4782 ± 0.0118 1.4718 ± 0.0118 1.4817 ± 0.0118 1.4662 ± 0.0117	(Ertuğral *et al*., 2006) (Öz, 2006) (Söğűt *et al*., 2009) (Aylikci *et al*., 2015) (Turhan *et al*., 2020) (Turhan and Akman 2023) (Gudennavar and Bubbly, 2023) (Gudennavar and Bubbly, 2023) (Gudennavar and Bubbly, 2023) (Gudennavar and Bubbly, 2023) (Gudennavar and Bubbly, 2023) (Gudennavar and Bubbly, 2023)	1.4768 ± 0.0053	-0.22 0.05 0.23 0.03 0.36 0.54 -0.33 0.8 0.11 -0.39 0.38 -0.83	0.03

	1.501 1.391	(Uğurlu and Demir, 2020) (Uğurlu and Demir, 2020)			
Z=26, Fe	1.453 ± 0.042 1.451 ± 0.13 1.442 ± 0.144 1.4760±0.0870 1.436 ± 0.071 1.492 ± 0.055 1.482 ± 0.008 1.463 ± 0.042 1.4488 ± 0.0739 1.4088 ± 0.035 1.4359 1.464 1.488	(Ertuğral *et al*., 2006) (Öz, 2006) (Söğűt *et al*., 2009) (Söğűt, 2009) (Han and Demir, 2010) (George *et al*., 2014) (George *et al*., 2014) (Kaya *et al*., 2014) (Aylikci *et al*., 2015) (Alim *et al*., 2017b) (Alim *et al*., 2017a) (Uğurlu and Demir, 2020) (Uğurlu and Demir, 2020)	1.4764 ± 0.0074	-0.55 -0.2 -0.24 0 -0.57 0.28 0.51 -0.31 -0.37 -1.89	-0.33
Z=27, Co	1.415 ± 0.057 1.418 ± 0.11 1.420 ± 0.142 1.384 ± 0.070 1.431 ± 0.041 1.454 ± 0.098 1.435 ± 0.098 1.4169 ± 0.0723 1.4077 ± 0.035 1.445 ± 0.003 1.435 ± 0.080 1.4310 1.443 1.467	(Ertuğral *et al*., 2006) (Öz, 2006) (Söğűt *et al*., 2009) (Han and Demir, 2010) (Kaya *et al*., 2014) (Anand *et al*., 2015) (Anand *et al*., 2015) (Aylikci *et al*., 2015) (Alim *et al*., 2017b) (Anand *et al*., 2018) (Turhan and Akman, 2023) (Alim *et al*., 2017a) (Uğurlu and Demir, 2020) (Uğurlu and Demir, 2020)	1.4444 ± 0.0030	-0.51 -0.24 -0.17 -0.86 -0.33 0.1 -0.1 -0.38 -1.04 0.15 -0.12	-0.32
Z=28, Ni	1.458 ± 0.036 1.394 ± 0.042 1.388 ± 0.11 1.364 ± 0.123 1.388 ± 0.070 1.412 ± 0.048 1.404 ± 0.042 1.3853 ± 0.0707 1.3758 ± 0.034 1.389 ± 0.082 1.415 ± 0.079 1.421 ± 0.073 1.3879 1.413 1.428	(Söğüt, 2006) (Ertuğral *et al*., 2006) (Öz, 2006) (Söğüt *et al*.,2009) (Han and Demir, 2010) (Anand *et al*., 2015) (Anand *et al*., 2015) (Aylikci *et al*., 2015) (Alim *et al*., 2017b) (Anand *et al*., 2018) (Turhan *et al*., 2020) (Turhan and Akman, 2023) (Alim *et al*., 2017a) (Uğurlu and Demir, 2020) (Uğurlu and Demir, 2020)	1.4056 ± 0.0153	1.34 -0.26 -0.16 -0.34 -0.25 0.13 -0.04 -0.28 -0.8 -0.2 0.12 0.21	-0.04
Z=29, Cu	1.361 ± 0.041 1.357 ± 0.12 1.342 ± 0.121 1.387 ± 0.070 1.372 ± 0.041 1.386 ± 0.111 1.375 ± 0.105 1.375 ± 0.017 1.375 ± 0.017 1.3523 ± 0.0690 1.385 ± 0.039 1.375 1.274	(Ertuğral *et al*., 2006) (Öz, 2006) (Söğűt *et al*., 2009) (Han and Demir 2010) (Kaya *et al*., 2014) (Anand *et al*., 2015) (Anand *et al*., 2015) (Mirji *et al*., 2015a) (Mirji *et al*., 2015b) (Aylikci *et al*., 2015) (Anand *et al*., 2018) (Uğurlu and Demir, 2020) (Uğurlu and Demir, 2020)	1.3741 ± 0.0103	-0.31 -0.14 -0.26 0.18 -0.05 0.11 0.01 0.04 0.04 -0.31 0.27	-0.04
Z=30, Zn	1.330 ± 0.040 1.327 ± 0.09	(Ertuğral *et al*., 2006) (Öz, 2006)	1.3447 ± 0.0054	-0.36 -0.2	-0.05

	1.298 ± 0.104 1.3501±0.0769 1.343 ± 0.040 1.352 ± 0.043 1.3439 ± 0.045 1.345 ± 0.008 1.345 ± 0.008 1.3311 ± 0.0679 1.338 ± 0.085 1.354 ± 0.082 1.359 ± 0.063 1.344 1.300	(Söğűt *et al*., 2009) (Söğűt, 2009) (Kaya *et al*., 2014) (Anand *et al*., 2015) (Anand *et al*., 2015) (Mirji *et al*., 2015a) (Mirji *et al*., 2015b) (Aylikci *et al*., 2015) (Akman, 2016b) (Anand *et al*., 2018) (Turhan and Akman, 2023) (Uğurlu and Demir, 2020) (Uğurlu and Demir, 2020)		-0.45 -0.04 0.17 -0.02 0.04 0.04 -0.2 -0.08 0.11 0.23 0.07	
Z=31, Ga	1.298 ± 0.10 1.305 ± 0.038 1.309 ± 0.062 1.315 1.303	(Öz, 2006) (Kaya *et al*., 2014) (Akman, 2016b) (Uğurlu and Demir, 2020) (Uğurlu and Demir, 2020)	1.3053 ± 0.0308	-0.07 -0.01 0.06	-0.01
Z=32, Ge	1.262 ± 0.10 1.290 ± 0.069 1.290 1.318	(Öz, 2006) (Akman, 2016b) (Uğurlu and Demir, 2020) (Uğurlu and Demir, 2020)	1.2810 ± 0.0568	-0.16 0.1	-0.03
Z=33, As	1.238 ± 0.037 1.231 ± 0.09 1.185 ± 0.083	(Ertuğral *et al*., 2006) (Öz, 2006) (Söğűt *et al*., 2009)	1.2294 ± 0.0316	0.18 0.02 -0.5	-0.1
Z=34, Se	1.204 ± 0.036 1.203 ± 0.08 1.235 ± 0.099 1.208 ± 0.036 1.214 ± 0.076 1.268 ± 0.058	(Ertuğral *et al*., 2006) (Öz, 2006) (Söğűt *et al*., 2009) (Kaya *et al*., 2014) (Akman, 2016b) (Turhan and Akman, 2023)	1.2158 ± 0.0210	-0.28 -0.15 0.19 -0.19 -0.02 0.85	0.06
Z=35, Br	1.200 ± 0.048 1.174 ± 0.07	(Ertuğral *et al*., 2006) (Öz, 2006)	1.1917 ± 0.0396	0.13 -0.22	-0.04
Z=37, Rb	1.12 ± 0.056 1.123 ± 0.045 1.128 ± 0.07	(Puri *et al*., 1993) (Ertuğral *et al*., 2006) (Öz, 2006)	1.1231 ± 0.0314	-0.05 0 0.06	0.01
Z=38, Sr	1.10 ± 0.055 1.104 ± 0.055 1.102 ± 0.07 1.341 ± 0.107	(Puri *et al*., 1993) (Ertuğral *et al*., 2006) (Öz, 2006) (Söğűt *et al*., 2009)	1.1239 ± 0.0324	-0.37 -0.31 -0.28 1.94	0.24
Z=39, Y	1.07 ± 0.053 1.081 ± 0.06 1.083 ± 0037 1.082 ± 0.064 1.085 ± 0.057 1.0720 0.9962 1.0720	(Puri *et al*., 1993) (Öz, 2006) (Kaya *et al*., 2014) (Akman, 2016b) (Turhan and Akman, 2023) (Uğurlu *et al*., 2020) (Uğurlu *et al*., 2020) (Uğurlu *et al*., 2020)	1.0805 ± 0.0228	-0.18 0.06 0.01 0.02 0.07	0
Z=40, Zr	1.03 ± 0.051 1.064 ± 0.032 1.061 ± 0.07 1.082 ± 0.031 1.063 ± 0.0011 1.082 ± 0.048 1.093 ± 0.059 1.086 ± 0.057 1.0079 0.9758 1.0729	(Puri *et al*., 1993) (Ertuğral *et al*., 2006) (Öz, 2006) (Tursucu *et al*., 2012) (Turşucu *et al*., 2013) (Onder *et al*., 2013) (Akman, 2016b) (Turhan and Akman, 2023) (Uğurlu *et al*., 2020) (Uğurlu *et al*., 2020) (Uğurlu *et al*., 2020)	1.0630 ± 0.0011	-0.65 0.03 -0.03 0.61 -0.02 0.39 0.51 0.4	0.16

Z=41, Nb	1.02 ± 0.051 1.042 ± 0.031 1.044 ± 0.06 1.061 ± 0.074 1.028 ± 0.031 1.047 ± 0.0002 1.064 ± 0.047 1.041 ± 0.052 1.034 ± 0.051 0.9641 0.8910 1.0206	(Puri *et al*., 1993) (Ertuğral *et al*., 2006) (Öz, 2006) (Cengiz *et al*., 2008) (Tursucu *et al*., 2012) (Turşucu *et al*., 2013) (Onder *et al*., 2013) (Akman, 2016b) (Turhan and Akman, 2023) (Uğurlu *et al*., 2020) (Uğurlu *et al*., 2020) (Uğurlu *et al*., 2020)	1.0470 ± 0.0001	-0.53 -0.16 -0.05 0.19 -0.61 0 0.36 -0.12 -0.25	-0.13
Z=42, Mo	1.02 ± 0.051 1.03 ± 0.18 1.026 ± 0.041 1.028 ± 0.05 1.070 ± 0.097 1.039 ± 0.005 1.047 ± 0.030 1.028 ± 0.0001 1.04 ± 0.006 1.046 ± 0.047 1.031 ± 0.041 1.020 ± 0.050 1.044 ± 0.051 0.8643 0.9447 1.0190	(Puri *et al*., 1993) (Santra *et al*., 2005) (Ertuğral *et al*., 2006) (Öz, 2006) (Söğűt *et al*., 2009) (Bennal *et al*., 2010) (Tursucu *et al*., 2012) (Turşucu *et al*., 2013) (Anand el al., 2013) (Onder *et al*., 2013) (Kaya *et al*., 2014) (Akman, 2016b) (Turhan and Akman, 2023) (Uğurlu *et al*., 2020) (Uğurlu *et al*., 2020) (Uğurlu *et al*., 2020)	1.0280 ± 0.0001	-0.16 0.01 -0.05 0 0.43 2.2 0.63 -0.06 2 0.38 0.07 -0.16 0.31	0.43
Z=44, Ru	1.041 ± 0.029 1.039 ± 0.0004 1.053 ± 0.047 1.020 ± 0.043 1.031 ± 0.047 0.7575 0.8180 0.9429	(Tursucu *et al*., 2012) (Turşucu *et al*., 2013) (Onder *et al*., 2013) (Akman, 2016b) (Turhan and Akman, 2023) (Uğurlu *et al*., 2020) (Uğurlu *et al*., 2020) (Uğurlu *et al*., 2020)	1.0390 ± 0.0004	0.07 0 0.3 -0.44 -0.17	-0.05
Z=45, Rh	0.992 ± 0.029 0.988 ± 0.0001 1.001 ± 0.045 0.971 ± 0.045 0.8253 0.7883 0.8869	(Tursucu *et al*., 2012) (Turşucu *et al*., 2013) (Onder *et al*., 2013) (Turhan and Akman, 2023) (Uğurlu *et al*., 2020) (Uğurlu *et al*., 2020) (Uğurlu *et al*., 2020)	0.9880 ± 0.0001	0.14 0 0.29 -0.38	0.01
Z=46, Pd	1.028 ± 0.050 0.99 ± 0.08 0.990 ± 0.043 0.934 ± 0.029 0.974 ± 0.0001 0.989 ± 0.044 0.989 ± 0.041 0.947 ± 0.043 0.7635 0.7271 0.7783	(Şimşek *et al*., 2003) (Santra *et al*., 2005) (Ertuğral *et al*., 2006) (Tursucu *et al* .,2012) (Turşucu *et al*., 2013) (Onder *et al*., 2013) (Akman, 2016b) (Turhan and Akman, 2023) (Uğurlu *et al*., 2020) (Uğurlu *et al*., 2020) (Uğurlu *et al*., 2020)	0.9740 ± 0.0001	1.08 0.2 0.37 -1.38 0 0.34 0.37 -0.63	0.04
Z=47, Ag	0.995 ± 0.030 0.964 ± 0.06 0.967 ± 0.029 0.940 ± 0.080 0.973 ± 0.006	(Şimşek *et al*., 2003) (Baydaş, 2005) (Ertuğral *et al*., 2006) (Söğűt *et al*., 2009) (Bennal *et al*., 2010)	0.9620 ± 0.0002	1.1 0.03 0.17 -0.28 1.83	0.69

	0.977 ± 0.028 0.962 ± 0.0002 0.981 ± 0.006 0.977 ± 0.043 0.969 ± 0.007 0.965 ± 0.021 0.978 ± 0.042 0.993 ± 0.045 0.9414 0.9077 0.9106	(Tursucu *et al*., 2012) (Turşucu *et al*., 2013) (Anand el al., 2013) (Onder *et al*., 2013) (George *et al*., 2014) (George *et al*., 2014) (Akman, 2016b) (Turhan and Akman, 2023) (Uğurlu *et al*., 2020) (Uğurlu *et al*., 2020) (Uğurlu *et al*., 2020)		0.53 -0.15 3.16 0.35 0.99 0.14 0.38 0.69	
Z=48, Cd	0.968 ± 0.039 0.99 ± 0.18 0.957 ± 0.05 0.962 ± 0.038 1.036 ± 0.104 0.964 ± 0.004 0.947 ± 0.028 0.947 ± 0.0006 0.956 ± 0.043 0.954 ± 0.038 0.959 ± 0.040 0.967 ± 0.044 1.0024 0.9982 0.9814	(Şimşek *et al*., 2003) (Santra *et al*., 2005) (Baydaş, 2005) (Ertuğral *et al*., 2006) (Söğüt *et al*., 2009) (Bennal *et al*., 2010) (Tursucu *et al*., 2012) (Turşucu *et al*., 2013) (Onder *et al*., 2013) (Kaya *et al*., 2014) (Akman, 2016b) (Turhan and Akman, 2023) (Uğurlu *et al*., 2020) (Uğurlu *et al*., 2020) (Uğurlu *et al*., 2020)	0.9474 ± 0.0006	0.53 0.24 0.19 0.38 0.85 4.11 -0.01 -0.47 0.2 0.17 0.29 0.45	0.58
Z=49, In	0.957 ± 0.035 0.950 ± 0.028 0.951 ± 0.006 0.941 ± 0.028 0.941 ± 0.041	(Şimşek *et al*., 2003) (Ertuğral *et al*., 2006) (Bennal *et al*., 2010) (Kaya *et al*., 2014) (Akman, 2016b)	0.9505± 0.0056	0.18 -0.02 0.06 -0.33 -0.23	-0.07
Z=50, Sn	0.928 ± 0.037 0.935 ± 0.05 0.943 ± 0.037 0.942 ± 0.005 0.944 ± 0.027 0.925 ± 0.0008 0.946 ± 0.042 0.926 ± 0.037 0.936 ± 0.041	(Şimşek *et al*., 2003) (Baydaş, 2005) (Ertuğral *et al*., 2006) (Bennal *et al*., 2010) (Tursucu *et al*., 2012) (Turşucu *et al*., 2013) (Onder *et al*., 2013) (Kaya *et al*., 2014) (Akman, 2016b)	0.9255 ± 0.0008	0.07 0.19 0.47 3.27 0.69 -0.41 0.49 0.01 0.26	0.56
Z=51, Sb	0.912 ± 0.027 0.926 ± 0.06 0.924 ± 0.037 0.899 ± 0.040	Şimşek *et al*., 2003) (Baydaş, 2005) (Ertuğral *et al*., 2006) (Akman, 2016b)	0.9135 ± 0.0182	-0.05 0.2 0.25 -0.33	0.02
Z=52, Te	0.908 ± 0.03 0.909 ± 0.027 0.923 ± 0.046 0.888 ± 0.017 0.895 ± 0.023 0.913 ± 0.046 0.887 ± 0.040	(Ertuğral *et al*., 2003) (Şimşek *et al*., 2003) (Ertuğral *et al*., 2006) (George *et al*., 2014) (George *et al*., 2014) (Kaya *et al*., 2014) (Akman, 2016b)	0.8978 ± 0.0103	0.32 0.39 0.53 -0.49 -0.11 0.32 -0.26	0.1
Z=53, I	0.898 ± 0.018 0.917 ± 0.036	(Şimşek *et al*., 2003) (Ertuğral *et al*., 2006)	0.9018 ± 0.0161	-0.16 0.39	0.11
Z=55, Cs	0.897 ± 0.036 0.887 ± 0.013 0.900 ± 0.05 0.917 ± 0.041	(Ertuğrul 2002d) (Şimşek *et al*., 2003) (Baydaş, 2005) (Akman, 2016b)	0.8910 ± 0.0114	0.16 -0.23 0.18 0.61	0.18
Z=56, Ba	0.873 ± 0.037 0.905 ± 0.04	(Ertuğrul, 2002d) (Ertuğral *et al*., 2003)	0.8787 ± 0.0041	-0.15 0.66	0.11

	0.890 ± 0.05 0.882 ± 0.026 0.832 ± 0.042 0.878 ± 0.005 0.878 ± 0.009 0.886 ± 0.026 0.910 ± 0.043 0.907 ± 0.054	(Baydaş, 2005) (Ertuğral *et al*., 2006) (Söğűt *et al*., 2009) (Sreevidya *et al*., 2014) (Sreevidya *et al*., 2014) (Kaya *et al*., 2014) (Akman, 2016b) (Durdu *et al*., 2022)		0.23 0.13 -1.1 -0.1 -0.06 0.28 0.73 0.52	
Z=57, La	0.885 ± 0.037 0.892 ± 0.04 0.883 ± 0.06 0.873 ± 0.035 0.975 ± 0.060 0.897 ± 0.045 0.884 ± 0.071	(Ertuğrul, 2002d) (Ertuğral *et al*., 2003) (Baydaş, 2005) (Ertuğral *et al*., 2006) (Söğűt *et al*., 2009) (Akman, 2016b) (Akman, 2016a)	0.8922 ± 0.0171	-0.18 -0.01 -0.15 -0.49 1.33 0.1 -0.11	0.07
Z=58, Ce	0.877 ± 0.036 0.869 ± 0.03 0.874 ± 0.053 0.876 ± 0.07 0.879 ± 0.079 0.883 ± 0.020 0.886 ± 0.040 0.875 ± 0.055	(Ertuğrul, 2003) (Ertuğral *et al*., 2003) (Ertuğral *et al*., 2005) (Baydaş, 2005) (Söğűt *et al*., 2009) (Turşucu and Demir, 2013) (Akman, 2016b) (Akman, 2016a)	0.8787 ± 0.0129	-0.04 -0.3 -0.09 -0.04 0 0.18 0.17 -0.06	-0.02
Z=59, Pr	0.876 ± 0.036 0.866 ± 0.04 0.877 ± 0.026 0.871 ± 0.06 0.901 ± 0.058	(Ertuğrul, 2003) (Ertuğral *et al*., 2003) (Ertuğral *et al*., 2005) (Baydaş, 2005) (Akman, 2016a)	0.8764 ± 0.0170	-0.01 -0.24 0.02 -0.09 0.41	0.02
Z=60, Nd	0.877 ± 0.036 0.861 ± 0.05 0.872 ± 0.035 0.867 ± 0.072	(Ertuğrul, 2003) (Ertuğral *et al*., 2003) (Ertuğral *et al*., 2005) (Akman, 2016a)	0.8713 ± 0.0214	0.14 -0.19 0.02 -0.06	-0.02
Z=62, Sm	0.877 ± 0.036 0.864 ± 0.04 0.862 ± 0.026 0.859 ± 0.05 0.849 ± 0.057 0.854 ± 0.065	(Ertuğrul, 2002c) (Ertuğral *et al*., 2003) (Ertuğral *et al*., 2005) (Baydaş, 2005) (Han *et al*., 2007) (Akman, 2016a)	0.8635 ± 0.0162	0.34 0.01 -0.05 -0.09 -0.24 -0.14	-0.03
Z=63, Eu	0.861 ± 0.03 0.853 ± 0.034 0.855 ± 0.07 0.851 ± 0.057 0.847 ± 0.065	(Ertuğral *et al*., 2003) (Ertuğral *et al*., 2005) (Baydaş, 2005) (Han *et al*., 2007) (Akman, 2016a)	0.8557 ± 0.0192	0.15 -0.07 -0.01 -0.08 -0.13	-0.03
Z=64, Gd	0.844 ± 0.04 0.846 ± 0.042 0.851 ± 0.05 0.843 ± 0.057 0.852 ± 0.072	(Ertuğral *et al*., 2003) (Ertuğral *et al*., 2005) (Baydaş, 2005) (Han *et al*., 2007) (Akman, 2016a)	0.8465 ± 0.0219	-0.05 -0.01 0.08 -0.06 0.07	-0.05
Z=65, Tb	0.876 ± 0.036 0.847 ± 0.05 0.851 ± 0.025 0.847 ± 0.06 0.838 ± 0.068	(Ertuğrul, 2002c) (Ertuğral *et al*., 2003) (Ertuğral *et al*., 2005) (Baydaş, 2005) (Akman, 2016a)	0.8552 ± 0.0175	0.52 -0.16 -0.14 -0.13 -0.25	0.01
Z=66, Dy	0.832 ± 0.03 0.852 ± 0.025 0.843 ± 0.06 0.835 ± 0.058 0.869 ± 0.078	(Ertuğral *et al*., 2003) (Ertuğral *et al*., 2005) (Baydaş, 2005) (Han *et al*., 2007) (Akman, 2016a)	0.8442 ± 0.0170	-0.35 0.26 -0.02 -0.15 0.31	0.01
Z=67, Ho	0.869 ± 0.036	(Ertuğrul, 2002b)	0.8459 ± 0.0188	0.57	-0.04

	0.834 ± 0.04 0.841 ± 0.034 0.838 ± 0.06 0.831 ± 0.059	(Ertuğral *et al*., 2003) (Ertuğral *et al*., 2005) (Baydaş, 2005) (Han *et al*., 2007)		-0.27 -0.12 -0.12 -0.24	
Z=68, Er	0.795 ± 0.036 0.839 ± 0.03 0.843 ± 0.051 0.833 ± 0.05 0.827 ± 0.060 0.826 ± 0.072	(Ertuğrul, 2002b) (Ertuğral *et al*., 2003) (Ertuğral *et al*., 2005) (Baydaş, 2005) (Han *et al*., 2007) (Akman, 2016a)	0.8260 ± 0.0179	-0.77 0.37 0.31 0.13 0.02 0	0.01
Z=69, Tm	0.836 ± 0.033	(Ertuğral *et al*., 2005)	0.836 ± 0.033	0	0
Z=70, Yb	0.831 ± 0.025	(Ertuğral *et al*., 2005)	0.831 ± 0.025	0	0
Z=71, Lu	0.836 ± 0.042	(Ertuğral *et al*., 2005)	0.836 ± 0.042	0	0
Z=72, Hf	0.827 ± 0.050 0.836 ± 0.005	(Ertuğral *et al*., 2005) (Bennal *et al*., 2010)	0.8359 ± 0.0045	0.01 -0.18	-0.08
Z=73, Ta	0.829 ± 0.002 0.822 ± 0.049 0.831 ± 0.007	(Ertuğrul *et al*., 1997a) (Ertuğral *et al*., 2005) (Bennal *et al*., 2010)	0.8291 ± 0.0019	-0.05 -0.15 0.27	0.02
Z=74, W	0.855 ± 0.004 0.823 ± 0.041 0.847 ± 0.049	(Ertuğrul *et al*., 1997a) (Ertuğral *et al*., 2005) (Cengiz *et al*., 2011)	0.8547 ± 0.004	0.06 -0.77 -0.16	-0.29
Z=75, Re	0.904 ± 0.005 0.824 ± 0.058 0.811 ± 0.048 0.840	(Ertuğrul *et al*., 1997a) (Ertuğral *et al*., 2005) (Cengiz *et al*., 2011) (Apaydin and Tiraşoğlu, 2012)	0.9024 ± 0.005	0.22 -1.35 -1.89	-1.01
Z=76, Os	0.795 ± 0.047 0.812	(Cengiz *et al*., 2011) (Apaydin and Tiraşoğlu 2012)	0.795 ± 0.047	0	0
Z=77, Ir	0.819 ± 0.025 0.657	(Ertuğral *et al*., 2005) (Apaydin and Tiraşoğlu, 2012)	0.819 ± 0.025	0	0
Z=78, Pt	0.883 ± 0.052 0.820 ± 0.001 0.826 ± 0.009 0.820 ± 0.009 0.823 ± 0.009 0.808	(Cengiz *et al*., 2011) (Anand *et al*., 2012) (Anand *et al*., 2014) (Anand *et al*., 2014) (Anand *et al*., 2014) (Apaydin and Tiraşoğlu, 2012)	0.8201 ± 0.0010	1.21 -0.09 0.65 -0.01 0.32	0.41
Z=79, Au	0.815 ± 0.008 0.820 ± 0.024 0.821 ± 0.004 0.822 ± 0.010 0.818 ± 0.011 0.818 ± 0.011 0.812 0.802	(Ertuğrul *et al*., 1997a) (Ertuğral *et al*., 2005) (Bennal *et al*., 2010) (Anand *et al*., 2014) (Anand *et al*., 2014) (Anand *et al*., 2014) (Cengiz *et al*., 2010a) (Apaydin and Tiraşoğlu, 2012)	0.8197 ± 0.0030	-0.55 0.01 0.22 -0.15 -0.15 0.32	-0.05
Z=80, Hg	0.815 ± 0.008 0.811 ± 0.032 0.795	(Ertuğrul *et al*., 1997a) (Ertuğral *et al*., 2005) (Apaydin and Tiraşoğlu, 2012)	0.8148 ± 0.0078	0.02 -0.11	-0.05
Z=81, Tl	0.795 ± 0.009 0.816 ± 0.024 0.809 ± 0.006 0.803 ± 0.007 0.766	(Ertuğrul *et al*., 1997a) (Ertuğral *et al*., 2005) (Sreevidya *et al*., 2014) (Sreevidya *et al*., 2014) (Apaydin and Tiraşoğlu, 2012)	0.8045 ± 0.0040	-0.96 0.47 0.63 -0.18	-0.01
Z=82, Pb	0.805 ± 0.012 0.809 ± 0.040 0.814 ± 0.006 0.810 ± 0.002 0.821 ± 0.010 0.803 ± 0.008	(Ertuğrul *et al*., 1997a) (Ertuğral *et al*., 2005) (Bennal *et al*., 2010) (Anand *et al*., 2012) (Anand *et al*., 2014) (Anand *et al*., 2014)	0.8101 ± 0.0018	-0.42 -0.03 -0.03 1.07 -0.87 -0.38	0

	0.807 ± 0.008 0.730	(Anand *et al*., 2014) (Apaydin and Tiraşoğlu, 2012)		0.65	
Z=83, Bi	0.637 ± 0.013 0.803 ± 0.032 0.644	(Ertuğrul *et al*., 1997a) (Ertuğral *et al*., 2005) (Apaydin and Tiraşoğlu, 2012)	0.6605 ± 0.0120	-1.33 4.17	1.42
Z=90, Th	0.636 ± 0.013 0.774 ± 0.056 0.761	(Ertuğrul *et al*., 1997a) (Ertuğral *et al*., 2005) (Apaydin and Tiraşoğlu, 2012)	0.6431 ± 0.0127	-0.39 2.28	0.95
Z=92, U	0.682 ± 0.021 0.770 ± 0.055 0.756	(Ertuğrul *et al*., 1997a) (Ertuğral *et al*., 2005) (Apaydin and Tiraşoğlu, 2012)	0.6932 ± 0.0196	-0.39 1.32	0.46

Table 3. Summary of the experimental $\eta_{\mathrm{KL1}}(A)$ radiationless vacancy transfer probabilities from $_{55}$Cs to $_{68}$Er according to their target atomic numbers. The references from which the databases are extracted, the weighted average values $((\eta_{\mathrm{KL1}}(A))_W$, the combined standard deviation and the average z-score were also listed.

Z, Symbol	$(\eta_{\mathrm{KL1}}(A))_{EXP-i} \pm \Delta(\eta_{\mathrm{KL1}}(A))_{EXP-i}$	References	$(\eta_{\mathrm{KL1}}(A))_W \pm \varepsilon$	z_i	$\bar{z}$
Z=55, Cs	0.051 ± 0.002	(Ertuğrul 2002d)	0.051 ± 0.002	0	0
Z=56, Ba	0.041 ± 0.002	(Ertuğrul, 2002d)	0.041 ± 0.002	0	0
Z=57, La	0.045 ± 0.002	(Ertuğrul, 2002d)	0.045 ± 0.002	0	0
Z=58, Ce	0.043 ± 0.002	(Ertuğrul, 2003)	0.043 ± 0.002	0	0
Z=59, Pr	0.043 ± 0.002	(Ertuğrul, 2003)	0.043 ± 0.002	0	0
Z=60, Nd	0.040 ± 0.002	(Ertuğrul, 2003)	0.040 ± 0.002	0	0
Z=62, Sm	0.039 ± 0.002 0.033 ± 0.002	(Ertuğrul, 2002c) (Han *et al*., 2007)	0.0360 ± 0.0014	1.22 -1.22	0
Z=63, Eu	0.031 ± 0.002	(Han *et al*., 2007)	0.031 ± 0.002	0	0
Z=64, Gd	0.031 ± 0.002	(Han *et al*., 2007)	0.031 ± 0.002	0	0
Z=65, Tb	0.035 ± 0.002	(Ertuğrul, 2002c)	0.035 ± 0.002	0	0
Z=66, Dy	0.028 ± 0.002	(Han *et al*., 2007)	0.028 ± 0.002	0	0
Z=67, Ho	0.033 ± 0.002 0.027 ± 0.002	(Ertuğrul, 2002b) (Han *et al*., 2007)	0.030 ± 0.0014	-1.22 1.22	0
Z=68, Er	0.032 ± 0.002 0.026 ± 0.002	(Ertuğrul, 2002b) (Han *et al*., 2007)	0.029 ± 0.0014	-1.22 1.22	0

Table 4. Summary of the experimental $\eta_{\mathrm{KL2}}(A)$ radiationless vacancy transfer probabilities from $_{55}$Cs to $_{68}$Er according to their target atomic numbers. The references from which the databases are extracted, the weighted average values $((\eta_{\mathrm{KL2}}(A))_W$, the combined standard deviation and the average z-score were also listed.

Z, Symbol	$(\eta_{\mathrm{KL2}}(A))_{EXP-i} \pm \Delta(\eta_{\mathrm{KL2}}(A))_{EXP-i}$	References	$(\eta_{\mathrm{KL2}}(A))_W \pm \varepsilon$	z_i	$\bar{z}$
Z=55, Cs	0.047±0.001	(Ertuğrul, 2002d)	0.047±0.001	0	0
Z=56, Ba	0.049±0.002	(Ertuğrul, 2002d)	0.049±0.002	0	0
Z=57, La	0.048±0.002	(Ertuğrul, 2002d)	0.048±0.002	0	0
Z=58, Ce	0.042±0.002	(Ertuğrul, 2003)	0.042±0.002	0	0
Z=59, Pr	0.039±0.002	(Ertuğrul, 2003)	0.039±0.002	0	0
Z=60, Nd	0.042±0.002	(Ertuğrul, 2003)	0.042±0.002	0	0
Z=62, Sm	0.035±0.001	(Ertuğrul, 2002c)	0.035±0.001	0	0
Z=65, Tb	0.048±0.002	(Ertuğrul, 2002c)	0.048±0.002	0	0
Z=67, Ho	0.032±0.002	(Ertuğrul, 2002b)	0.032±0.002	0	0
Z=68, Er	0.010±0.002	(Ertuğrul, 2002b)	0.010±0.002	0	0

Table 5. Summary of the experimental $\eta_{\mathrm{KL2}}(R)$ radiative vacancy transfer probabilities from ${}_{23}$V to ${}_{92}$U according to their target atomic numbers. The references from which the databases are extracted, the weighted average values $((\eta_{\mathrm{KL2}}(R))_W$, the combined standard deviation and the average z-score were also listed.

Z, Symbol	$(\eta_{\mathrm{KL2}}(R))_{EXP-i} \pm \Delta(\eta_{\mathrm{KL2}}(R))_{EXP-i}$	References	$(\eta_{\mathrm{KL2}}(R))_W \pm \varepsilon$	z_i	$\bar{z}$
Z=23, V	0.079 ± 0.007	(Durak *et al*., 2012)	0.079 ± 0.007	0	0
Z=24, Cr	0.091 ± 0.002	(Söğüt, 2006)	0.091 ± 0.002	0	0
Z=26, Fe	0.1023 ± 0.0056	(Söğüt, 2009)	0.1023 ± 0.0056	0	0
Z=27, Co	0.079 ± 0.007	(Durak *et al*., 2012)	0.079 ± 0.007	0	0
Z=28, Ni	0.091 ± 0.002	(Söğüt, 2006)	0.091 ± 0.002	0	0
Z=30, Zn	0.138 ± 0.004 0.1424 ± 0.0082 0.142 ± 0.012	(Ertuğrul, 2002a) (Söğüt, 2009) (Durak *et al*., 2012)	0.1391 ± 0.0034	-0.21 0.23 0.37	0.13
Z=33, As	0.164 ± 0.006	(Ertuğrul, 2002a)	0.164 ± 0.006	0	0
Z=34, Se	0.172 ± 0.010 0.176 ± 0.014	(Ertuğrul, 2002a) (Durak *et al*., 2012)	0.1734 ± 0.0081	-0.1 0.19	0.04
Z=37, Rb	0.195 ± 0.009	(Ertuğrul, 2002a)	0.195 ± 0.009	0	0
Z=38, Sr	0.203 ± 0.008	(Ertuğrul, 2002a)	0.203 ± 0.008	0	0
Z=39, Y	0.207 ± 0.010	(Ertuğrul, 2002a)	0.207 ± 0.010	0	0
Z=40, Zr	0.211 ± 0.006 0.219 ± 0.017	(Ertuğrul, 2002a) (Turhan *et al*., 2017)	0.2119 ± 0.0057	-0.11 0.42	0.16
Z=41, Nb	0.216 ± 0.012	(Çalilşkan *et al*., 2002)	0.216 ± 0.012	0	0
Z=42, Mo	0.218 ± 0.008 0.230 ± 0.018	(Çalilşkan *et al*., 2002) (Turhan *et al*., 2017)	0.220 ± 0.007	-0.18 0.56	0.19
Z=46, Pd	0.239 ± 0.011	(Çalilşkan *et al*., 2002)	0.239 ± 0.011	0	0
Z=47, Ag	0.237 ± 0.009	(Çalilşkan *et al*., 2002)	0.237 ± 0.009	0	0
Z=48, Cd	0.239 ± 0.014 0.256 ± 0.022	(Çalilşkan *et al*., 2002) (Turhan *et al*., 2017)	0.2439 ± 0.012	-0.35 0.55	0.1
Z=49, In	0.240 ± 0.012	(Çalilşkan *et al*., 2002)	0.240 ± 0.012	0	0
Z=50, Sn	0.248 ± 0.014	(Çalilşkan *et al*., 2002)	0.248 ± 0.014	0	0
Z=51, Sb	0.244 ± 0.007	(Çalilşkan *et al*., 2002)	0.244 ± 0.007	0	0
Z=52, Te	0.253 ± 0.012	(Çalilşkan *et al*., 2002)	0.253 ± 0.012	0	0
Z=53, I	0.251 ± 0.010	(Çalilşkan *et al*., 2002)	0.251 ± 0.010	0	0
Z=55, Cs	0.261 ± 0.022 0.254 ± 0.01 0.254 ± 0.015	(Durak and Özdemir, 2000) (Ertuğrul, 2002d) (Çalilşkan *et al*., 2002)	0.2549 ± 0.0078	0.26 -0.07 -0.05	0.05
Z=56, Ba	0.255 ± 0.01 0.255 ± 0.007	(Ertuğrul, 2002d) (Çalilşkan *et al*., 2002)	0.2550 ± 0.0057	0 0	0
Z=57, La	0.256 ± 0.01 0.256 ± 0.010 0.2697 ± 0.0225	(Ertuğrul, 2002d) (Çalilşkan *et al*., 2002) (Akman, 2016a)	0.2572 ± 0.0068	-0.1 -0.1 0.53	0.11
Z=58, Ce	0.260 ± 0.01 0.259 ± 0.015 0.263 ± 0.018 0.268 ± 0.019 0.2612 ± 0.0176	(Çalilşkan *et al*., 2002) (Ertuğrul, 2003) (Reyes-Herrera and Miranda, 2008) (Reyes-Herrera and Miranda, 2009) (Akman, 2016a)	0.2613 ± 0.0065	-0.11 -0.14 0.09 0.33 -0.01	0.03
Z=59, Pr	0.260 ± 0.023 0.261 ± 0.013 0.260 ± 0.01 0.2671 ± 0.0194	(Durak and Özdemir, 2000) (Çalilşkan *et al*., 2002) (Ertuğrul, 2003) (Akman, 2016a)	0.2612 ± 0.0067	-0.05 -0.01 -0.1 0.29	0.03
Z=60, Nd	0.264 ± 0.021 0.263 ± 0.022	(Durak and Özdemir, 1998) (Durak and Özdemir, 2000)	0.2617 ± 0.0047	0.11 0.06	0.12

	0.259 ± 0.007 0.259 ± 0.01 0.268 ± 0.022 0.267 ± 0.020 0.267 ± 0.020 0.269 ± 0.019 0.2696 ± 0.0242	(Çalilşkan *et al*., 2002) (Ertuğrul, 2003) (Demir and Şahin, 2007) (Demir and Şahin, 2007) (Demir and Şahin, 2007) (Reyes-Herrera and Miranda, 2008) (Akman, 2016a)		-0.32 -0.24 0.28 0.26 0.26 0.37 0.32	
Z=62, Sm	0.265 ± 0.017 0.264 ± 0.015 0.267 ± 0.01 0.267 ± 0.013 0.2646 ± 0.0221	(Durak and Özdemir, 1998) (Durak and Özdemir, 2000) (Çalilşkan *et al*., 2002) (Ertuğrul, 2002c) (Akman, 2016a)	0.2660 ± 0.0062	-0.06 -0.12 0.08 0.07 -0.06	-0.02
Z=63, Eu	0.266 ± 0.017 0.267 ± 0.023 0.269 ± 0.021 0.269 ± 0.020 0.2561 ± 0.0216	(Durak and Özdemir, 1998) (Demir and Şahin, 2007) (Demir and Şahin, 2007) (Demir and Şahin, 2007) (Akman, 2016a)	0.2660 ± 0.0017	0.04 0.14 0.15 -0.46 0.01	-0.02
Z=64, Gd	0.267 ± 0.017 0.267 ± 0.019 0.267 ± 0.010 0.262 ± 0.022 0.261 ± 0.027 0.261 ± 0.026 0.273 ± 0.019 0.284 ± 0.020 0.291 ± 0.021 0.2668±0.0246	(Durak and Özdemir, 1998) (Durak and Özdemir, 2000) (Çalilşkan *et al*., 2002) (Demir and Şahin, 2007) (Demir and Şahin, 2007) (Demir and Şahin, 2007) (Reyes-Herrera and Miranda, 2008) (Reyes-Herrera and Miranda, 2009) (Reyes-Herrera and Miranda, 2009) (Akman, 2016a)	0.2698 ± 0.0057	-0.16 -0.14 -0.25 -0.34 -0.32 -0.33 0.16 0.68 0.97 -0.12	0.02
Z=65, Tb	0.267 ± 0.022 0.258 ± 0.01 0.258 ± 0.015 0.2808±0.0254	(Durak and Özdemir, 2000) (Ertuğrul, 2002c) (Çalilşkan *et al*., 2002) (Akman, 2016a)	0.2610 ± 0.0074	0.26 -0.24 -0.18 0.75	0.15
Z=66, Dy	0.269 ± 0.020 0.269 ± 0.020 0.265 ± 0.010 0.261 ± 0.015 0.262 ± 0.017 0.261 ± 0.015 0.273 ± 0.019 0.281 ± 0.020 0.294 ± 0.022 0.2615±0.0263	(Durak and Özdemir, 1998) (Durak and Özdemir, 2000) (Çalilşkan *et al*., 2002) (Demir and Şahin, 2007) (Demir and Şahin, 2007) (Demir and Şahin, 2007) (Reyes-Herrera and Miranda, 2008) (Reyes-Herrera and Miranda, 2009) (Reyes-Herrera and Miranda, 2009) (Akman, 2016a)	0.2675 ± 0.0053	0.07 0.07 -0.22 -0.41 -0.31 -0.41 0.28 0.65 1.17 -0.22	0.07
Z=67, Ho	0.269 ± 0.018 0.270 ± 0.021 0.265 ± 0.02 0.266 ± 0.013 0.271 ± 0.017 0.271 ± 0.017 0.271 ± 0.016 0.274 ± 0.019 0.276 ± 0.019 0.294 ± 0.022	(Durak and Özdemir, 1998) (Durak and Özdemir, 2000) (Ertuğrul, 2002b) (Çalilşkan *et al*., 2002) (Demir and Şahin, 2007) (Demir and Şahin, 2007) (Demir and Şahin, 2007) (Reyes-Herrera and Miranda, 2008) (Reyes-Herrera and Miranda, 2009) (Reyes-Herrera and Miranda, 2009)	0.2723 ± 0.0861	-0.01 -0.01 -0.03 -0.02 0 0 0 0.01 0.01 0.07	0
Z=68, Er	0.270 ± 0.016 0.271 ± 0.020 0.269 ± 0.02 0.269 ± 0.008 0.278 ± 0.020 0.287 ± 0.021 0.2583±0.025 0.277 ± 0.026	(Durak and Özdemir, 1998) (Durak and Özdemir, 2000) (Ertuğrul, 2002b) (Çalilşkan *et al*., 2002) (Reyes-Herrera and Miranda, 2009) (Reyes-Herrera and Miranda, 2009) (Akman, 2016a) (Turhan *et al*., 2017)	0.271 ± 0.0056	-0.06 0 -0.1 -0.21 0.33 0.73 -0.5 0.23	0.05

Z=69, Tm	0.270 ± 0.019	(Ertuğrul *et al*., 1997b)	0.270 ± 0.019	0	0
Z=70, Yb	0.270 ± 0.019 0.272 ± 0.022	(Ertuğrul *et al*., 1997b) (Durak and Özdemir, 1998)	0.2720 ± 0.0022	-0.1 0.01	-0.05
Z=71, Lu	0.271 ± 0.019	(Ertuğrul *et al*., 1997b)	0.271 ± 0.019	0	0
Z=73, Ta	0.273 ± 0.017 0.274 ± 0.019 0.277 ± 0.005	(Ertuğrul *et al*., 1997b) (Durak and Özdemir, 1998) (Bennal and Badiger, 2006)	0.2765 ± 0.0047	-0.2 -0.13 0.07	-0.09
Z=74, W	0.274 ± 0.020 0.274 ± 0.020	(Ertuğrul *et al*., 1997b) (Durak and Özdemir, 1998)	0.274 ± 0.0141	0 0	0
Z=75, Re	0.278 ± 0.017	(Ertuğrul *et al*., 1997b)	0.278 ± 0.017	0	0
Z=78, Pt	0.282 ± 0.002 0.284 ± 0.014 0.283 ± 0.014	(Anand *et al*., 2014) (Anand *et al*., 2014) (Anand *et al*., 2014)	0.2821 ± 0.002	-0.02 0.14 0.07	0.06
Z=79, Au	0.278 ± 0.021 0.280 ± 0.005 0.285 ± 0.005 0.286 ± 0.019 0.286 ± 0.019	(Ertuğrul *et al*., 1997b) (Bennal and Badiger, 2006) (Anand *et al*., 2014) (Anand *et al*., 2014) (Anand *et al*., 2014)	0.2826 ± 0.0034	-0.22 -0.43 0.4 0.18 0.18	0.02
Z=80, Hg	0.278 ± 0.015 0.280 ± 0.020	(Ertuğrul *et al*., 1997b) (Durak and Özdemir, 1998)	0.2787 ± 0.0120	-0.04 0.05	0.01
Z=81, Tl	0.277 ± 0.024 0.281 ± 0.005 0.283 ± 0.006	(Ertuğrul *et al*., 1997b) (Sreevidya *et al*., 2014) (Sreevidya *et al*., 2014)	0.2817 ± 0.0038	-0.19 -0.11 0.18	-0.04
Z=82, Pb	0.278 ± 0.024 0.281 ± 0.022 0.283 ± 0.004 0.289 ± 0.002 0.292 ± 0.020 0.290 ± 0.020	(Ertuğrul *et al*., 1997b) (Durak and Özdemir, 1998) (Bennal and Badiger, 2006) (Anand *et al*., 2014) (Anand *et al*., 2014) (Anand *et al*., 2014)	0.2878 ± 0.0018	-0.41 -0.31 -1.09 0.47 0.21 0.11	-0.17
Z=83, Bi	0.280 ± 0.020	(Ertuğrul *et al*., 1997b)	0.280 ± 0.020	0	0
Z=90, Th	0.290 ± 0.022	(Ertuğrul *et al*., 1997b)	0.290 ± 0.022	0	0
Z=92, U	0.291 ± 0.022	(Ertuğrul *et al*., 1997b)	0.291 ± 0.022	0	0

Table 6. Summary of the experimental $\eta_{\mathrm{KL2}}(T)$ total vacancy transfer probabilities from $_{55}$Cs to $_{68}$Er according to their target atomic numbers. The references from which the databases are extracted, the weighted average values $((\eta_{\mathrm{KL2}}(T))_W$, the combined standard deviation and the average z-score were also listed.

Z, Symbol	$(\eta_{\mathrm{KL2}}(T))_{EXP-i} \pm \Delta(\eta_{\mathrm{KL2}}(T))_{EXP-i}$	References	$(\eta_{\mathrm{KL2}}(T))_W \pm \varepsilon$	z_i	$\bar{z}$
Z=55, Cs	0.301 ± 0.01	(Ertuğrul, 2002d)	0.301 ± 0.01	0	0
Z=56, Ba	0.304 ± 0.01	(Ertuğrul, 2002d)	0.304 ± 0.01	0	0
Z=57, La	0.306 ± 0.01	(Ertuğrul, 2002d)	0.306 ± 0.01	0	0
Z=58, Ce	0.302 ± 0.01	(Ertuğrul, 2003)	0.302 ± 0.01	0	0
Z=59, Pr	0.299 ± 0.01	(Ertuğrul, 2003)	0.299 ± 0.01	0	0
Z=60, Nd	0.302 ± 0.01	(Ertuğrul, 2003)	0.302 ± 0.01	0	0
Z=62, Sm	0.302 ± 0.01 0.289±0.021	(Ertuğrul, 2002c) (Han *et al*., 2007)	0.2996 ± 0.0090	0.18 -0.46	-0.14
Z=63, Eu	0.289±0.021	(Han *et al*., 2007)	0.289±0.021	0	0
Z=64, Gd	0.288±0.022	(Han *et al*., 2007)	0.288±0.022	0	0
Z=65, Tb	0.303 ± 0.01	(Ertuğrul, 2002c)	0.303 ± 0.01	0	0
Z=66, Dy	0.288±0.022	(Han *et al*., 2007)	0.288±0.022	0	0
Z=67, Ho	0.297 ± 0.01 0.288±0.023	(Ertuğrul, 2002b) (Han *et al*., 2007)	0.2956 ± 0.0092	0.11 -0.31	-0.10
Z=68, Er	0.279 ± 0.01 0.287±0.024	(Ertuğrul, 2002b) (Han *et al*., 2007)	0.2802 ± 0.0092	-0.1 0.27	0.09

Table 7. Summary of the experimental $\eta_{\mathrm{KL3}}(A)$ radiationless vacancy transfer probabilities from $_{55}$Cs to $_{68}$Er according to their target atomic numbers. The references from which the databases are extracted, the weighted average values $((\eta_{\mathrm{KL3}}(A))_W$, the combined standard deviation and the average z-score were also listed.

Z, Symbol	$(\eta_{\mathrm{KL3}}(A))_{EXP-i} \pm \Delta(\eta_{\mathrm{KL3}}(A))_{EXP-i}$	References	$(\eta_{\mathrm{KL3}}(A))_W \pm \varepsilon$	z_i	$\bar{z}$
Z=55, Cs	0.076±0.003	(Ertuğrul, 2002d)	0.076±0.003	0	0
Z=56, Ba	0.058±0.003	(Ertuğrul, 2002d)	0.058±0.003	0	0
Z=57, La	0.070±0.003	(Ertuğrul, 2002d)	0.070±0.003	0	0
Z=58, Ce	0.057±0.002	(Ertuğrul, 2003)	0.057±0.002	0	0
Z=59, Pr	0.059±0.002	(Ertuğrul, 2003)	0.059±0.002	0	0
Z=60, Nd	0.064±0.002	(Ertuğrul, 2003)	0.064±0.002	0	0
Z=62, Sm	0.053±0.003	(Ertuğrul, 2002c)	0.053±0.003	0	0
Z=65, Tb	0.076±0.003	(Ertuğrul, 2002c)	0.076±0.003	0	0
Z=67, Ho	0.065±0.002	(Ertuğrul, 2002b)	0.065±0.002	0	0
Z=68, Er	0.060±0.002	(Ertuğrul, 2002b)	0.060±0.002	0	0

Table 8. Summary of the experimental $\eta_{\mathrm{KL3}}(R)$ radiative vacancy transfer probabilities from $_{23}$V to $_{92}$U according to their target atomic numbers. The references from which the databases are extracted, the weighted average values $((\eta_{\mathrm{KL3}}(R))_W$, the combined standard deviation and the average z-score were also listed.

Z, Symbol	$(\eta_{\mathrm{KL3}}(R))_{EXP-i} \pm \Delta(\eta_{\mathrm{KL3}}(R))_{EXP-i}$	References	$(\eta_{\mathrm{KL3}}(R))_W \pm \varepsilon$	z_i	$\bar{z}$
Z=23, V	0.154 ± 0.014	(Durak *et al*., 2012)	0.154 ± 0.014	0	0
Z=24, Cr	0.179 ± 0.004	(Söğüt, 2006)	0.179 ± 0.004	0	0
Z=26, Fe	0.2002± 0.012	(Söğüt, 2009)	0.2002± 0.012	0	0
Z=27, Co	0.241 ± 0.019	(Durak *et al*., 2012)	0.241 ± 0.019	0	0
Z=28, Ni	0.211 ± 0.005	(Söğüt, 2006)	0.211 ± 0.005	0	0
Z=30, Zn	0.270 ± 0.008 0.2771 ± 0.0166 0.277 ± 0.022	(Ertuğrul, 2002a) (Söğüt, 2009) (Durak *et al*., 2012)	0.2719 ± 0.0069	-0.24 0.23 0.31	0.10
Z=33, As	0.318 ± 0.012	(Ertuğrul, 2002a)	0.318 ± 0.012	0	0
Z=34, Se	0.333 ± 0.020 0.340 ± 0.028	(Ertuğrul, 2002a) (Durak *et al*., 2012)	0.3354 ± 0.0163	-0.12 0.17	0.02
Z=37, Rb	0.375 ± 0.018	(Ertuğrul, 2002a)	0.375 ± 0.018	0	0
Z=38, Sr	0.390 ± 0.015	(Ertuğrul, 2002a)	0.390 ± 0.015	0	0
Z=39, Y	0.397 ± 0.019	(Ertuğrul, 2002a)	0.397 ± 0.019	0	0
Z=40, Zr	0.404 ± 0.012 0.419 ± 0.033	(Ertuğrul, 2002a) (Turhan *et al*., 2017)	0.4058 ± 0.0113	-0.15 0.40	0.13
Z=41, Nb	0.413 ± 0.024	(Çalilşkan *et al*., 2002)	0.413 ± 0.024	0	0
Z=42, Mo	0.416 ± 0.016 0.439 ± 0.035	(Çalilşkan *et al*., 2002) (Turhan *et al*., 2017)	0.420 ± 0.015	-0.25 0.54	0.15
Z=46, Pd	0.452 ± 0.022	(Çalilşkan *et al*., 2002)	0.452 ± 0.022	0	0
Z=47, Ag	0.446 ± 0.017	(Çalilşkan *et al*., 2002)	0.446 ± 0.017	0	0
Z=48, Cd	0.451 ± 0.027 0.480 ± 0.041	(Çalilşkan *et al*., 2002) (Turhan *et al*., 2017)	0.451 ± 0.023	-0.32 0.49	0.08
Z=49, In	0.452 ± 0.022	(Çalilşkan *et al*., 2002)	0.452 ± 0.022	0	0
Z=50, Sn	0.464 ± 0.027	(Çalilşkan *et al*., 2002)	0.464 ± 0.027	0	0
Z=51, Sb	0.456 ± 0.013	(Çalilşkan *et al*., 2002)	0.456 ± 0.013	0	0
Z=52, Te	0.471 ± 0.023	(Çalilşkan *et al*., 2002)	0.471 ± 0.023	0	0
Z=53, I	0.466 ± 0.018	(Çalilşkan *et al*., 2002)	0.466 ± 0.018	0	0
Z=55, Cs	0.483 ± 0.032 0.469 ± 0.02 0.469 ± 0.028	(Durak and Özdemir, 2000) (Ertuğrul, 2002d) (Çalilşkan *et al*., 2002)	0.4719 ± 0.0145	0.32 -0.12 -0.09	0.04
Z=56, Ba	0.470 ± 0.02 0.470 ± 0.014	(Ertuğrul, 2002d) (Çalilşkan *et al*., 2002)	0.470 ± 0.0115	0 0	0
Z=57, La	0.470 ± 0.02 0.470 ± 0.018 0.4557±0.0381	(Ertuğrul, 2002d) (Çalilşkan *et al*., 2002) (Akman, 2016a)	0.4684 ± 0.0126	0.07 0.07 -0.32	-0.06
Z=58, Ce	0.475 ± 0.028 0.475 ± 0.02 0.479 ± 0.045 0.521 ± 0.047 0.4826±0.0325	(Çalilşkan *et al*., 2002) (Ertuğrul, 2003) (Reyes-Herrera and Miranda, 2008) (Reyes-Herrera and Miranda, 2009) (Akman, 2016a)	0.4803 ± 0.0133	-0.17 -0.22 -0.03 0.83 0.07	0.10
Z=59, Pr	0.480 ± 0.034 0.477 ± 0.023 0.475 ± 0.02 0.4583±0.0334	(Durak and Özdemir, 2000) (Çalilşkan *et al*., 2002) (Ertuğrul, 2003) (Akman, 2016a)	0.4739 ± 0.0128	0.17 0.12 0.05 -0.44	-0.03
Z=60, Nd	0.480 ± 0.038 0.479 ± 0.030	(Durak and Özdemir, 1998) (Durak and Özdemir, 2000)	0.4793 ± 0.0088	0.02 -0.01	0.14

	0.471 ± 0.014 0.471 ± 0.02 0.490 ± 0.032 0.506 ± 0.035 0.506 ± 0.035 0.483 ± 0.045 0.4921±0.0441	(Çalilşkan *et al*., 2002) (Ertuğrul, 2003) (Demir and Şahin, 2007) (Demir and Şahin, 2007) (Demir and Şahin, 2007) (Reyes-Herrera and Miranda, 2008) (Akman, 2016a)		-0.5 -0.38 0.32 0.74 0.74 0.08 0.29	
Z=62, Sm	0.481 ± 0.029 0.480 ± 0.031 0.483 ± 0.024 0.483 ± 0.02 0.5036±0.042	(Durak and Özdemir, 1998) (Durak and Özdemir, 2000) (Çalilşkan *et al*., 2002) (Ertuğrul, 2002c) (Akman, 2016a)	0.4839 ± 0.0119	-0.09 -0.12 -0.03 -0.04 0.45	0.03
Z=63, Eu	0.481 ± 0.035 0.492 ± 0.034 0.500 ± 0.036 0.500 ± 0.036 0.5078±0.0428	(Durak and Özdemir, 1998) (Demir and Şahin, 2007) (Demir and Şahin, 2007) (Demir and Şahin, 2007) (Akman, 2016a)	0.4955 ± 0.0166	-0.37 -0.09 0.11 0.11 0.29	0.01
Z=64, Gd	0.482 ± 0.038 0.482 ± 0.028 0.481 ± 0.019 0.496 ± 0.030 0.516 ± 0.026 0.516 ± 0.026 0.490 ± 0.045 0.508 ± 0.048 0.513 ± 0.049 0.4949±0.0457	(Durak and Özdemir, 1998) (Durak and Özdemir, 2000) (Çalilşkan *et al*., 2002) (Demir and Şahin, 2007) (Demir and Şahin, 2007) (Demir and Şahin, 2007) (Reyes-Herrera and Miranda, 2008) (Reyes-Herrera and Miranda, 2009) (Reyes-Herrera and Miranda, 2009) (Akman, 2016a)	0.4959 ± 0.0097	-0.35 -0.47 -0.70 0 0.72 0.72 -0.13 0.25 0.34 -0.02	0.04
Z=65, Tb	0.482 ± 0.033 0.461 ± 0.02 0.461 ± 0.027 0.4856±0.0439	(Durak and Özdemir, 2000) (Ertuğrul, 2002c) (Çalilşkan *et al*., 2002) (Akman, 2016a)	0.4670 ± 0.0137	0.42 -0.25 -0.20 0.40	0.09
Z=66, Dy	0.483 ± 0.040 0.482 ± 0.035 0.474 ± 0.018 0.487 ± 0.031 0.507 ± 0.033 0.507 ± 0.033 0.489 ± 0.045 0.522 ± 0.048 0.0507 ± 0.049 0.4562±0.0459	(Durak and Özdemir, 1998) (Durak and Özdemir, 2000) (Çalilşkan *et al*., 2002) (Demir and Şahin, 2007) (Demir and Şahin, 2007) (Demir and Şahin, 2007) (Reyes-Herrera and Miranda, 2008) (Reyes-Herrera and Miranda, 2009) (Reyes-Herrera and Miranda, 2009) (Akman, 2016a)	0.4870 ± 0.0104	-0.10 -0.14 -0.62 0 0.58 0.58 0.04 0.71 0.40 -0.65	0.08
Z=67, Ho	0.482 ± 0.036 0.482 ± 0.026 0.474 ± 0.02 0.474 ± 0.023 0.486 ± 0.028 0.489 ± 0.032 0.489 ± 0.032 0.494 ± 0.046 0.511 ± 0.046 0.516 ± 0.050	(Durak and Özdemir, 1998) (Durak and Özdemir, 2000) (Ertuğrul, 2002b) (Çalilşkan *et al*., 2002) (Demir and Şahin, 2007) (Demir and Şahin, 2007) (Demir and Şahin, 2007) (Reyes-Herrera and Miranda, 2008) (Reyes-Herrera and Miranda, 2009) (Reyes-Herrera and Miranda, 2009)	0.4835 ± 0.0094	-0.04 -0.05 -0.43 -0.38 0.09 0.17 0.17 0.22 0.59 0.64	0.10
Z=68, Er	0.482 ± 0.039 0.482 ± 0.036 0.478 ± 0.02 0.478 ± 0.014 0.509 ± 0.046 0.515 ± 0.049 0.4875±0.0473 0.492 ± 0.047	(Durak and Özdemir, 1998) (Durak and Özdemir, 2000) (Ertuğrul, 2002b) (Çalilşkan *et al*., 2002) (Reyes-Herrera and Miranda, 2009) (Reyes-Herrera and Miranda, 2009) (Akman, 2016a) (Turhan *et al*., 2017)	0.482 ± 0.0096	-0.01 -0.01 -0.19 -0.25 0.57 0.66 0.11 0.21	0.13

Z=69, Tm	0.482 ± 0.035	(Ertuğrul *et al*., 1997b)	0.482 ± 0.035	0	0
Z=70, Yb	0.484 ± 0.035 0.482 ± 0.036	(Ertuğrul *et al*., 1997b) (Durak and Özdemir, 1998)	0.4830 ± 0.0251	0.02 -0.02	0
Z=71, Lu	0.480 ± 0.034	(Ertuğrul *et al*., 1997b)	0.480 ± 0.034	0	0
Z=73, Ta	0.477 ± 0.030 0.480 ± 0.034 0.483 ± 0.008	(Ertuğrul *et al*., 1997b) (Durak and Özdemir, 1998) (Bennal and Badiger, 2006)	0.4825 ± 0.0075	-0.18 -0.07 0.05	-0.07
Z=74, W	0.478 ± 0.036 0.480 ± 0.035	(Ertuğrul *et al*., 1997b) (Durak and Özdemir, 1998)	0.4790 ± 0.0251	-0.02 0.02	0
Z=75, Re	0.479 ± 0.030	(Ertuğrul *et al*., 1997b)	0.479 ± 0.030	0	0
Z=78, Pt	0.473 ± 0.003 0.477 ± 0.035 0.475 ± 0.035	(Anand *et al*., 2014) (Anand *et al*., 2014) (Anand *et al*., 2014)	0.4730 ± 0.003	-0.01 0.11 0.06	0.05
Z=79, Au	0.478 ± 0.037 0.479 ± 0.008 0.480 ± 0.004 0.482 ± 0.012 0.482 ± 0.012	(Ertuğrul *et al*., 1997b) (Bennal and Badiger, 2006) (Anand *et al*., 2014) (Anand *et al*., 2014) (Anand *et al*., 2014)	0.4801 ± 0.0033	-0.06 -0.13 -0.02 0.15 0.15	0.02
Z=80, Hg	0.474 ± 0.026 0.476 ± 0.037	(Ertuğrul *et al*., 1997b) (Durak and Özdemir, 1998)	0.4747 ± 0.0213	-0.02 0.03	0.01
Z=81, Tl	0.473 ± 0.042 0.462 ± 0.008 0.466 ± 0.009	(Ertuğrul *et al*., 1997b) (Sreevidya *et al*., 2014) (Sreevidya *et al*., 2014)	0.4640 ± 0.0059	0.21 -0.2 0.19	0.07
Z=82, Pb	0.473 ± 0.041 0.474 ± 0.038 0.477 ± 0.006 0.483 ± 0.003 0.487 ± 0.009 0.485 ± 0.009	(Ertuğrul *et al*., 1997b) (Durak and Özdemir, 1998) (Bennal and Badiger, 2006) (Anand *et al*., 2014) (Anand *et al*., 2014) (Anand *et al*., 2014)	0.4824 ± 0.0025	-0.23 -0.22 -0.83 0.16 0.50 0.28	-0.06
Z=83, Bi	0.471 ± 0.034	(Ertuğrul *et al*., 1997b)	0.471 ± 0.034	0	0
Z=90, Th	0.464 ± 0.035	(Ertuğrul *et al*., 1997b)	0.464 ± 0.035	0	0
Z=92, U	0.462 ± 0.036	(Ertuğrul *et al*., 1997b)	0.462 ± 0.036	0	0

Table 9. Summary of the experimental $\eta_{\mathrm{KL3}}(T)$ total vacancy transfer probabilities from $_{55}$Cs to $_{68}$Er according to their target atomic numbers. The references from which the databases are extracted, the weighted average values $((\eta_{\mathrm{KL3}}(T))_W$, the combined standard deviation and the average z-score were also listed.

Z, Symbol	$(\eta_{\mathrm{KL3}}(T))_{EXP-i} \pm \Delta(\eta_{\mathrm{KL3}}(T))_{EXP-i}$	References	$(\eta_{\mathrm{KL1}}(T))_W \pm \varepsilon$	z_i	$\bar{z}$
Z=55, Cs	0.545 ± 0.02	(Ertuğrul, 2002d)	0.545 ± 0.020	0	0
Z=56, Ba	0.527 ± 0.02	(Ertuğrul, 2002d)	0.527 ± 0.020	0	0
Z=57, La	0.540 ± 0.02	(Ertuğrul, 2002d)	0.54 ± 0.020	0	0
Z=58, Ce	0.532 ± 0.02	(Ertuğrul, 2003)	0.532 ± 0.020	0	0
Z=59, Pr	0.534 ± 0.02	(Ertuğrul, 2003)	0.534 ± 0.020	0	0
Z=60, Nd	0.535 ± 0.02	(Ertuğrul, 2003)	0.535 ± 0.02	0	0
Z=62, Sm	0.536 ± 0.02 0.527±0.035	(Ertuğrul, 2002c) (Han *et al*., 2007)	0.5338 ± 0.0174	0.08 -0.17	-0.05
Z=63, Eu	0.524±0.035	(Han *et al*., 2007)	0.524 ± 0.035	0	0
Z=64, Gd	0.522±0.035	(Han *et al*., 2007)	0.522 ± 0.035	0	0
Z=65, Tb	0.537 ± 0.02	(Ertuğrul, 2002c)	0.537 ± 0.02	0	0
Z=66, Dy	0.518±0.036	(Han *et al*., 2007)	0.518 ± 0.036	0	0
Z=67, Ho	0.539 ± 0.02 0.516±0.036	(Ertuğrul, 2002b) (Han *et al*., 2007)	0.5336 ± 0.0175	0.20 -0.44	-0.12
Z=68, Er	0.484 ± 0.02 0.513±0.037	(Ertuğrul, 2002b) (Han *et al*., 2007)	0.4906 ± 0.0176	-0.25 0.55	0.15

Table 10. Summary of the experimental $\eta_{\mathrm{KM}}(R)$ radiative vacancy transfer probabilities from $_{24}$Cr to $_{92}$U according to their target atomic numbers. The references from which the databases are extracted, the weighted average values $((\eta_{\mathrm{KM}}(R))_{W}$, the combined standard deviation and the average z-score were also listed.

Z, Symbol	$(\eta_{\mathrm{KM}}(R))_{EXP-i}$ $\pm\ \Delta(\eta_{\mathrm{KM}}(R))_{EXP-i}$	References	$(\eta_{\mathrm{KM}}(R))_{W} \pm \varepsilon$	z_i	$\bar{z}$
Z=24, Cr	0.021 ± 0.0005	(Söğüt, 2006)	0.021 ± 0.0005	0	0
Z=28, Ni	0.026 ± 0.0006	(Söğüt, 2006)	0.026 ± 0.0006	0	0
Z=30, Zn	0.050 ± 0.001	(Ertuğrul, 2002a)	0.050 ± 0.001	0	0
Z=33, As	0.064 ± 0.002	(Ertuğrul, 2002a)	0.064 ± 0.002	0	0
Z=34, Se	0.068 ± 0.004	(Ertuğrul, 2002a)	0.068 ± 0.004	0	0
Z=37, Rb	0.082 ± 0.004	(Ertuğrul, 2002a)	0.082 ± 0.004	0	0
Z=38, Sr	0.087 ± 0.003	(Ertuğrul, 2002a)	0.087 ± 0.003	0	0
Z=39, Y	0.091 ± 0.004	(Ertuğrul, 2002a)	0.091 ± 0.004	0	0
Z=40, Zr	0.094 ± 0.002	(Ertuğrul, 2002a)	0.094 ± 0.002	0	0
Z=41, Nb	0.098 ± 0.005	(Çalilşkan *et al*., 2002)	0.098 ± 0.005	0	0
Z=42, Mo	0.100 ± 0.004	(Çalilşkan *et al*., 2002)	0.100 ± 0.004	0	0
Z=46, Pd	0.115 ± 0.005	(Çalilşkan *et al*., 2002)	0.115 ± 0.005	0	0
Z=47, Ag	0.115 ± 0.004	(Çalilşkan *et al*., 2002)	0.115 ± 0.004	0	0
Z=48, Cd	0.117 ± 0.007	(Çalilşkan *et al*., 2002)	0.117 ± 0.007	0	0
Z=49, In	0.119 ± 0.005	(Çalilşkan *et al*., 2002)	0.119 ± 0.005	0	0
Z=50, Sn	0.124 ± 0.007	(Çalilşkan *et al*., 2002)	0.124 ± 0.007	0	0
Z=51, Sb	0.123 ± 0.003	(Çalilşkan *et al*., 2002)	0.123 ± 0.003	0	0
Z=52, Te	0.128 ± 0.006	(Çalilşkan *et al*., 2002)	0.128 ± 0.006	0	0
Z=53, I	0.128 ± 0.005	(Çalilşkan *et al*., 2002)	0.128 ± 0.005	0	0
Z=55, Cs	0.136 ± 0.011 0.131 ± 0.007	(Durak and Özdemir, 2000) (Çalilşkan *et al*., 2002)	0.1324 ± 0.006	0.29 -0.16	0.06
Z=56, Ba	0.133 ± 0.003 0.152 ± 0.003 0.152 ± 0.003	(Çalilşkan *et al*., 2002) (Sreevidya *et al*., 2014) (Sreevidya *et al*., 2014)	0.1457 ± 0.0173	-0.37 0.18 0.18	-0.01
Z=57, La	0.134 ± 0.004 0.1426±0.0133	(Çalilşkan *et al*., 2002) (Akman, 2016a)	0.1347 ± 0.0038	-0.13 0.57	0.22
Z=58, Ce	0.137 ± 0.008 0.1433±0.0108	(Çalilşkan *et al*., 2002) (Akman 2016a)	0.1392 ± 0.0064	-0.22 0.32	0.05
Z=59, Pr	0.141 ± 0.012 0.138 ± 0.006 0.1323±0.0105	(Durak and Özdemir, 2000) (Çalilşkan *et al*., 2002) (Akman, 2016a)	0.1373 ± 0.0048	0.29 0.09 -0.43	-0.02
Z=60, Nd	0.142 ± 0.011 0.143 ± 0.010 0.138 ± 0.004 0.145 ± 0.011 0.149 ± 0.012 0.149 ± 0.012 0.1377±0.0134	(Durak and Özdemir, 1998) (Durak and Özdemir, 2000) (Çalilşkan *et al*., 2002) (Demir and Şahin, 2007) (Demir and Şahin, 2007) (Demir and Şahin, 2007) (Akman, 2016a)	0.1407 ± 0.003	0.11 0.22 -0.54 0.38 0.67 0.67 -0.22	0.19
Z=62, Sm	0.144 ± 0.011 0.145 ± 0.013 0.143 ± 0.007 0.1457±0.0133	(Durak and Özdemir, 1998) (Durak and Özdemir, 2000) (Çalilşkan *et al*., 2002) (Akman, 2016a)	0.1439 ± 0.005	0.01 0.08 -0.1 0.13	0.03
Z=63, Eu	0.144 ± 0.012 0.146 ± 0.012 0.149 ± 0.010 0.149 ± 0.010 0.1507±0.0140	(Durak and Özdemir, 1998) (Demir and Şahin, 2007) (Demir and Şahin, 2007) (Demir and Şahin, 2007) (Akman, 2016a)	0.1478 ± 0.0051	-0.29 -0.14 0.11 0.11 0.19	0

Z=64, Gd	0.146 ± 0.012 0.148 ± 0.011 0.145 ± 0.005 0.151 ± 0.010 0.155 ± 0.012 0.155 ± 0.012 0.1449±0.0146	(Durak and Özdemir, 1998) (Durak and Özdemir, 2000) (Çalilşkan *et al*., 2002) (Demir and Şahin, 2007) (Demir and Şahin, 2007) (Demir and Şahin, 2007) (Akman, 2016a)	0.1478 ± 0.0035	-0.14 0.02 -0.45 0.31 0.58 0.58 -0.19	0.10
Z=65, Tb	0.149 ± 0.013 0.140 ± 0.008 0.1524±0.0148	(Durak and Özdemir, 2000) (Çalilşkan *et al*., 2002) (Akman 2016a)	0.1442 ± 0.0062	0.33 -0.42 0.51	0.14
Z=66, Dy	0.148 ± 0.010 0.149 ± 0.012 0.145 ± 0.005 0.162 ± 0.013 0.166 ± 0.011 0.166 ± 0.011 0.1501±0.0165	(Durak and Özdemir, 1998) (Durak and Özdemir, 2000) (Çalilşkan *et al*., 2002) (Demir and Şahin, 2007) (Demir and Şahin, 2007) (Demir and Şahin, 2007) (Akman, 2016a)	0.1513 ± 0.0035	-0.31 -0.19 -1.04 0.79 1.27 1.27 -0.07	0.25
Z=67, Ho	0.150 ± 0.009 0.150 ± 0.010 0.146 ± 0.007 0.155 ± 0.012 0.156 ± 0.010 0.156 ± 0.010	(Durak and Özdemir, 1998) (Durak and Özdemir, 2000) (Çalilşkan *et al*., 2002) (Demir and Şahin, 2007) (Demir and Şahin, 2007) (Demir and Şahin, 2007)	0.1511 ± 0.0038	-0.11 -0.1 -0.63 0.31 0.46 0.46	0.07
Z=68, Er	0.151 ± 0.009 0.151 ± 0.012 0.148 ± 0.004 0.1609±0.0174	(Durak and Özdemir, 1998) (Durak and Özdemir, 2000) (Çalilşkan *et al*., 2002) (Akman, 2016a)	0.1492 ± 0.0034	0.19 0.15 -0.22 0.66	0.19
Z=69, Tm	0.154 ± 0.011	(Ertuğrul *et al*., 1997b)	0.154 ± 0.011	0	0
Z=70, Yb	0.156 ± 0.011 0.153 ± 0.010	(Ertuğrul *et al*., 1997b) (Durak and Özdemir, 1998)	0.1544 ± 0.0074	0.12 -0.11	0.01
Z=71, Lu	0.156 ± 0.011	(Ertuğrul *et al*., 1997b)	0.156 ± 0.011	0	0
Z=73, Ta	0.155 ± 0.010 0.156 ± 0.011	(Ertuğrul *et al*., 1997b) (Durak and Y. Özdemir 1998)	0.1555 ± 0.008	-0.04 0.04	0
Z=74, W	0.157 ± 0.012 0.157 ± 0.013	(Ertuğrul *et al*., 1997b) (Durak and Özdemir, 1998)	0.157 ± 0.0088	0 0	0
Z=75, Re	0.157 ± 0.010	(Ertuğrul *et al*., 1997b)	0.157 ± 0.010	0	0
Z=78, Pt	0.160 ± 0.001 0.161 ± 0.011 0.161 ± 0.011	(Anand *et al*., 2014) (Anand *et al*., 2014) (Anand *et al*., 2014)	0.160 ± 0.001	-0.01 0.09 0.09	0.06
Z=79, Au	0.160 ± 0.012 0.162 ± 0.004 0.163 ± 0.023 0.163 ± 0.023	(Ertuğrul *et al*., 1997b) (Anand *et al*., 2014) (Anand *et al*., 2014) (Anand *et al*., 2014)	0.1619 ± 0.0037	-0.15 0.03 0.05 0.05	-0.01
Z=80, Hg	0.160 ± 0.009 0.161 ± 0.013	(Ertuğrul *et al*., 1997b) (Durak and Özdemir, 1998)	0.1603 ± 0.0074	-0.03 0.05	0.01
Z=81, Tl	0.161 ± 0.014 0.166 ± 0.005 0.167 ± 0.005	(Ertuğrul *et al*., 1997b) (Sreevidya *et al*., 2014) (Sreevidya *et al*., 2014)	0.1662 ± 0.00343	-0.36 -0.03 0.14	-0.08
Z=82, Pb	0.162 ± 0.014 0.163 ± 0.009 0.171 ± 0.001 0.173 ± 0.013 0.172 ± 0.013	(Ertuğrul *et al*., 1997b) (Durak and Özdemir, 1998) (Anand *et al*., 2014) (Anand *et al*., 2014) (Anand *et al*., 2014)	0.1709 ± 0.001	-0.63 -0.87 0.09 0.16 0.09	-0.23
Z=83, Bi	0.162 ± 0.012	(Ertuğrul *et al*., 1997b)	0.162 ± 0.012	0	0
Z=90, Th	0.163 ± 0.012	(Ertuğrul *et al*., 1997b)	0.163 ± 0.012	0	0
Z=92, U	0.166 ± 0.013	(Ertuğrul *et al*., 1997b)	0.166 ± 0.013	0	0

Table 11. Summary of the experimental $\eta_{\mathrm{KM2}}(R)$, $\eta_{\mathrm{KM3}}(R)$, $\eta_{\mathrm{L1M}}(R)$, $\eta_{\mathrm{L2M}}(R)$, $\eta_{\mathrm{L1N}}(R)$, and $\eta_{\mathrm{L2N}}(R)$ radiative vacancy transfer probabilities according to their target atomic numbers and the references from which the databases are extracted.

Z, Symbol	$(\eta_{\mathrm{KM2}}(R))_{EXP} \pm \Delta(\eta_{\mathrm{KM2}}(R))_{EXP}$	$(\eta_{\mathrm{KM3}}(R))_{EXP} \pm \Delta(\eta_{\mathrm{KM3}}(R))_{EXP}$	$(\eta_{\mathrm{L1M}}(R))_{EXP} \pm \Delta(\eta_{\mathrm{L1M}}(R))_{EXP}$	$(\eta_{\mathrm{L2M}}(R))_{EXP} \pm \Delta(\eta_{\mathrm{L2M}}(R))_{EXP}$	$(\eta_{\mathrm{L1N}}(R))_{EXP} \pm \Delta(\eta_{\mathrm{L1N}}(R))_{EXP}$	$(\eta_{\mathrm{L2N}}(R))_{EXP} \pm \Delta(\eta_{\mathrm{L2N}}(R))_{EXP}$
	(Turhan *et al.*, 2017)	(Turhan *et al.*, 2017)	(Sharma *et al.*, 2005)	(Sharma *et al.*, 2005)	(Sharma *et al.*, 2005)	(Sharma *et al.*, 2005)
Z=23, V	0.0091±0.0008	0.0179±0.0016	–	–	–	–
Z=27, Co	0.0149±0.0012	0.0293±0.0024	–	–	–	–
Z=30, Zn	0.0176±0.0014	0.0344±0.0028	–	–	–	–
Z=34, Se	0.0237±0.0019	0.0464±0.0038	–	–	–	–
Z=40, Zr	0.0330±0.0026	0.0644±00051	–	–	–	–
Z=42, Mo	0.0358±0.0028	0.0696±0.0055	–	–	–	–
Z=48, Cd	0.0424±0.0036	0.0824±0.0070	–	–	–	–
Z=68, Er	0.0512±0.0049	0.0990±0.0094	–	–	–	–
Z=77, Ir	–	–	0.086	0.288	0.025	0.057
Z=78, Pt	–	–	0.086	0.290	0.024	0.062
Z=79, Au	–	–	0.076	0.288	0.021	0.057
Z=80, Hg	–	–	0.078	0.293	0.020	0.066
Z=81, Tl	–	–	0.086	0.291	0.022	0.066
Z=82, Pb	–	–	0.088	0.312	0.023	0.069
Z=83, Bi	–	–	0.088	0.324	0.024	0.071
Z=90, Th	–	–	0.119	0.365	0.027	0.093
Z=92, U	–	–	0.143	0.367	0.032	0.098

Table 12. Summary of the experimental $\eta_{\mathrm{L3M}}(R)$ radiative vacancy transfer probabilities from $_{64}$Gd to $_{92}$U according to their target atomic numbers. The references from which the databases are extracted, the weighted average values $((\eta_{\mathrm{L3M}}(R))_W$, the combined standard deviation and the average z-score were also listed.

Z, Symbol	$(\eta_{\mathrm{L3M}}(R))_{EXP-i} \pm \Delta(\eta_{\mathrm{L3M}}(R))_{EXP-i}$	References	$(\eta_{\mathrm{L3M}}(R))_W \pm \varepsilon$	z_i	$\bar{z}$
Z=64, Gd	0.087 ± 0.001	(Krishnananda, *et al*., 2016)	0.087 ± 0.001	0	0
Z=65, Tb	0.092 ± 0.001	(Krishnananda, *et al*., 2016)	0.092 ± 0.001	0	0
Z=67, Ho	0.097 ± 0.002	(Krishnananda, *et al*., 2016)	0.097 ± 0.002	0	0
Z=72, Hf	0.208 ± 0.012	(Tuzluca *et al*., 2008)	0.208 ± 0.012	0	0
Z=73, Ta	0.219 ± 0.013	(Tuzluca *et al*., 2008)	0.219 ± 0.013	0	0
Z=74, W	0.219 ± 0.002 0.243 ± 0.015	(Bonzi, 2006) (Tuzluca *et al*., 2008)	0.2194 ± 0.002	-0.15 1.56	0.70
Z=75, Re	0.226 ± 0.002 0.219 ± 0.013	(Bonzi, 2006) (Tuzluca *et al*., 2008)	0.2259 ± 0.002	0.06 -0.52	-0.23
Z=77, Ir	0.248 ± 0.017	(Sharma *et al*., 2005)	0.248 ± 0.017	0	0
Z=78, Pt	0.242 ± 0.017 0.255 ± 0.015	(Sharma *et al*., 2005) (Tuzluca *et al*., 2008)	0.2493 ± 0.0113	-0.36 0.3	-0.03
Z=79, Au	0.250 ± 0.017 0.271 ± 0.016	(Sharma *et al*., 2005) (Tuzluca *et al*., 2008)	0.2611 ± 0.0117	-0.54 0.5	-0.02
Z=80, Hg	0.262 ± 0.018 0.222 ± 0.013	(Sharma *et al*., 2005) (Tuzluca *et al*., 2008)	0.2357 ± 0.0105	1.26 -0.82	0.22
Z=81, Tl	0.256 ± 0.017 0.262 ± 0.016	(Sharma *et al*., 2005) (Tuzluca *et al*., 2008)	0.25918 ± 0.0117	-0.15 0.14	-0.01
Z=82, Pb	0.303 ± 0.029 0.270 ± 0.018 0.283 ± 0.004 0.289 ± 0.017	(Şimşek, 2002) (Sharma *et al*., 2005) (Bonzi, 2006) (Tuzluca *et al*., 2008)	0.2835 ± 0.00377	0.68 -0.71 -0.01 0.34	0.08
Z=83, Bi	0.284 ± 0.019 0.284 ± 0.017	(Sharma *et al*., 2005) (Tuzluca *et al*., 2008)	0.284 ± 0.0127	0 0	0
Z=90, Th	0.316 ± 0.026 0.346 ± 0.024 0.396 ± 0.024	(Şimşek, 2002) (Sharma *et al*., 2005) (Tuzluca *et al*., 2008)	0.3546± 0.0142	-1.3 -0.31 1.49	-0.04
Z=92, U	0.330 ± 0.025 0.363 ± 0.025 0.438 ± 0.026	(Şimşek, 2002) (Sharma *et al*., 2005) (Tuzluca *et al*., 2008)	0.3754 ± 0.0146	-1.57 -0.43 2.10	0.03

Table 13. Summary of the experimental $\eta_{L3M1}(R)$ radiative vacancy transfer probabilities from $_{62}$Sm to $_{92}$U according to their target atomic numbers. The references from which the databases are extracted, the weighted average values $((\eta_{L3M1}(R))_W$, the combined standard

Z, Symbol	$(\eta_{L3M1}(R))_{EXP-i} \pm \Delta(\eta_{L3M1}(R))_{EXP-i}$	References	$(\eta_{L3M1}(R))_W \pm \varepsilon$	z_i	$\bar{z}$
Z=62, Sm	0.00457 ± 0.0003	(Durdu, 2018)	0.00457 ± 0.0003	0	0
Z=63, Eu	0.00491 ± 0.0003	(Durdu, 2018)	0.00491 ± 0.0003	0	0
Z=72, Hf	0.009 ± 0.001	(Tuzluca *et al*., 2008)	0.009 ± 0.001	0	0
Z=73, Ta	0.008 ± 0.001 0.009 ± 0.001	(Dogan and Ertuğrul, 2004) (Tuzluca *et al*., 2008)	0.0085 ± 0.0007	-0.41 0.41	0
Z=74, W	0.0096±0.001 0.009 ± 0.001 0.0126 ± 0.0006	(Dogan and Ertuğrul, 2004) (Tuzluca *et al*., 2008) (Cengiz *et al*., 2010b)	0.0112 ± 0.0005	-1.47 -2.02 1.83	-0.55
Z=75, Re	0.010 ± 0.001 0.009 ± 0.001 0.0114 ± 0.0006	(Dogan and Ertuğrul, 2004) (Tuzluca *et al*., 2008) (Cengiz *et al*., 2010b)	0.0110 ± 0.0005	-0.55 -1.46 1.054	-0.32
Z=76, Os	0.0112 ± 0.0006	(Cengiz *et al*., 2010b)	0.0112 ± 0.0006	0	0
Z=78, Pt	0.010 ± 0.001 0.0135 ± 0.0007	(Tuzluca *et al*., 2008) (Cengiz *et al*., 2010b)	0.0124 ± 0.0006	-2.04 1.27	-0.38
Z=79, Au	0.012 ± 0.001 0.012 ± 0.001	(Dogan and Ertuğrul, 2004) (Tuzluca *et al*., 2008)	0.012 ± 0.0007	0 0	0
Z=80, Hg	0.013 ± 0.001 0.012 ± 0.001	(Dogan and Ertuğrul, 2004) (Tuzluca *et al*., 2008)	0.0125 ± 0.0007	0.41 -0.41	0
Z=81, Tl	0.014 ± 0.001 0.012 ± 0.001	(Dogan and Ertugrul 2004) (Tuzluca *et al*., 2008)	0.013 ± 0.0007	0.82 -0.82	0
Z=82, Pb	0.015 ± 0.001 0.012 ± 0.001 0.014 ± 0.001	(Dogan and Ertuğrul, 2004) (Tuzluca *et al*., 2008) (Hiremath *et al*., 2019)	0.0137 ± 0.0006	1.15 -1.44 0.28	0
Z=83, Bi	0.015 ± 0.001 0.013 ± 0.001 0.010 ± 0.001	(Dogan and Ertuğrul, 2004) (Tuzluca *et al*., 2008) (Hiremath *et al*., 2019)	0.0127 ± 0.0057	2.02 0.29 -2.31	0
Z=90, Th	0.020 ± 0.002 0.022 ± 0.001	(Dogan and Ertuğrul, 2004) (Tuzluca *et al*., 2008)	0.0216 ± 0.0009	-0.73 0.30	-0.22
Z=92, U	0.022 ± 0.002 0.026 ± 0.002	(Dogan and Ertuğrul, 2004) (Tuzluca *et al*., 2008)	0.024 ± 0.0014	-0.8165 0.8165	0

deviation and the average z-score were also listed.

Table 14. Summary of the experimental $\eta_{L3M4}(R)$ radiative vacancy transfer probabilities from $_{62}$Sm to $_{92}$U according to their target atomic numbers. The references from which the databases are extracted, the weighted average values $((\eta_{L3M4}(R))_W$, the combined standard deviation and the average z-score were also listed.

Z, Symbol	$(\eta_{L3M4}(R))_{EXP-i} \pm \Delta(\eta_{L3M4}(R))_{EXP-i}$	References	$(\eta_{L3M4}(R))_W \pm \varepsilon$	z_i	$\bar{z}$
Z=62, Sm	0.0112 ± 0.0007	(Durdu, 2018)	0.0112 ± 0.0007	0	0
Z=63, Eu	0.0122 ± 0.0007	(Durdu, 2018)	0.0122 ± 0.0007	0	0
Z=72, Hf	0.020 ± 0.001	(Tuzluca *et al*., 2008)	0.020 ± 0.001	0	0
Z=73, Ta	0.020 ± 0.018 0.021 ± 0.001	(Dogan and Ertuğrul, 2004) (Tuzluca *et al*., 2008)	0.0208 ± 0.0009	-0.38 0.18	-0.10
Z=74, W	0.021 ± 0.020 0.024 ± 0.001 0.021 ± 0.001	(Dogan and Ertuğrul, 2004) (Tuzluca *et al*., 2008) (Cengiz *et al*., 2010b)	0.0223 ± 0.0007	-0.63 1.39 -1.11	-0.12
Z=75, Re	0.022 ± 0.020 0.021 ± 0.001 0.020 ± 0.001	(Dogan and Ertuğrul, 2004) (Tuzluca *et al*., 2008) (Cengiz *et al*., 2010b)	0.0207 ± 0.0007	0.63 0.28 -0.55	0.12
Z=76, Os	0.021 ± 0.001	(Cengiz et al., 2010b)	0.021 ± 0.001	0	0
Z=78, Pt	0.025 ± 0.001 0.018 ± 0.001	(Tuzluca *et al*., 2008) (Cengiz *et al*., 2010b)	0.0215 ± 0.0007	2.86 -2.86	0
Z=79, Au	0.025 ± 0.002 0.026 ± 0.002	(Dogan and Ertuğrul, 2004) (Tuzluca *et al*., 2008)	0.0255 ± 0.0014	-0.20 0.20	0
Z=80, Hg	0.026 ± 0.002 0.021 ± 0.001	(Dogan and Ertuğrul, 2004) (Tuzluca *et al*., 2008)	0.022 ± 0.0009	1.83 -0.75	0.54
Z=81, Tl	0.027 ± 0.002 0.025 ± 0.002	(Dogan and Ertugrul 2004) (Tuzluca *et al*., 2008)	0.026 ± 0.0014	0.41 -0.41	0
Z=82, Pb	0.029 ± 0.003 0.028 ± 0.002 0.028 ± 0.001	(Dogan and Ertuğrul, 2004) (Tuzluca *et al*., 2008) (Hiremath *et al*., 2019)	0.0281 ± 0.0009	0.29 -0.04 -0.06	0.06
Z=83, Bi	0.029 ± 0.003 0.028 ± 0.002 0.020 ± 0.001	(Dogan and Ertuğrul, 2004) (Tuzluca *et al*., 2008) (Hiremath *et al*., 2019)	0.0222 ± 0.0009	2.18 2.66 -1.67	1.06
Z=90, Th	0.035 ± 0.003 0.038 ± 0.002	(Dogan and Ertuğrul, 2004) (Tuzluca *et al*., 2008)	0.0371 ± 0.0017	-0.61 0.35	-0.13
Z=92, U	0.037 ± 0.003 0.042 ± 0.003	(Dogan and Ertuğrul, 2004) (Tuzluca *et al*., 2008)	0.0395 ± 0.0021	-0.68 0.68	0

Table 15. Summary of the experimental $\eta_{L3M5}(R)$ radiative vacancy transfer probabilities from $_{62}$Sm to $_{92}$U according to their target atomic numbers. The references from which the databases are extracted, the weighted average values $((\eta_{L3M5}(R))_W$, the combined standard deviation and the average z-score were also listed.

Z, Symbol	$(\eta_{L3M5}(R))_{EXP-i} \pm \Delta(\eta_{L3M5}(R))_{EXP-i}$	References	$(\eta_{L3M5}(R))_W \pm \varepsilon$	z_i	$\bar{z}$
Z=62, Sm	0.0995±0.006	(Durdu, 2018)	0.0995±0.006	0	0
Z=63, Eu	0.1065±0.007	(Durdu, 2018)	0.1065±0.007	0	0
Z=72, Hf	0.179 ± 0.011	(Tuzluca *et al.*, 2008)	0.179 ± 0.011	0	0
Z=73, Ta	0.176 ± 0.012 0.188 ± 0.011	(Dogan and Ertuğrul, 2004) (Tuzluca *et al.*, 2008)	0.1825 ± 0.0081	-0.450 0.40	-0.03
Z=74, W	0.184 ± 0.015 0.210 ± 0.013 0.187 ± 0.010	(Dogan and Ertuğrul, 2004) (Tuzluca *et al.*, 2008) (Cengiz *et al.*, 2010b)	0.1930 ± 0.0070	-0.55 1.15 -0.49	0.04
Z=75, Re	0.192 ± 0.016 0.188 ± 0.011 0.180 ± 0.009	(Dogan and Ertuğrul, 2004) (Tuzluca *et al.*, 2008) (Cengiz *et al.*, 2010b)	0.1846 ± 0.0064	0.43 0.27 -0.42	0.09
Z=76, Os	0.184 ± 0.009	(Cengiz *et al.*, 2010b)	0.184 ± 0.009	0	0
Z=78, Pt	0.220 ± 0.013 0.158 ± 0.008	(Tuzluca *et al.*, 2008) (Cengiz *et al.*, 2010b)	0.1750 ± 0.0068	3.06 -1.62	0.72
Z=79, Au	0.226 ± 0.020 0.233 ± 0.014	(Dogan and Ertuğrul, 2004) (Tuzluca *et al.*, 2008)	0.2307 ± 0.01147	-0.20 0.13	-0.04
Z=80, Hg	0.234 ± 0.020 0.189 ± 0.011	(Dogan and Ertuğrul, 2004) (Tuzluca *et al.*, 2008)	0.1995 ± 0.0096	1.56 -0.71	0.42
Z=81, Tl	0.244 ± 0.022 0.224 ± 0.013	(Dogan and Ertugrul 2004) (Tuzluca *et al.*, 2008)	0.2292 ± 0.0112	0.60 -0.30	0.15
Z=82, Pb	0.252 ± 0.021 0.249 ± 0.015 0.248 ± 0.012	(Dogan and Ertuğrul, 2004) (Tuzluca *et al.*, 2008) (Hiremath *et al.*, 2019)	0.2490 ± 0.0086	0.13 0 -0.07	0.02
Z=83, Bi	0.260 ± 0.024 0.243 ± 0.015 0.173 ± 0.008	(Dogan and Ertuğrul, 2004) (Tuzluca *et al.*, 2008) (Hiremath *et al.*, 2019)	0.1942 ± 0.0068	2.64 2.97 -2.02	1.20
Z=90, Th	0.315 ± 0.030 0.335 ± 0.020	(Dogan and Ertuğrul, 2004) (Tuzluca *et al.*, 2008)	0.3289 ± 0.0166	-0.40 0.24	-0.08
Z=92, U	0.330 ± 0.028 0.370 ± 0.022	(Dogan and Ertuğrul, 2004) (Tuzluca *et al.*, 2008)	0.3547 ± 0.0173	-0.75 0.55	-0.10

Table 16. Summary of the experimental $\eta_{L3N}(R)$ radiative vacancy transfer probabilities from $_{72}$Hf to $_{92}$U according to their target atomic numbers. The references from which the databases are extracted, the weighted average values ($(\eta_{L3N}(R))_W$, the combined standard deviation and the average z-score were also listed.

Z, Symbol	$(\eta_{L3N}(R))_{EXP-i} \pm \Delta(\eta_{L3N}(R))_{EXP-i}$	References	$(\eta_{L3N}(R))_W \pm \varepsilon$	z_i	$\bar{z}$
Z=72, Hf	0.040 ± 0.002	(Tuzluca *et al*., 2008)	0.040 ± 0.002	0	0
Z=73, Ta	0.042 ± 0.003	(Tuzluca *et al*., 2008)	0.042 ± 0.003	0	0
Z=74, W	0.042 ± 0.002 0.048 ± 0.003	(Bonzi, 2006) (Tuzluca *et al*., 2008)	0.0439 ± 0.0017	-0.71 1.21	0.25
Z=75, Re	0.045 ± 0.002 0.052 ± 0.003	(Bonzi, 2006) (Tuzluca *et al*., 2008)	0.0472 ± 0.0017	-0.83 1.41	0.30
Z=77, Ir	0.048 ± 0.0033	(Sharma *et al*., 2005)	0.048 ± 0.0033	0	0
Z=78, Pt	0.048 ± 0.0033 0.057 ± 0.003	(Sharma *et al*., 2005) (Tuzluca *et al*., 2008)	0.0529 ± 0.0022	-1.24 1.09	-0.07
Z=79, Au	0.049 ± 0.0034 0.059 ± 0.004	(Sharma *et al*., 2005) (Tuzluca *et al*., 2008)	0.0532 ± 0.0026	-0.98 1.22	0.12
Z=80, Hg	0.051 ± 0.0035 0.047 ± 0.003	(Sharma *et al*., 2005) (Tuzluca *et al*., 2008)	0.0487 ± 0.0023	0.55 -0.45	0.05
Z=81, Tl	0.055 ± 0.0038 0.056 ± 0.003	(Sharma *et al*., 2005) (Tuzluca *et al*., 2008)	0.0556 ± 0.0024	-0.14 0.10	-0.02
Z=82, Pb	0.0498±0.0053 0.055 ± 0.0038 0.060 ± 0.004 0.062 ± 0.004	(Şimşek, 2002) (Sharma *et al*., 2005) (Bonzi, 2006) (Tuzluca *et al*., 2008)	0.0575 ± 0.0021	-1.35 -0.57 0.56 1.00	-0.09
Z=83, Bi	0.06 ± 0.0042 0.061 ± 0.004	(Sharma *et al*., 2005) (Tuzluca *et al*., 2008)	0.0605 ± 0.0029	-0.10 0.10	0
Z=90, Th	0.0653±0.0062 0.072 ± 0.0050 0.087 ± 0.005	(Şimşek, 2002) (Sharma *et al*., 2005) (Tuzluca *et al*., 2008)	0.0760 ± 0.0031	-1.55 -0.68 1.87	-0.12
Z=92, U	0.0812±0.0064 0.075 ± 0.0052	(Şimşek, 2002) (Tuzluca *et al*., 2008)	0.0775 ± 0.0040	0.49 -0.37	0.06

Table 17. Summary of the experimental $\eta_{\mathrm{L3N1}}(R)$ radiative vacancy transfer probabilities from $_{62}$Sm to $_{92}$U according to their target atomic numbers. The references from which the databases are extracted, the weighted average values $((\eta_{\mathrm{L3N1}}(R))_W$, the combined standard deviation and the average z-score were also listed.

Z, Symbol	$(\eta_{\mathrm{L3N1}}(R))_{EXP-i} \pm \Delta(\eta_{\mathrm{L3N1}}(R))_{EXP-i}$	References	$(\eta_{\mathrm{L3N1}}(R))_W \pm \varepsilon$	z_i	$\bar{z}$
Z=62, Sm	0.00104±0.00006	(Durdu, 2018)	0.00104±0.00006	0	0
Z=63, Eu	0.00115±0.00007	(Durdu, 2018)	0.00115±0.00007	0	0
Z=72, Hf	0.0021±0.0001	(Tuzluca *et al*., 2008)	0.0021±0.0001	0	0
Z=73, Ta	0.0021±0.0002 0.0023±0.0001	(Dogan and Ertuğrul, 2004) (Tuzluca *et al*., 2008)	0.0023 ± 0.0001	-0.73 0.30	-0.22
Z=74, W	0.0022±0.0002 0.0026±0.0002 0.0023±0.0001	(Dogan and Ertuğrul, 2004) (Tuzluca *et al*., 2008) (Cengiz *et al*., 2010b)	0.0023 ± 0.0001	-0.62 1.23 -0.26	0.12
Z=75, Re	0.0024±0.0002 0.0024±0.0001 0.0023±0.0001	(Dogan and Ertuğrul, 2004) (Tuzluca *et al*., 2008) (Cengiz *et al*., 2010b)	0.0024 ± 0.0007	0.21 0.37 -0.46	0.04
Z=76, Os	0.0023±0.0001	(Cengiz et al., 2010b)	0.0023±0.0001	0	0
Z=78, Pt	0.0030±0.0002 0.0027±0.0001	(Tuzluca *et al*., 2008) (Cengiz *et al*., 2010b)	0.0028 ± 0.0001	1.10 -0.45	0.32
Z=79, Au	0.0030±0.0003 0.0032±0.0002	(Dogan and Ertuğrul, 2004) (Tuzluca *et al*., 2008)	0.0031 ± 0.0002	-0.40 0.24	-0.08
Z=80, Hg	0.0033±0.0003 0.0026±0.0002	(Dogan and Ertuğrul, 2004) (Tuzluca *et al*., 2008)	0.0028 ± 0.0002	1.41 -0.83	0.29
Z=81, Tl	0.0034±0.0003 0.0032±0.0002	(Dogan and Ertugrul 2004) (Tuzluca *et al*., 2008)	0.0033 ± 0.0002	0.40 -0.24	0.08
Z=82, Pb	0.0036±0.0003 0.0036±0.0002 0.0036±0.0003	(Dogan and Ertuğrul, 2004) (Tuzluca *et al*., 2008) (Hiremath *et al*., 2019)	0.0036 ± 0.0001	0 0 0	0
Z=83, Bi	0.0037±0.0003 0.0036±0.0002 0.0026±0.0002	(Dogan and Ertuğrul, 2004) (Tuzluca *et al*., 2008) (Hiremath *et al*., 2019)	0.00321 ± 0.0001	1.51 1.65 -2.57	0.20
Z=90, Th	0.0050±0.0004 0.0057±0.0003	(Dogan and Ertuğrul, 2004) (Tuzluca *et al*., 2008)	0.0055 ± 0.0002	-0.96 0.66	-0.15
Z=92, U	0.0058±0.0004 0.0065±0.0004	(Dogan and Ertuğrul, 2004) (Tuzluca *et al*., 2008)	0.0062 ± 0.0003	-0.71 0.71	0

Table 18. Summary of the experimental $\eta_{\mathrm{L3N4}}(R)$ radiative vacancy transfer probabilities from $_{62}$Sm to $_{92}$U according to their target atomic numbers. The references from which the databases are extracted, the weighted average values $((\eta_{\mathrm{L3N4}}(R))_W$, the combined standard deviation and the average z-score were also listed.

Z, Symbol	$(\eta_{\mathrm{L3N4}}(R))_{EXP-i} \pm \Delta(\eta_{\mathrm{L3N4}}(R))_{EXP-i}$	References	$(\eta_{\mathrm{L3N4}}(R))_W \pm \varepsilon$	z_i	$\bar{z}$
Z=62, Sm	0.00185 ± 0.0001	(Durdu, 2018)	0.00185 ± 0.0001	0	0
Z=63, Eu	0.00203 ± 0.0001	(Durdu, 2018)	0.00203 ± 0.0001	0	0
Z=72, Hf	0.0035±0.0002	(Tuzluca *et al*., 2008)	0.0035±0.0002	0	0
Z=73, Ta	0.0034±0.0003 0.0037±0.0002	(Dogan and Ertuğrul, 2004) (Tuzluca *et al*., 2008)	0.0036 ± 0.0002	-0.61 0.35	-0.13
Z=74, W	0.0035±0.0003 0.0041±0.0002 0.0037±0.0002	(Dogan and Ertuğrul, 2004) (Tuzluca *et al*., 2008) (Cengiz *et al*., 2010b)	0.0038 ± 0.0001	-1.00 1.15 -0.54	-0.13
Z=75, Re	0.0037±0.0003 0.0038±0.0002 0.0036±0.0002	(Dogan and Ertuğrul, 2004) (Tuzluca *et al*., 2008) (Cengiz *et al*., 2010b)	0.0037 ± 0.0001	0 0.42 -0.42	0
Z=76, Os	0.0037±0.0002	(Cengiz *et al*., 2010b)	0.0037±0.0002	0	0
Z=78, Pt	0.0045±0.0003 0.0041±0.0002	(Tuzluca *et al*., 2008) (Cengiz *et al*., 2010b)	0.0042 ± 0.0002	0.81 -0.47	0.17
Z=79, Au	0.0046±0.0004 0.0048±0.0003	(Dogan and Ertuğrul, 2004) (Tuzluca *et al*., 2008)	0.0047 ± 0.0002	-0.27 0.19	-0.04
Z=80, Hg	0.0049±0.0004 0.0040±0.0002	(Dogan and Ertuğrul, 2004) (Tuzluca *et al*., 2008)	0.0042 ± 0.0002	1.64 -0.67	0.49
Z=81, Tl	0.0052±0.0005 0.0047±0.0003	(Dogan and Ertugrul 2004) (Tuzluca *et al*., 2008)	0.0048 ± 0.0003	0.65 -0.33	0.16
Z=82, Pb	0.0054±0.0005 0.0053±0.0003 0.0055±0.0004	(Dogan and Ertuğrul, 2004) (Tuzluca *et al*., 2008) (Hiremath *et al*., 2019)	0.0054 ± 0.0002	0.04 -0.21 0.27	0.03
Z=83, Bi	0.0055±0.0005 0.0052±0.0003 0.0039±0.0003	(Dogan and Ertuğrul, 2004) (Tuzluca *et al*., 2008) (Hiremath *et al*., 2019)	0.0047 ± 0.0002	1.50 1.41 -2.22	0.23
Z=90, Th	0.0069±0.0005 0.0076±0.0005	(Dogan and Ertuğrul, 2004) (Tuzluca *et al*., 2008)	0.0073 ± 0.0004	-0.57 0.57	0
Z=92, U	0.0073±0.0006 0.0085±0.0005	(Dogan and Ertuğrul, 2004) (Tuzluca et al., 2008)	0.0080 ± 0.0004	-0.99 0.78	-0.10

Table 19. Summary of the experimental $\eta_{L3N5}(R)$ radiative vacancy transfer probabilities from $_{62}$Sm to $_{92}$U according to their target atomic numbers. The references from which the databases are extracted, the weighted average values $((\eta_{L3N5}(R))_W$, the combined standard deviation and the average z-score were also listed.

Z, Symbol	$(\eta_{L3N5}(R))_{EXP-i} \pm \Delta(\eta_{L3N5}(R))_{EXP-i}$	References	$(\eta_{L3N5}(R))_W \pm \varepsilon$	z_i	$\bar{z}$
Z=62, Sm	0.0165±0.001	(Durdu, 2018)	0.0165±0.001	0	0
Z=63, Eu	0.0182±0.001	(Durdu, 2018)	0.0182±0.001	0	0
Z=72, Hf	0.0310 ± 0.0019	(Tuzluca *et al*., 2008)	0.0310 ± 0.0019	0	0
Z=73, Ta	0.032 ± 0.003 0.0330 ± 0.0020	(Dogan and Ertuğrul, 2004) (Tuzluca *et al*., 2008)	0.0327 ± 0.0017	-0.61 0.35	-0.13
Z=74, W	0.032 ± 0.003 0.0370 ± 0.0022 0.033 ± 0.002	(Dogan and Ertuğrul, 2004) (Tuzluca *et al*., 2008) (Cengiz *et al*., 2010b)	0.0343 ± 0.0013	-1.00 1.15 -0.54	-0.13
Z=75, Re	0.034 ± 0.003 0.0340 ± 0.0020 0.032 ± 0.002	(Dogan and Ertuğrul, 2004) (Tuzluca *et al*., 2008) (Cengiz *et al*., 2010b)	0.0332 ± 0.0013	0 0.42 -0.42	0
Z=76, Os	0.033 ± 0.002	(Cengiz *et al*., 2010b)	0.033 ± 0.002	0	0
Z=78, Pt	0.0410 ± 0.0024 0.037 ± 0.002	(Tuzluca *et al*., 2008) (Cengiz *et al*., 2010b)	0.0386 ± 0.0015	0.81 -0.47	0.17
Z=79, Au	0.041 ± 0.004 0.0440 ± 0.0026	(Dogan and Ertuğrul, 2004) (Tuzluca *et al*., 2008)	0.0431 ± 0.0022	-0.27 0.19	-0.04
Z=80, Hg	0.044 ± 0.004 0.0360 ± 0.0021	(Dogan and Ertuğrul, 2004) (Tuzluca *et al*., 2008)	0.0377 ± 0.0019	1.64 -0.67	0.49
Z=81, Tl	0.046 ± 0.004 0.0430 ± 0.0026	(Dogan and Ertugrul 2004) (Tuzluca *et al*., 2008)	0.0439 ± 0.0022	0.65 -0.34	0.16
Z=82, Pb	0.048 ± 0.004 0.0480 ± 0.0029 0.050 ± 0.004	(Dogan and Ertuğrul, 2004) (Tuzluca *et al*., 2008) (Hiremath *et al*., 2019)	0.0485 ± 0.0020	0.04 -0.21 0.27	0.03
Z=83, Bi	0.049 ± 0.004 0.0470 ± 0.0028 0.035 ± 0.002	(Dogan and Ertuğrul, 2004) (Tuzluca *et al*., 2008) (Hiremath *et al*., 2019)	0.0405 ± 0.0015	1.50 1.41 -2.22	0.23
Z=90, Th	0.064 ± 0.005 0.0690 ± 0.0042	(Dogan and Ertuğrul, 2004) (Tuzluca *et al*., 2008)	0.0669 ± 0.0032	-0.57 0.57	0
Z=92, U	0.070 ± 0.005 0.0780 ± 0.0047	(Dogan and Ertuğrul, 2004) (Tuzluca *et al*., 2008)	0.0743 ± 0.0034	-0.99 0.78	-0.11

Table 20. Summary of the experimental $\eta_{L3O1}(R)$ radiative vacancy transfer probabilities from $_{72}$Hf to $_{92}$U according to their target atomic numbers. The references from which the databases are extracted, the weighted average values $((\eta_{L3O1}(R))_W$, the combined standard deviation and the average z-score were also listed.

Z, Symbol	$(\eta_{L3O1}(R))_{EXP-i} \pm \Delta(\eta_{L3O1}(R))_{EXP-i}$	References	$(\eta_{L3O1}(R))_W \pm \varepsilon$	z_i	$\bar{z}$
Z=72, Hf	0.0004 ± 0.0001	(Tuzluca *et al*., 2008)	0.0004 ± 0.0001	0	0
Z=73, Ta	0.00038 ± 0.00003 0.0004 ± 0.0001	(Dogan and Ertuğrul, 2004) (Tuzluca *et al*., 2008)	0.00038 ± 0.00003	-0.04 0.18	0.07
Z=74, W	0.00038 ± 0.00003 0.0005 ± 0.0001 0.00042 ± 0.00002	(Dogan and Ertuğrul, 2004) (Tuzluca *et al*., 2008) (Cengiz *et al*., 2010b)	0.00041± 0.00001	-0.88 0.89 0.38	0.13
Z=75, Re	0.00042 ± 0.00003 0.0004 ± 0.0001 0.00044 ± 0.00002	(Dogan and Ertuğrul, 2004) (Tuzluca *et al*., 2008) (Cengiz *et al*., 2010b)	0.00043 ± 0.00001	-0.38 -0.32 0.27	-0.14
Z=76, Os	0.00043 ± 0.00002	(Cengiz *et al*., 2010b)	0.00043 ± 0.00002	0	0
Z=78, Pt	0.0006 ± 0.0001 0.00053 ± 0.00003	(Tuzluca *et al*., 2008) (Cengiz *et al*., 2010b)	0.00053 ± 0.00003	0.62 -0.14	0.24
Z=79, Au	0.00057 ± 0.00004 0.0006 ± 0.0001	(Dogan and Ertuğrul, 2004) (Tuzluca *et al*., 2008)	0.00057 ± 0.00004	-0.08 0.24	0.08
Z=80, Hg	0.00069 ± 0.00005 0.0005 ± 0.0001	(Dogan and Ertuğrul, 2004) (Tuzluca *et al*., 2008)	0.00065 ± 0.00005	0.57 -1.39	-0.41
Z=81, Tl	0.00073 ± 0.00006 0.0007 ± 0.0001	(Dogan and Ertugrul 2004) (Tuzluca *et al*., 2008)	0.00072 ± 0.00005	0.10 -0.20	-0.05
Z=82, Pb	0.00075 ± 0.00007 0.0008 ± 0.0001 0.00077 ± 0.00005	(Dogan and Ertuğrul, 2004) (Tuzluca *et al*., 2008) (Hiremath *et al*., 2019)	0.00064 ± 0.00004	1.34 1.46 -1.49	0.44
Z=83, Bi	0.00082 ± 0.00008 0.0008 ± 0.0001 0.00055 ± 0.00004	(Dogan and Ertuğrul, 2004) (Tuzluca *et al*., 2008) (Hiremath *et al*., 2019)	0.00062 ± 0.00003	2.23 1.65 -1.46	0.81
Z=90, Th	0.0012 ± 0.0001 0.0014 ± 0.0001	(Dogan and Ertuğrul, 2004) (Tuzluca *et al*., 2008)	0.0013 ± 0.00007	-0.82 0.82	0
Z=92, U	0.0015 ± 0.0001 0.0017 ± 0.0001	(Dogan and Ertuğrul, 2004) (Tuzluca *et al*., 2008)	0.0016 ± 0.00007	-0.82 0.82	0

Table 21. Summary of the experimental $\eta_{\mathrm{L3O4,5}}(R)$ radiative vacancy transfer probabilities from $_{72}$Hf to $_{92}$U according to their target atomic numbers. The references from which the databases are extracted, the weighted average values ($(\eta_{\mathrm{L3O4,5}}(R))_W$, the combined standard deviation and the average z-score were also listed.

Z, Symbol	$(\eta_{\mathrm{L3O4,5}}(R))_{EXP-i}$ $\pm\ \Delta(\eta_{\mathrm{L3O4,5}}(R))_{EXP-i}$	References	$(\eta_{\mathrm{L3O4,5}}(R))_W \pm \varepsilon$	z_i	$\bar{z}$
Z=72, Hf	0.0003 ± 0.0001	(Tuzluca *et al*., 2008)	0.0003 ± 0.0001	0	0
Z=73, Ta	0.00094 ± 0.00008 0.0006 ± 0.0001	(Dogan and Ertuğrul, 2004) (Tuzluca *et al*., 2008)	0.0008 ± 0.00006	1.31 -1.76	-0.23
Z=74, W	0.00094 ± 0.00008 0.0011 ± 0.0001 0.00097 ± 0.00005	(Dogan and Ertuğrul, 2004) (Tuzluca *et al*., 2008) (Cengiz *et al*., 2010b)	0.001 ± 0.00004	-0.48 1.09 -0.20	0.14
Z=75, Re	0.0014 ± 0.0001 0.0014 ± 0.0001 0.0017 ± 0.00009	(Dogan and Ertuğrul, 2004) (Tuzluca *et al*., 2008) (Cengiz *et al*., 2010b)	0.0015 ± 0.00006	-1.00 -1.00 1.75	-0.08
Z=76, Os	0.0013 ± 0.0001	(Cengiz et al., 2010b)	0.0013 ± 0.0001	0	0
Z=78, Pt	0.0034 ± 0.0002 0.0031 ± 0.0002	(Tuzluca *et al*., 2008) (Cengiz *et al*., 2010b)	0.0033 ± 0.0001	0.61 -0.61	0
Z=79, Au	0.0041 ± 0.0004 0.0043 ± 0.0003	(Dogan and Ertuğrul, 2004) (Tuzluca *et al*., 2008)	0.0042 ± 0.0002	-0.27 0.19	-0.04
Z=80, Hg	0.0053 ± 0.0005 0.0039 ± 0.0002	(Dogan and Ertuğrul, 2004) (Tuzluca *et al*., 2008)	0.0041 ± 0.0002	2.26 -0.71	0.78
Z=81, Tl	0.0055 ± 0.0005 0.0052 ± 0.0003	(Dogan and Ertugrul 2004) (Tuzluca *et al*., 2008)	0.0053 ± 0.0003	0.39 -0.20	0.10
Z=82, Pb	0.0061 ± 0.0006 0.0064 ± 0.0004 0.0073 ± 0.0005	(Dogan and Ertuğrul, 2004) (Tuzluca *et al*., 2008) (Hiremath *et al*., 2019)	0.0066 ± 0.0003	-0.78 -0.44 1.20	0
Z=83, Bi	0.0070 ± 0.0008 0.0068 ± 0.0004 0.0054 ± 0.0004	(Dogan and Ertuğrul, 2004) (Tuzluca *et al*., 2008) (Hiremath *et al*., 2019)	0.0062 ± 0.0003	0.95 1.25 -1.66	0.18
Z=90, Th	0.013 ± 0.001 0.0141 ± 0.0008	(Dogan and Ertuğrul, 2004) (Tuzluca *et al*., 2008)	0.0137 ± 0.0006	-0.06 0.04	-0.01
Z=92, U	0.014 ± 0.001 0.0163 ± 0.0010	(Dogan and Ertuğrul, 2004) (Tuzluca *et al*., 2008)	0.0152 ± 0.0007	-0.09 0.09	0

Table 22. Summary of fitting coefficients according to Eq. (13).

η_{XY}	Z-group	Parameters	Values
$\eta_{KL}(T)$	16 to 70	A_0	1.67627
		A_1	0.04881
		A_2	- 0.00374
		A_3	7.01012×10^{-5}
		A_4	-4.16257×10^{-7}
	71 to 92	A_0	0.62178
		A_1	0.00899
		A_2	-8.35634×10^{-6}
$\eta_{KL2}(R)$	23 to 92	A_0	- 0.40961
		A_1	0.03151
		A_2	-5.53847×10^{-4}
		A_3	4.34223×10^{-6}
		A_4	-1.24104×10^{-8}
$\eta_{KL3}(R)$	23 to 92	A_0	- 0.73121
		A_1	0.0567
		A_2	-9.62491×10^{-4}
		A_3	7.11097×10^{-6}
		A_4	-1.97484×10^{-8}
$\eta_{KM}(R)$	24 to 92	A_0	- 0.21218
		A_1	0.01293
		A_2	-1.69499×10^{-4}
		A_3	1.02306×10^{-6}
		A_4	-2.40743×10^{-9}

Table 23. Empirical (this work), theoretical, fitted and experimental (other works) of total vacancy transfer probabilities η_{KL}(T) from $_{16}$S to $_{92}$U.

Z, Symbol	This work		Other works			
			Theoretical	Fitted	Experimental	
	Empirical	ε_{RMS}(%)	(Rao *et al.*, 1972)	(Schönfeld and JanBen, 1996)		(Ertuğral *et al.*, 2006)
Z=16, S	1.7596	2.98		1.807		
Z=17, Cl	1.7348	2.43		1.751		
Z=18, Ar	1.7082			1.697		
Z=19, K	1.6801	1.78		1.697		
Z=20, Ca	1.6507	2.22	1.595	1.621		
Z=21, Sc	1.6202	2.83		1.594		
Z=22, Ti	1.5888	1.18	1.548	1.566		
Z=23, V	1.5569	1.18		1.539		1.544
Z=24, Cr	1.5244	2.64	1.495	1.508		1.509
Z=25, Mn	1.4917	2.24		1.478	1.483[a]	1.467
Z=26, Fe	1.4589	2.70	1.439	1.447	1.451[a]	1.453
Z=27, Co	1.4262	1.42		1.418	1.418[a]	1.415
Z=28, Ni	1.3938	1.73	1.375	1.388	1.388[a]	1.394
Z=29, Cu	1.3617	2.11		1.357	1.357[a]	1.361
Z=30, Zn	1.3301	1.41	1.316	1.326	1.327[a]	1.330
Z=31, Ga	1.2992	0.68		1.294	1.298[a]	
Z=32, Ge	1.2690	2.27	1.255	1.263	1.262[a]	
Z=33, As	1.2397	2.58		1.232	1.231[a]	1.238
Z=34, Se	1.2113	2.11	1.200	1.202	1.203[a]	1.204
Z=35, Br	1.1840	1.13		1.174	1.174[a]	1.200
Z=36, Kr	1.1579		1.149	1.149		
Z=37, Rb	1.1329	0.87		1.125	1.128[a]	1.123
Z=38, Sr	1.1091	10.47	1.104	1.102	1.102[a]	1.104
Z=39, Y	1.0866	3.08		1.081	1.081[a]	
Z=40, Zr	1.0655	3.40	1.064	1.062	1.061[a]	1.064
Z=41, Nb	1.0457	5.01		1.045	1.044[a]	1.042
Z=42, Mo	1.0273	4.66	1.030	1.029	1.028[a]	1.026
Z=43, Tc	1.0103			1.014		
Z=44, Ru	0.9946	11.22	1.000	1.000		
Z=45, Rh	0.9803	10.22		0.987		
Z=46, Pd	0.9673	11.75	0.963	0.975		0.990
Z=47, Ag	0.9556	2.69		0.964		0.967
Z=48, Cd	0.9451	3.85	0.952	0.953		0.962
Z=49, In	0.9359	1.45		0.944		0.950
Z=50, Sn	0.9278	1.22	0.932	0.934		0.943
Z=51, Sb	0.9208	1.32		0.925		0.924
Z=52, Te	0.9147	1.86	0.914	0.917		0.923
Z=53, I	0.9095	1.07		0.909		0.917
Z=54, Xe	0.9051		0.899	0.902		
Z=55, Cs	0.9014	1.21		0.895		
Z=56, Ba	0.8982	2.85	0.887	0.888		0.882
Z=57, La	0.8954	3.59		0.882		0.873
Z=58, Ce	0.8929	1.83	0.876	0.876	0.874[b]	
Z=59, Pr	0.8905	2.61	−	0.871	0.877[b]	
Z=60, Nd	0.8880	2.21	0.865	0.866	0.872[b]	
Z=61, Pm	0.8853	2.62	−	0.861		
Z=62, Sm	0.8822		0.857	0.857	0.862[b]	
Z=63, Eu	0.8785	2.91	−	0.853	0.853[b]	

Z=64, Gd	0.8740	3.09	0.850	0.85	0.846[b]	
Z=65, Tb	0.8685	2.42	–	0.847	0.851[b]	
Z=66, Dy	0.8617	2.37	0.843	0.843	0.852[b]	
Z=67, Ho	0.8535	2.05	–	0.841	0.841[b]	
Z=68, Er	0.8435	2.68	0.836	0.838	0.843[b]	
Z=69, Tm	0.8315	0.54	–	0.835	0.836[b]	
Z=70, Yb	0.8173	1.68	0.831	0.833	0.831[b]	
Z=71, Lu	0.8388	0.33	–	0.831	0.836[b]	
Z=72, Hf	0.8359	0.75	0.826	0.829	0.827[b]	
Z=73, Ta	0.8327	0.79	–	0.827	0.822[b]	
Z=74, W	0.8294	2.21	0.821	0.825	0.823[b]	
Z=75, Re	0.8260	4.88	–	0.823	0.824[b]	
Z=76, Os	0.8224	2.52	0.816	0.821		
Z=77, Ir	0.8186	13.96	–	0.819	0.819[b]	
Z=78, Pt	0.8146	3.54	0.813	0.818		
Z=79, Au	0.8105	1.01	–	0.816	0.820[b]	
Z=80, Hg	0.8062	1.08	0.809	0.813	0.811[b]	
Z=81, Tl	0.8017	2.22	–	0.812	0.816[b]	
Z=82, Pb	0.7971	3.40	0.806	0.811	0.809[b]	
Z=83, Bi	0.7923	15.74	–	0.809	0.803[b]	
Z=84, Po	0.7873		0.805	0.807		
Z=85, At	0.7822		–	0.805		
Z=86, Rn	0.7769		0.802	0.804		
Z=87, Fr	0.7714		–	0.803		
Z=88, Ra	0.7658		0.798	0.801		
Z=89, Ac	0.7600		–	0.799		
Z=90, Th	0.7540	9.18	0.795	0.797	0.774[b]	
Z=91, Pa	0.7479		–	0.795		
Z=92, U	0.7416	5.26	0.793	0.794	0.770[b]	

[a](Öz, 2006)
[b](Ertuğral *et al*., 2005)

Table 24. Empirical (this work), theoretical, and experimental (other works) of radiative vacancy transfer probabilities η_{KL2}(R) from $_{23}$V to $_{92}$U.

Z, Symbol	This work		Other works	
			Theoretical	Experimental
	Empirical	ε_{RMS}(%)	(Rao *et al.*, 1972)	
Z=23, V	0.0715	10.49		
Z=24, Cr	0.0835	8.98	0.083	
Z=25, Mn	**0.0950**			
Z=26, Fe	0.1059	3.4	0.103	
Z=27, Co	0.1163	5.76		
Z=28, Ni	0.1261	14.35	0.123	
Z=29, Cu	**0.1355**			
Z=30, Zn	0.1444	2.85	0.142	0.138[a]
Z=31, Ga	**0.1529**			
Z=32, Ge	**0.1608**		0.159	
Z=33, As	0.1684	2.61		0.164[a]
Z=34, Se	0.1756	1.46	0.175	
Z=35, Br	**0.1823**			
Z=36, Kr	**0.1887**		0.188	
Z=37, Rb	0.1947	0.15		0.195[a]
Z=38, Sr	0.2004	1.3	0.2	0.203[a]
Z=39, Y	0.2057	0.63		0.207[a]
Z=40, Zr	0.2108	2.75	0.211	0.211[a]
Z=41, Nb	0.2155	0.23		0.216[b]
Z=42, Mo	0.2199	3.3	0.220	0.218[b]
Z=43, Tc	**0.2241**			
Z=44, Ru	**0.2280**		0.227	
Z=45, Rh	**0.2316**			
Z=46, Pd	0.2350	1.7	0.234	0.239[b]
Z=47, Ag	0.2382	0.5		0.237[b]
Z=48, Cd	0.2411	4.41	0.240	0.239[b]
Z=49, In	0.2439	1.6		0.240[b]
Z=50, Sn	0.2465	0.61	0.245	0.248[b]
Z=51, Sb	0.2489	1.97		0.244[b]
Z=52, Te	0.2511	0.76	0.249	0.253[b]
Z=53, I	0.2532	0.87		0.251[b]
Z=54, Xe	**0.2551**		0.253	
Z=55, Cs	0.2569	1.3		0.254[b]
Z=56, Ba	0.2586	1.39	0.256	0.255[b]
Z=57, La	0.2602	2.49		0.257[b]
Z=58, Ce	0.2616	1.24	0.259	0.259[b]
Z=59, Pr	0.2630	1.18		0.261[b]
Z=60, Nd	0.2642	1.48	0.261	0.264[c]
Z=61, Pm	**0.2654**			
Z=62, Sm	0.2665	0.6	0.264	0.265[c]
Z=63, Eu	0.2676	1.97		0.266[c]
Z=64, Gd	0.2686	3.59	0.266	0.267[c]
Z=65, Tb	0.2695	3.7		
Z=66, Dy	0.2704	3.76	0.268	0.269[c]
Z=67, Ho	0.2712	2.91		0.269[c]
Z=68, Er	0.2721	2.89	0.27	0.270[c]
Z=69, Tm	0.2729	1.06		0.270[d]
Z=70, Yb	0.2737	1.05	0.272	0.272[c]

Z=71, Lu	0.2744	1.24		0.271[d]
Z=72, Hf	**0.2752**		0.274	
Z=73, Ta	0.2759	0.76		0.274[c]
Z=74, W	0.2767	0.98	0.275	0.274[c]
Z=75, Re	0.2775	0.18		0.278[d]
Z=76, Os	**0.2782**		0.277	
Z=77, Ir	**0.2790**			
Z=78, Pt	0.2798	1.18	0.278	
Z=79, Au	0.2806	1.47		0.278[d]
Z=80, Hg	0.2815	0.96	0.28	0.280[c]
Z=81, Tl	0.2823	1.13		
Z=82, Pb	0.2832	1.98	0.281	0.281[c]
Z=83, Bi	0.2841	1.44		0.280[d]
Z=84, Po	**0.2851**		0.284	
Z=85, At	**0.2860**			
Z=86, Rn	**0.2870**		0.285	
Z=87, Fr	**0.2881**			
Z=88, Ra	**0.2891**		0.286	
Z=89, Ac	**0.2902**			
Z=90, Th	0.2914	0.48	0.288	0.290[d]
Z=91, Pa	**0.2925**			
Z=92, U	0.2937	0.92	0.289	0.291[d]

[a](Ertuğrul, 2002a)
[b](Çalilskan *et al*., 2002)
[c](Durak and Özdemir, 1998)
[d](Ertuğrul *et al*., 1997b)

Table 25. Empirical (this work), theoretical, and experimental (other works) of radiative vacancy transfer probabilities η_{KL3}(R) from ${}_{23}$V to ${}_{92}$U.

Z, Symbol	This work		Other works	
			Theoretical	Experimental
	Empirical	ε_{RMS}(%)	(Rao *et al.*, 1972)	
Z=23, V	0.1447	6.43		
Z=24, Cr	0.1669	7.25	0.165	
Z=25, Mn	**0.1881**			
Z=26, Fe	0.2083	3.89	0.203	
Z=27, Co	0.2275	5.93		
Z=28, Ni	0.2458	14.16	0.242	
Z=29, Cu	**0.2631**			
Z=30, Zn	0.2795	2.09	0.279	0.270[a]
Z=31, Ga	**0.2951**			
Z=32, Ge	**0.3099**		0.311	
Z=33, As	0.3239	1.82		0.318[a]
Z=34, Se	0.3370	1.05	0.340	0.333[a]
Z=35, Br	**0.3495**			
Z=36, Kr	**0.3612**		0.365	
Z=37, Rb	0.3722	0.75		0.375[a]
Z=38, Sr	0.3826	1.93	0.387	0.390[a]
Z=39, Y	0.3923	1.20		0.397[a]
Z=40, Zr	0.4014	3.13	0.405	0.404[a]
Z=41, Nb	0.4098	0.78		0.413[b]
Z=42, Mo	0.4177	3.62	0.421	0.416[b]
Z=43, Tc	**0.4251**			
Z=44, Ru	**0.4319**		0.433	
Z=45, Rh	**0.4383**			
Z=46, Pd	0.4441	1.78	0.443	0.452[b]
Z=47, Ag	0.4495	0.78		0.446[b]
Z=48, Cd	0.4544	4.02	0.452	0.451[b]
Z=49, In	0.4589	1.50		0.452[b]
Z=50, Sn	0.4630	0.22	0.460	0.464[b]
Z=51, Sb	0.4667	2.29		0.456[b]
Z=52, Te	0.4701	0.19	0. 465	0.471[b]
Z=53, I	0.4731	1.50		0.466[b]
Z=54, Xe	**0.4758**		0.469	
Z=55, Cs	0.4781	1.66		0.469[b]
Z=56, Ba	0.4802	2.12	0.473	0.470[b]
Z=57, La	0.4820	3.75		0.470[b]
Z=58, Ce	0.4835	3.67	0.475	0.475[b]
Z=59, Pr	0.4848	3.06		0.477[b]
Z=60, Nd	0.4859	2.57	0.477	0.480[c]
Z=61, Pm	**0.4867**			
Z=62, Sm	0.4873	1.83	0.479	0.481[c]
Z=63, Eu	0.4877	2.57		0.481[c]
Z=64, Gd	0.4880	3.45	0.479	0.482[c]
Z=65, Tb	0.4881	3.98		
Z=66, Dy	0.4880	3.84	0.480	0.483[c]
Z=67, Ho	0.4878	2.77		0.482[c]
Z=68, Er	0.4875	2.79	0.479	0.482[c]
Z=69, Tm	0.4870	1.03		0.482[d]
Z=70, Yb	0.4865	0.75	0.480	0.482[c]

Z=71, Lu	0.4858 1.19		0.480[d]
Z=72, Hf	**0.4851**	0.479	
Z=73, Ta	0.4842 1.00		0.480[c]
Z=74, W	0.4833 0.91	0.478	0.480[c]
Z=75, Re	0.4824 0.70		0.479[d]
Z=76, Os	**0.4813**	0.478	
Z=77, Ir	**0.4803**		
Z=78, Pt	0.4791 0.92	0.477	
Z=79, Au	0.4780 0.57		0.478[d]
Z=80, Hg	0.4768 0.43	0.476	0.476[c]
Z=81, Tl	0.4755 2.03		
Z=82, Pb	0.4743 1.63	0.475	0.474[c]
Z=83, Bi	0.4730 0.42		0.471[d]
Z=84, Po	**0.4717**	0.474	
Z=85, At	**0.4704**		
Z=86, Rn	**0.4691**	0. 473	
Z=87, Fr	**0.4678**		
Z=88, Ra	**0.4665**	0.472	
Z=89, Ac	**0.4652**		
Z=90, Th	0.4638 0.04	0.470	0.464[d]
Z=91, Pa	**0.4625**		
Z=92, U	0.4611 0.20	0.469	0.462[d]

[a](Ertuğrul, 2002a)
[b](Çalilskan *et al*., 2002)
[c](Durak and Özdemir, 1998)
[d](Ertuğrul *et al*., 1997b)

Table 26. Empirical (this work), theoretical, and experimental (other works) of radiative vacancy transfer probabilities η_{KM}(R) from $_{24}$Cr to $_{92}$U.

Z, Symbol	This work		Other works	
			Theoretical	Experimental
	Empirical	ε_{RMS}(%)	(Rao *et al.*, 1972)	
Z=24, Cr	0.0139	51.08		
Z=25, Mn	**0.0202**			
Z=26, Fe	**0.0263**		0.0371	
Z=27, Co	**0.0322**			
Z=28, Ni	0.0380	31.58		
Z=29, Cu	**0.0435**			
Z=30, Zn	0.0488	2.46	0.0532	0.050[a]
Z=31, Ga	**0.0540**			
Z=32, Ge	**0.0590**		0.0624	
Z=33, As	0.0638	0.31		0.064[a]
Z=34, Se	0.0685	0.73		0.068[a]
Z=35, Br	**0.0730**			
Z=36, Kr	**0.0773**		0.0806	
Z=37, Rb	0.0815	0.61		0.082[a]
Z=38, Sr	0.0855	1.75		0.087[a]
Z=39, Y	0.0894	1.79		0.091[a]
Z=40, Zr	0.0931	0.97	0.0967	0.094[a]
Z=41, Nb	0.0967	1.34		0.098[b]
Z=42, Mo	0.1002	0.20	0.104	0.10[b]
Z=43, Tc	**0.1035**			
Z=44, Ru	**0.1067**			
Z=45, Rh	**0.1098**			
Z=46, Pd	0.1127	2.04		0.115[b]
Z=47, Ag	0.1156	0.52	0.119	0.115[b]
Z=48, Cd	0.1183	1.10		0.117[b]
Z=49, In	0.1209	1.57		0.119[b]
Z=50, Sn	0.1234	0.49	0.126	0.124[b]
Z=51, Sb	0.1258	2.23		0.123[b]
Z=52, Te	0.1281	0.08		0.128[b]
Z=53, I	0.1303	1.77		0.128[b]
Z=54, Xe	**0.1324**			
Z=55, Cs	0.1344	1.98		0.131[b]
Z=56, Ba	0.1363	9.51	0.137	0.133[b]
Z=57, La	0.1382	3.11		0.134[b]
Z=58, Ce	0.1399	2.26		0.137[b]
Z=59, Pr	0.1416	4.07		0.138[b]
Z=60, Nd	0.1432	3.00	0.143	0.142[c]
Z=61, Pm	**0.1447**			
Z=62, Sm	0.1462	1.40		0.144[c]
Z=63, Eu	0.1476	1.63		0.144[c]
Z=64, Gd	0.1489	2.77		0.146[c]
Z=65, Tb	0.1501	4.01	0.149	
Z=66, Dy	0.1513	6.14		0.148[c]
Z=67, Ho	0.1524	2.47		0.150[c]
Z=68, Er	0.1535	3.22		0.151[c]
Z=69, Tm	0.1545	0.32		0.154[d]
Z=70, Yb	0.1555	1.16	0.154	0.153[c]
Z=71, Lu	0.1564	0.26		0.156[d]

Z=72, Hf	**0.1573**			
Z=73, Ta	0.1581	1.67		0.156[c]
Z=74, W	0.1588	1.13		0.157[c]
Z=75, Re	0.1596	1.63		0.157[d]
Z=76, Os	**0.1603**			
Z=77, Ir	**0.1609**			
Z=78, Pt	0.1615	0.59		
Z=79, Au	0.1621	0.76		0.160[d]
Z=80, Hg	0.1626	1.33		0.161[c]
Z=81, Tl	0.1631	1.91		
Z=82, Pb	0.1636	4.26		0.163[c]
Z=83, Bi	0.1641	0.98		0.162[d]
Z=84, Po	**0.1645**			
Z=85, At	**0.1649**			
Z=86, Rn	**0.1652**			
Z=87, Fr	**0.1656**			
Z=88, Ra	**0.1659**			
Z=89, Ac	**0.1662**			
Z=90, Th	0.1664	0.67		0.163[d]
Z=91, Pa	**0.1667**			
Z=92, U	0.1669	0.24		0.166[d]

[a](Ertuğrul, 2002a)
[b](Çalilskan *et al*., 2002)
[c](Durak and Özdemir, 1998)
[d](Ertuğrul *et al*., 1997b)