# Extended calculations of energy levels, radiative properties, $A_J$, $B_J$ hyperfine interaction constants, and Landé $g_J$-factors for oxygen-like Kr XXIX

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**Abstract**

Using the multiconfiguration Dirac–Fock method and the second–order many–body perturbation theory method, highly accurate calculations are performed for the lowest 344 fine-structure levels arising from the $2s^22p^4$, $2s2p^5$, $2p^6$, $2s^22p^33s$, $2s^22p^33p$, $2s^22p^33d$, $2s2p^43s$, $2s2p^43p$, $2s2p^43d$, $2p^53s$, $2p^53p$, $2p^53d$, $2s^22p^34s$, $2s^22p^34p$, $2s^22p^34d$, $2s^22p^34f$, and $2s2p^44s$ configurations in O-like Kr XXIX. Complete and consistent atomic data, including excitation energies, lifetimes, wavelengths, hyperfine structures, Landé $g_J$-factors, and E1, M1, E2, M2 transition rates, line strengths, and oscillator strengths among these 344 levels are obtained. Comparisons are made between our two different sets of results, as well as with the other available experimental and theoretical values. For O-like Kr only a few levels have been experimentally established. The accuracy of our calculated energies is however high enough to facilitate identifications of observed lines involving the $n = 3, 4$ levels. The calculated data are also useful for modeling and diagnosing fusion plasmas.

*Keywords:* Atomic data; O-like Kr XXIX, Multiconfiguration Dirac–Fock; Many–body perturbation theory.

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## 1. Introduction

Accurate spectroscopic data for ions have practical applications in astrophysics and fusion science. As a rare gas, Krypton can easily be introduced into the plasma and does not pollute the vacuum vessel. For this reason it is widely used as an injected impurity for diagnosing tokamak fusion plasmas [1–3]. To analyze the observations of Kr ions, accurate atomic parameters including energies, transition rates, and lifetimes, are required. Previously, for highly ionized Kr, few, if any, atomic data were available. In response to this, we have reported full sets of consistent and highly accurate energies and transition parameters for Kr XXV [4, 5], Kr XXVII [6], and Kr XXX [7], and this work continues our efforts for O-like Kr XXIX.

Experimental determinations of some levels of O-like Kr reported by Wyart and the TFR Group [1], Dietrich et al. [8], Denne et al. [9], and Rice et al. [10] were compiled by Saloman [11] incorporated in the Atomic Spectra Database (ASD) of the National Institute of Standards and Technology (NIST) [12]. Using an electron-beam ion trap, Kink et al. [13] reported a few spectral lines for the $(1s^2)2s^22p^33l$ – $2s^22p^4$ transitions of Kr XXIX with a microcalorimeter detector. Using the same equipment, Podpaly et al. [14] observed the extreme-ultraviolet spectra containing a few transitions among the $n = 2$ levels of Kr XXIX.

When experimental data are not available, theoretical approaches should provide relevant information. Unfortunately, theoretical data for Kr XXIX are scarce. Using various methods, some studies of energy and transition data limited to the $2s^22p^4$, $2s2p^5$, and $2p^6$ configurations were carried out [15–19]. It is clear that atomic data involving the $n = 3, 4$ levels are also important because of their wide applications in fusion science [10, 13]. To our knowledge, the only published work for these levels were the calculations performed by Rice et al. [10] and Aggarwal et al. [20]. Rice et al. [10] gave some calculated data for the $n \geq 3$ levels in O-like Kr. Aggarwal et al. [20] reported energies and oscillator strengths for the transitions among the 272 levels of the $n \leq 3$ complexes using both the multiconfiguration Dirac-Fock (MCDF) method implemented in the GRASP1 code [21, 22] and the standard relativistic configuration interaction (RCI) method in the FAC package [23]. However, because of limited account for configuration interaction (CI) effects, the atomic data presented in their work, although very valuable, are not accurate enough to directly aid line identification and diagnostics in fusion plasmas. Therefore, there is a demand for providing extensive and accurate atomic data for Kr XXIX for applications in controlled fusion.

The objective of the present study is to provide highly accurate spectroscopic data including energy levels, wavelengths, lifetimes, hyperfine interaction constants, Landé $g_J$-factors, as well as E1, M1, E2, and M2 transition rates, line strengths, and oscillator strengths among the lowest 344 levels belonging to the $2s^22p^4$, $2s2p^5$, $2p^6$, $2s^22p^33s$, $2s^22p^33p$, $2s^22p^33d$, $2s2p^43s$, $2s2p^43p$, $2s2p^43d$, $2p^53s$, $2p^53p$, $2p^53d$, $2s^22p^34s$, $2s^22p^34p$, $2s^22p^34d$, $2s^22p^34f$, and $2s2p^44s$ configurations for O-like Kr XXIX. Calculations are performed using the MCDF method [24] implemented in the GRASP2K code [25, 26]. To obtain highly accurate atomic data, configuration spaces are elaborately built to consider various correlation effects. Relativistic corrections arising from the Breit interaction and quantum electrodynamics (QED) effects are added in the subsequent RCI procedure using the GRASP2K code. To assess the accuracy of the present MCDF data, independent calculations are performed using the second-order many-body perturbation theory (MBPT) as implemented in the FAC package [23, 27–29]. Comparisons with previous calculations and available experimental determinations are also carried out. Excitation energies obtained from the two independent methods, MCDF and MBPT, are in excellent agreement with the NIST experimental values, i.e., the difference is within 0.07 %. The calculated energies are accurate enough to directly aid and confirm experimental identifications. The present work significantly increases the amount of accurate data for the $n = 3, 4$ levels.

## 2. Calculations

### *2.1. MCDF*

The MCDF method has been described by Grant [24]. Based on the active space approach [30, 31] for the generation of the configuration state function (CSF) expansions, separate calculations are done for the even and odd parity states. For the even parity states, the CSF expansions are obtained by allowing single and double (SD) excitations from the multi-reference (MR) configurations $2s^22p^4$, $2p^6$, $2s^22p^33p$, $2s2p^43s$, $2s2p^43d$, $2p^53p$, $2s^22p^34p$, $2s^22p^34f$, and $2s2p^44s$ to an active space (AS) of orbitals. For the odd parity states, the CSF expansions are obtained by allowing SD excitations from the MR configurations $2s2p^5$, $2s^22p^33s$, $2s^22p^33d$, $2s2p^43p$, $2p^53s$, $2p^53d$, $2s^22p^34s$, and $2s^22p^34d$ to the AS. In the first step of the calculation, the AS is

AS1 = {4s, 4p, 4d, 4f}

Then, we increase the AS in the following way:

AS2 = AS1 + {5s, 5p, 5d, 5f, 5g}

AS3 = AS2 + {6s, 6p, 6d, 6f, 6g, 6h}

AS4 = AS3 + {7s, 7p, 7d, 7f, 7g, 7h}

AS5 = AS4 + {8s, 8p, 8d, 8f, 8g, 8h}

By enlarging the AS layer by layer, the convergence of the computed properties can be monitored. At each stage only the outer orbitals are optimized, while the inner ones are fixed. To reduce the number of CSFs, the $1s^2$ core is closed during the the relativistic self-consistent field (RSCF) calculations, but is opened during the RCI calculations, where the Breit and QED corrections are included in the Hamiltonian and the mixing coefficients $c_r$ are recalculated without changing the radial functions. The final model using the AS5 active set contains about 4 020 000/14 410 000 even and 2 880 000/10 440 000 odd parity CSFs with the $1s^2$ core closed/opened. Once the atomic state functions (ASFs) have been obtained, atomic parameters, such as line strengths, transition rates, hyperfine interaction constants, and Landé $g_J$-factors can be calculated. A more detailed description of these parameters can be found in our recent work [7] as well as in the original write-ups of the computer codes [32, 33].

### *2.2. MBPT*

The MBPT method is explained in [28, 29, 34–36]. The method has been implemented in the FAC package [23], and successfully used to calculate atomic data of high accuracy [37–42]. The key feature of the MBPT method is the partitioning of the Hilbert space of the system into two subspaces, the model space $M$ and the orthogonal space $O$. The configuration interaction effects in the $M$ space is exactly considered, while the interaction between the space $M$ and $O$ is taken into account with the second-order perturbation method. For the MBPT calculation, the model space $M$ contains the even and odd multi-reference configurations of the MCDF method, while the space $O$ contains all the possible configurations that are generated by SD virtual excitations of the $O$ space. For single/double excitations, the maximum $n$ value is 125/65, with the maximum $l$ value is 25. Just as for the multiconfiguration calculations, QED effects are also included.

## 3. Results and Discussions

In the relativistic calculations, the ASFs are obtained as expansions over *jj*-coupled CSFs. To provide the $LSJ$ labeling system used by the experimentalists, as well as used in other sources, such as the NIST and CHIANTI databases, the ASFs are transformed from a *jj*-coupled CSF basis into a $LSJ$-coupled CSF basis using the method provided by Gaigalas et al. [43, 44] The computed excitation energies for all the 344 levels of the $2s^22p^4$, $2s2p^5$, $2p^6$, $2s^22p^33s$, $2s^22p^33p$, $2s^22p^33d$, $2s2p^43s$, $2s2p^43p$, $2s2p^43d$, $2p^53s$, $2p^53p$, $2p^53d$, $2s^22p^34s$, $2s^22p^34p$, $2s^22p^34d$, $2s^22p^34f$, and $2s2p^44s$ configurations from our MCDF and MBPT calculations are listed in Table 1, along with the $LSJ$ coupling expansion coefficients obtained from our MCDF calculations.

### *3.1. Excitation energies*

One check on the accuracy of the calculations is provided by the excitation energies. The MCDF excitation energies of the lowest 10 levels belonging to the $2s^22p^4$, $2s2p^5$, and $2p^6$ configurations are listed in Table 2 as a function of increasing AS. Inspection of Table 2 shows that excitation energies converge quite fast with increasing AS. The correlations arising from AS3 affect the MR results by about 1%, while the AS4/AS5 correlations only adjust the values of AS3/AS4 by approximately 0.02%/0.003%. The RCI excitation energies of the AS5 expansion including the Breit and QED effects are also listed in Table 2. These effects change the $n = 2$ excitation energies considerably. For demonstrating the effects clearer, their contributions to the MCDF and MBPT excitation energies of all the 344 levels are shown in Figure 1. Their contributions to the MCDF and MBPT data show good agreement. For low/high-lying levels of the $n$=2/$n$=3, 4 complexes, the Breit and QED effects reduce significantly/slightly excitation energies by about 0.4-1.8%/0.05-0.20%, with one exception for the $2s^2\,2p^4\ {}^3P_0$ level, for which they significantly increase the excitation energy by up to 3.4%. Moreover, the Breit and QED corrections change the level order in both the MCDF and MBPT calculations, e.g., for the levels 18/19, 32/33, 44/45, 59/60, 68/69, and 73/74.

The energy levels for the present two complementary calculations are compared in Table 3. Also collected in the table are the experimental values from the NIST ASD and theoretical energies calculated by Rynkun et al. [19] using the MCDF method (hereafter referred to as MCDF2), by Vilkas et al. [36] using the relativistic multireference Möller−Plesset perturbation theory (MRMP), and by Aggarwal et al. [20] (GRASP1 and FAC). Here, the parity $P$, $J$, and energy, rather than level identifications, are adopted to match the levels from various sources.

Compared with the present MCDF energy values for the levels of the $n = 2$ complex, three elaborate calculations (MCDF2, MBPT and MRMP) give very consistent values, and the agreement is within 0.05 % for MCDF2, 0.07 % for MBPT, and 0.13 % for MRMP. The NIST observations are available for seven levels, and agreement of the NIST values and the present MCDF excitation energies is well within the NIST uncertainties (1 000 cm$^{-1}$ - 1 500 cm$^{-1}$) [11]. The other two theoretical results (GRASP1 and FAC) reported by Aggarwal et al. [20] are not accurate enough to meet the requirement of line identification and interpretation, due to limited configuration interaction effects included in their calculations. For example, the differences between the GRASP1/FAC values and the NIST experimental values for the $n = 2$ levels are one order of magnitude larger than the corresponding differences between the MCDF/MBPT and NIST data. The deviation for the GRASP1 and FAC values from the MCDF/MBPT data is up to 1 % for the $2p^6\ {}^1S_0$ level.

For the remaining levels belonging to the $n = 3, 4$ configurations, the average absolute difference with the standard deviation of the present MBPT and MCDF energy values is $-589 \pm 724$ cm$^{-1}$, corresponding to the average relative difference with the standard deviation of $-0.003\% \pm 0.004\%$. The average absolute difference (with the standard deviation) between the GRASP1/FAC and MCDF energy values are $2257 \pm 11436/6183 \pm 12108$ cm$^{-1}$, i.e., one order of magnitude larger than the corresponding difference of the MCDF and MBPT values. The experimental values from the NIST ASD are only available for three levels, being 20142200 cm$^{-1}$ for $2s^22p^3({}^4S)4d\ {}^3D_3$, 20162300 cm$^{-1}$ for $2s^22p^3({}^4S)4d\ {}^3D^o_1$, and 21161800 cm$^{-1}$ for $2s2p^4({}^4P)4s\ {}^3P_2$, respectively. The deviations from our MCDF results for these three NIST values are 7000 - 24000 cm$^{-1}$, while the corresponding differences of our MCDF and MBPT values are within 1200 cm$^{-1}$. The differences of the present results from these NIST values are significantly larger than the NIST uncertainties (1 900 cm$^{-1}$ - 2 500 cm$^{-1}$) [11], which implies that either the identifications of observed spectra are incorrect or a systematic error exists in both the MCDF and MBPT calculations. Further precise measurements and systematic elaborate calculations along the sequence (similar as those performed in Ref. [41]) may be needed to resolve these relatively large discrepancy.

To further assess the accuracy of the present two data sets, relative differences between the MCDF and MBPT excitation energies are plotted in Figure 2. It is clear that our calculated energies in two methods agree well with each other, i.e., the differences are within 0.073 % for the 10 levels of the $n = 2$ complex, and 0.011 % for the remaining 334 levels.

### 3.2. *Transition rates*

Table 4 lists transition probabilities for the E1, M1, E2, and M2 transitions among all the 344 levels of O-like Kr XXIX, obtained from both the MCDF and MBPT methods. Also included in this table are wavelengths $\lambda$, line strengths $S$, and oscillator strengths $gf$. All the E1 and E2 values are computed in the length form, which is considered to be more accurate than the velocity form.

In Table 5, we compare the present two sets of transition rates among the lowest 10 levels belonging to the $2s^22p^4$, $2s2p^5$, and $2p^6$ configurations with previous published values. Included are the results reported by Rynkun et al. [19] using the MCDF method (hereafter referred to as MCDF2), the GRASP1 calculations [20], and the multiconfiguration Hartree-Fock calculations with relativistic corrections in the Breit-Pauli approximation (MCHF-BP) [15], as well as the values listed by the NIST ASD [12]. The present two data sets and the MCDF2 values are in good agreement, which is within 1 % for all the transitions. The NIST values also agree within 1 % with the present data sets. The GRASP1 and MCHF-BP results deviate from our MCDF values by over 6 % in many cases, with the largest deviations up to 14 %. To some extent, this may be attributed to the limited configuration interaction effects included in these two calculations.

To further estimate the uncertainty of our two data sets, line strengths from our MCDF calculations ($S_{\rm MCDF}$) with $S_{\rm MCDF} \geq 10^{-4}$ for the E1 transitions are compared with the MBPT line strengths ($S_{\rm MBPT}$) in Figure 3. Our two data sets agree within 10 % for most of the transitions. According to the uncertainty estimation method suggested by Kramida [45, 46] we have the following averaged uncertainties for the $S$ values of E1 transitions in various ranges of the line strengths: 1.5 % for $S \geq 10^{-1}$; 3 % for $10^{-1} > S \geq 10^{-2}$; 4 % for $10^{-2} > S \geq 10^{-3}$; 7 % for $10^{-3} > S \geq 10^{-4}$; 16 % for $10^{-4} > S \geq 10^{-5}$; and 26 % for $10^{-5} > S \geq 10^{-6}$. Accounting also for the contributions from the uncertainty of the wavelengths, about 4.6 % E1 transitions included in Table 4 have $A$-value uncertainties of $\leq 2$ % (the category $A^+$ in the terminology of the NIST ASD), 13.9 % have uncertainties of $\leq 3$ % (the category A), 30.3 % have uncertainties of $\leq 7$ % (the category $B^+$), 40.4 % have uncertainties of $\leq 10$ % (the category B), 7.6 % have uncertainties of $\leq 18$ % (the category $C^+$), 0.8 % have uncertainties of $\leq 25$ % (the category C), while only 2.4 % have uncertainties of $> 40$ % (categories $D^+$, D, and E). The uncertainty estimates of $A$ values for each transition are listed in the last column of Table 4. The largest differences between the two set of results generally occur for the weakest transitions. Most of them are two-electrons-one-photon transitions. These transitions are strictly forbidden in the single configuration approximation and are induced through configuration interaction effects. Even with today's methods, which allow massive CSF expansions, such transitions are very difficult to compute accurately.

Again, using the method suggested in [45, 46], the uncertainties of the $A$ values for the M1, E2, and M2 transitions are estimated. The estimated uncertainties for all M1, E2, and M2 transitions are listed in Table 4.

### 3.3. *Lifetimes, Hyperfine interaction constants, and Landé $g_J$-factors*

Table 6 presents our MCDF and MBPT lifetimes in the length form. The differences between our two data sets are within 4 % except for four excited levels, namely, levels 73 ($2s^22p^3(^2P)3p\ ^3P_2$), 91 ($2s2p^4(^4P)3p\ ^5P_1$), 93 ($2s^22p^3(^2P)3d\ ^3P_1$), and 98 ($2s2p^4(^4P)3p\ ^3P_2$), for which the discrepancies are larger, but are still less than 8 %. The theoretical results of Rynkun et al. [19] (MCDF2), and of [20] (GRASP1) are also included in Table 6 for comparison. The MCDF2 results for the $n = 2$ levels are very close to our MCDF and MBPT values, and the differences are within 1 %. However, the GRASP1 results differ substantially from the present two data sets for many levels. The differences are often larger than 10% (up to a factor of five) for some levels, such as the levels 71, 73, 93, and 95.

The total energies, $A_J$, $B_J$ hyperfine interaction constants and Landé $g_J$-factors for the 344 levels of Kr XXIX calculated using the MCDF method are also given in Table 6. In the MCDF calculations, the nuclear parameters $I$, $\mu_I$, and $Q$ are all set to 1. To obtain the $A_J$ and $B_J$ values for a specific isotope, the given values can be scaled with the tabulated values. Unfortunately, no experimental or theoretical values for the $A_J$, $B_J$ constants are yet available in the literature.

## 4. Conclusions

By employing the MCDF and MBPT methods, we have determined energy levels, lifetimes, wavelengths, hyperfine interaction constants, Landé $g_J$-factors, E1, M1, E2, and M2 transition rates, line strengths, and oscillator strengths among the lowest 344 levels belonging to the $2s^22p^4$, $2s2p^5$, $2p^6$, $2s^22p^33s$, $2s^22p^33p$, $2s^22p^33d$, $2s2p^43s$, $2s2p^43p$, $2s2p^43d$, $2p^53s$, $2p^53p$, $2p^53d$, $2s^22p^34s$, $2s^22p^34p$, $2s^22p^34d$, $2s^22p^34f$, and $2s2p^44s$ configurations of O-like Kr XXIX. Uncertainties of energy levels and transition probabilities are estimated by comparing the MCDF and MBPT results with experimental data. Our results are also compared with the available calculated data for Kr XXIX. Based on a variety of comparisons, excitation energies are accurate to ± 350 $cm^{-1}$ on average for the $n = 2$ levels, while the uncertainty is smaller than 0.1 % for the $n \geq 3$ levels, and lifetimes are assessed to be accurate to better than 4% for most levels. The high accuracy carries over to the $n = 3, 4$ levels, for which experimental data are largely missing. We believe that the present sets of results are the most complete and accurate to date. These data are expected to be very useful for modeling and diagnosing plasmas.

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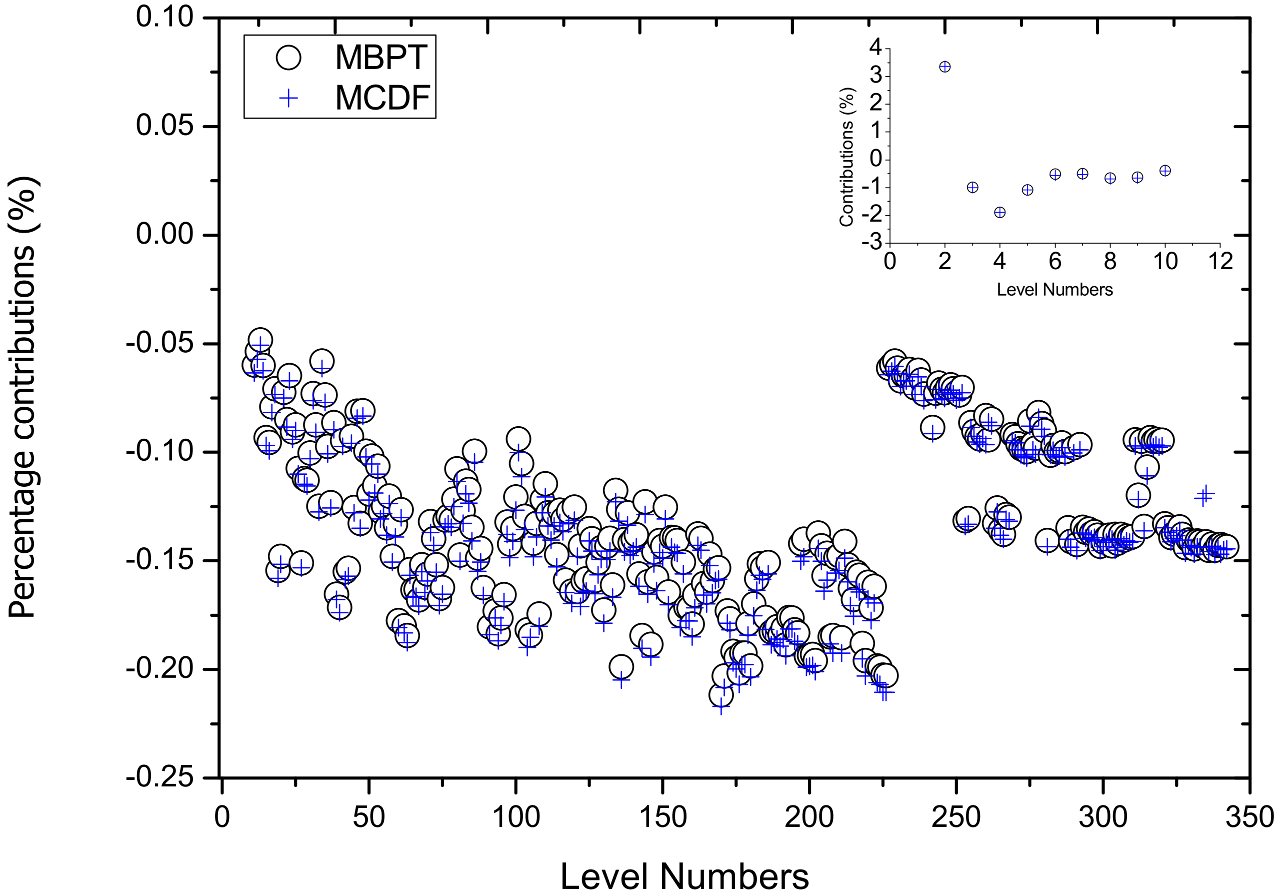


**Figure 1.** The Breit and QED effects on the MCDF and MBPT excitation energies for the 344 levels of O-like Kr XXIX.

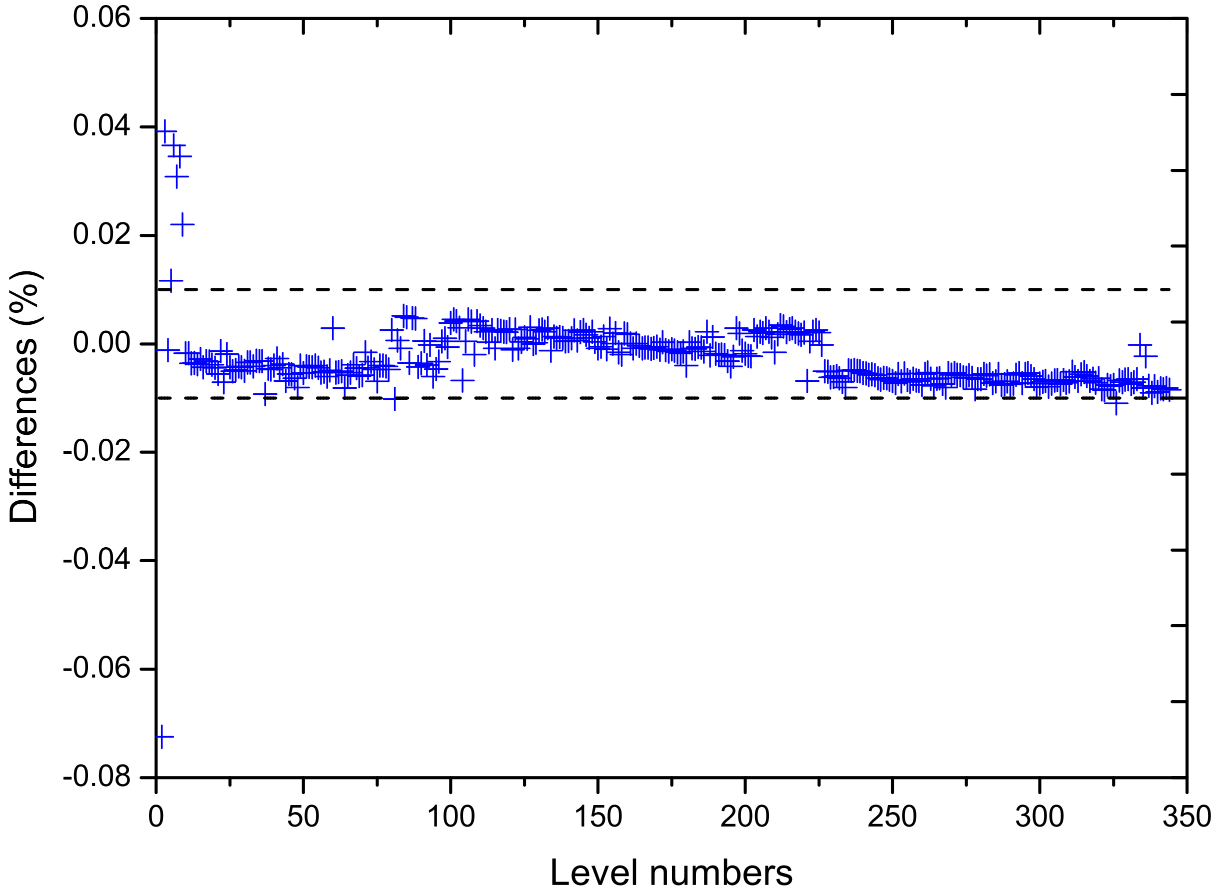


**Figure 2.** Percentage differences of the MBPT values relative to the MCDF excitation energies for the 344 levels in O-like Kr XXIX. Dashed lines indicate the differences of ±0.01%.

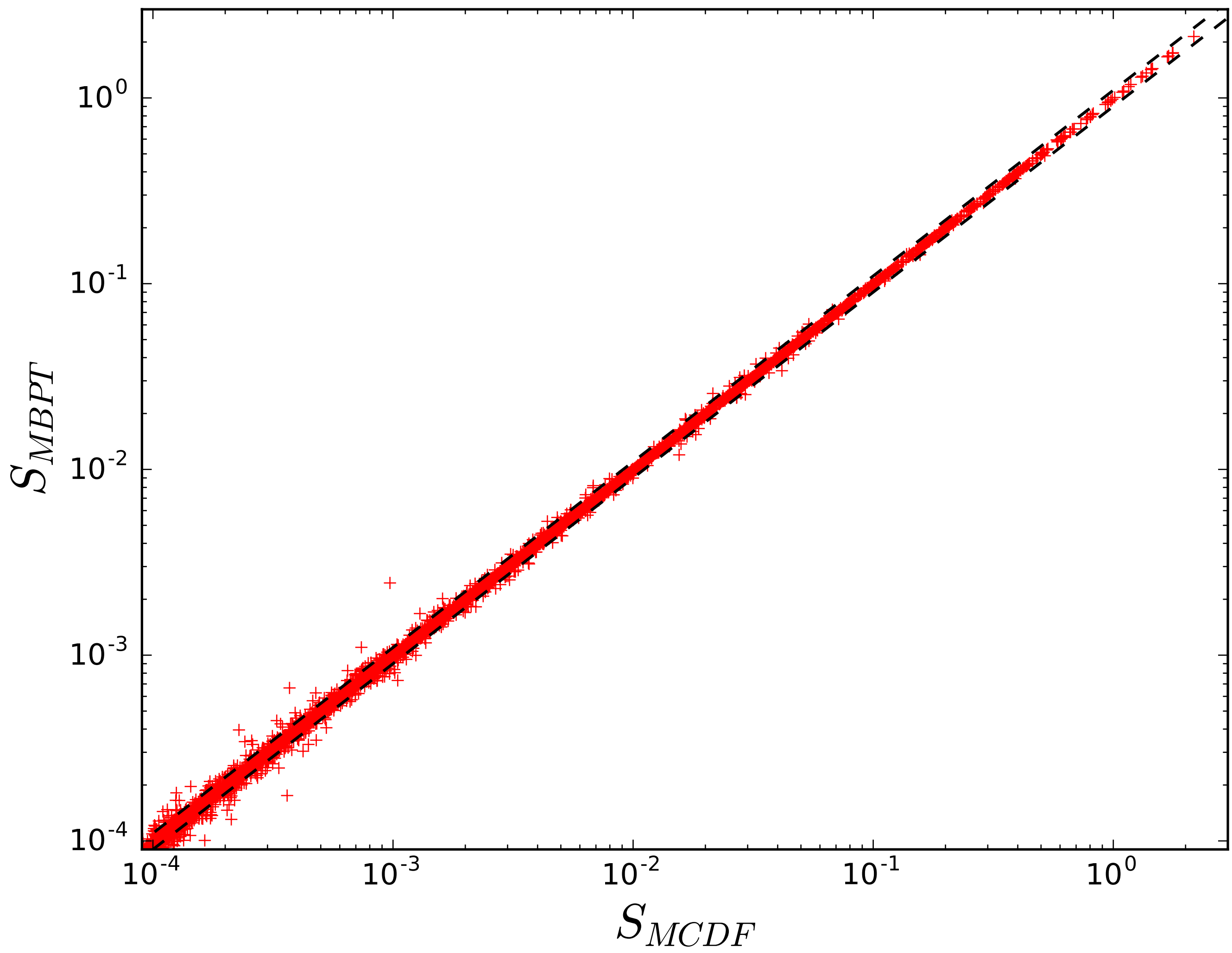


**Figure 3.** Comparison of the line strengths from our MCDF ($S_{\mathrm{MCDF}}$) and MBPT ($S_{\mathrm{MBPT}}$) calculations for the E1 transitions. Dashed lines indicate the ±10% deviations.

**Table 1.** Energies ($E$ in cm$^{-1}$) relative to the ground state for the lowest 344 levels arising from the $2s^22p^4$, $2s2p^5$, $2p^6$, $2s^22p^33s$, $2s^22p^33p$, $2s^22p^33d$, $2s2p^43s$, $2s2p^43p$, $2s2p^43d$, $2p^53s$, $2p^53p$, $2p^53d$, $2s^22p^34s$, $2s^22p^34p$, $2s^22p^34d$, $2s^22p^34f$, and $2s2p^44s$ configurations of Kr XXIX. The *LS* term designation and seniority for each subshell are given in parentheses ( ) if more than one *LS* term could be generated by this subshell. The *LS* term for each subshell is the coupled from left to right. The last column denotes the *LSJ* wavefunction compositions obtained from our MCDF calculations.

| Key | Config. | *LS J* | $E_{\mathrm{MCDF}}$ | $E_{\mathrm{MBPT}}$ | Components |
|---|---|---|---|---|---|
| 1 | $2s^22p^4$ | $^3P_2$ | 0 | 0 | 0.89 ( 1) 0.46 ( 4) |
| 2 | $2s^22p^4$ | $^3P_0$ | 159993 | 159877 | 0.72 ( 2) 0.69 ( 5) |
| 3 | $2s^22p^4$ | $^3P_1$ | 424128 | 424294 | 1.00 ( 3) |
| 4 | $2s^22p^4$ | $^1D_2$ | 525261 | 525255 | 0.89 ( 4) -0.46 ( 1) |
| 5 | $2s^22p^4$ | $^1S_0$ | 1020259 | 1020378 | -0.71 ( 5) 0.70 ( 2) |
| 6 | $2s2p^5$ | $^3P_2$ | 1674341 | 1674953 | -1.00 ( 6) |
| 7 | $2s2p^5$ | $^3P_1$ | 1864481 | 1865056 | 0.88 ( 7) -0.47 ( 9) |
| 8 | $2s2p^5$ | $^3P_0$ | 2134878 | 2135616 | -1.00 ( 8) |
| 9 | $2s2p^5$ | $^1P_1$ | 2378285 | 2378808 | 0.88 ( 9) 0.47 ( 7) |
| 10 | $2p^6$ | $^1S_0$ | 3779450 | 3779383 | 0.99 ( 10) |
| 11 | $2s^22p^3(^4S)3s$ | $^5S_2$ | 14524170 | 14523923 | -0.71 ( 11) -0.58 ( 41) 0.32 ( 15) |
| 12 | $2s^22p^3(^4S)3s$ | $^3S_1$ | 14570414 | 14569893 | 0.65 ( 12) 0.48 ( 43) -0.47 ( 16) 0.36 ( 24) |
| 13 | $2s^22p^3(^4S)3p$ | $^5P_1$ | 14883016 | 14882497 | 0.72 ( 13) -0.46 ( 49) 0.38 ( 25) 0.35 ( 58) |
| 14 | $2s^22p^3(^4S)3p$ | $^5P_2$ | 14892369 | 14891805 | 0.65 ( 14) 0.48 ( 50) 0.45 ( 21) -0.38 ( 26) |
| 15 | $2s^22p^3(^2D)3s$ | $^3D_2$ | 14912895 | 14912479 | 0.64 ( 15) 0.62 ( 11) -0.37 ( 20) |
| 16 | $2s^22p^3(^2D)3s$ | $^3D_1$ | 14942904 | 14942256 | -0.72 ( 16) -0.68 ( 12) |
| 17 | $2s^22p^3(^4S)3p$ | $^5P_3$ | 15007888 | 15007404 | -0.72 ( 17) -0.58 ( 67) 0.30 ( 27) |
| 18 | $2s^22p^3(^2D)3s$ | $^3D_3$ | 15015517 | 15015028 | 1.00 ( 18) |
| 19 | $2s^22p^3(^4S)3p$ | $^3P_1$ | 15015632 | 15015051 | 0.63 ( 19) -0.48 ( 68) -0.45 ( 58) 0.41 ( 44) |
| 20 | $2s^22p^3(^2D)3s$ | $^1D_2$ | 15043510 | 15042852 | -0.82 ( 20) -0.57 ( 15) |
| 21 | $2s^22p^3(^4S)3p$ | $^3P_2$ | 15090290 | 15089448 | 0.57 ( 14) -0.52 ( 21) -0.47 ( 64) -0.42 ( 73) |
| 22 | $2s^22p^3(^2P)3s$ | $^3P_0$ | 15151616 | 15151415 | 0.99 ( 22) |
| 23 | $2s^22p^3(^4S)3p$ | $^3P_0$ | 15159798 | 15158725 | 0.76 ( 23) -0.48 ( 48) 0.34 ( 81) |
| 24 | $2s^22p^3(^2P)3s$ | $^3P_1$ | 15164439 | 15164153 | -0.82 ( 24) 0.56 ( 43) |
| 25 | $2s^22p^3(^2D)3p$ | $^3D_1$ | 15259543 | 15258887 | -0.61 ( 13) 0.53 ( 25) 0.48 ( 33) -0.36 ( 44) |
| 26 | $2s^22p^3(^2D)3p$ | $^3F_2$ | 15300804 | 15300035 | -0.61 ( 26) 0.51 ( 28) -0.48 ( 21) -0.37 ( 14) |
| 27 | $2s^22p^3(^2D)3p$ | $^3F_3$ | 15375644 | 15374907 | 0.76 ( 27) -0.49 ( 38) 0.37 ( 29) |
| 28 | $2s^22p^3(^2D)3p$ | $^3D_2$ | 15389809 | 15389167 | -0.63 ( 28) -0.50 ( 21) 0.47 ( 14) -0.37 ( 37) |
| 29 | $2s^22p^3(^2D)3p$ | $^1F_3$ | 15396478 | 15395812 | 0.61 ( 29) -0.60 ( 17) -0.37 ( 38) -0.35 ( 27) |
| 30 | $2s^22p^3(^2D)3p$ | $^3P_0$ | 15415817 | 15415049 | -0.82 ( 30) -0.49 ( 23) |
| 31 | $2s^22p^3(^4S)3d$ | $^5D_2$ | 15428443 | 15427913 | -0.62 ( 31) 0.46 ( 96) -0.45 ( 52) -0.44 ( 40) |
| 32 | $2s^22p^3(^4S)3d$ | $^5D_3$ | 15438839 | 15438307 | 0.72 ( 32) 0.48 ( 77) -0.39 ( 95) 0.32 ( 45) |
| 33 | $2s^22p^3(^2D)3p$ | $^1P_1$ | 15439580 | 15438931 | -0.61 ( 33) 0.54 ( 25) 0.46 ( 42) -0.35 ( 19) |
| 34 | $2s^22p^3(^4S)3d$ | $^5D_0$ | 15451225 | 15450744 | 0.74 ( 34) 0.57 ( 89) |
| 35 | $2s^22p^3(^4S)3d$ | $^5D_1$ | 15451382 | 15450894 | 0.76 ( 35) 0.49 ( 93) -0.33 ( 79) |
| 36 | $2s^22p^3(^4S)3d$ | $^5D_4$ | 15464724 | 15464229 | 0.72 ( 36) 0.58 ( 90) |
| 37 | $2s^22p^3(^2D)3p$ | $^3P_2$ | 15488280 | 15486848 | 0.74 ( 37) -0.44 ( 47) -0.38 ( 28) -0.33 ( 21) |
| 38 | $2s^22p^3(^2D)3p$ | $^3D_3$ | 15492238 | 15491533 | -0.78 ( 38) -0.57 ( 29) |
| 39 | $2s^22p^3(^2D)3p$ | $^3F_4$ | 15501268 | 15500531 | 1.00 ( 39) |
| 40 | $2s^22p^3(^4S)3d$ | $^3D_2$ | 15501666 | 15501045 | 0.58 ( 31) -0.51 ( 40) 0.47 ( 92) -0.43 ( 69) |
| 41 | $2s^22p^3(^2P)3s$ | $^3P_2$ | 15524781 | 15524356 | -0.77 ( 41) -0.41 ( 15) 0.37 ( 20) 0.32 ( 11) |
| 42 | $2s^22p^3(^2P)3p$ | $^3D_1$ | 15526011 | 15525328 | -0.73 ( 42) -0.51 ( 68) -0.32 ( 19) 0.32 ( 25) |
| 43 | $2s^22p^3(^2P)3s$ | $^1P_1$ | 15547458 | 15546878 | -0.66 ( 43) -0.52 ( 16) -0.41 ( 24) 0.35 ( 12) |
| 44 | $2s^22p^3(^2D)3p$ | $^3P_1$ | 15570315 | 15569252 | 0.69 ( 44) 0.51 ( 33) -0.43 ( 19) |
| 45 | $2s^22p^3(^4S)3d$ | $^3D_3$ | 15575037 | 15574168 | -0.60 ( 45) -0.52 ( 94) 0.45 ( 56) 0.40 ( 32) |
| 46 | $2s^22p^3(^4S)3d$ | $^3D_1$ | 15589124 | 15588244 | 0.75 ( 46) 0.44 (104) -0.38 ( 79) -0.32 ( 70) |
| 47 | $2s^22p^3(^2D)3p$ | $^1D_2$ | 15630146 | 15629156 | -0.70 ( 47) -0.52 ( 37) 0.35 ( 64) -0.34 ( 73) |
| 48 | $2s^22p^3(^2P)3p$ | $^3P_0$ | 15651362 | 15650106 | 0.78 ( 48) 0.58 ( 81) |
| 49 | $2s^22p^3(^2P)3p$ | $^3P_1$ | 15658815 | 15658182 | 0.66 ( 49) 0.58 ( 58) -0.36 ( 68) 0.32 ( 42) |

**Table 1.** (*continued*)

| Key | Config. | *LS J* | $E_{\rm MCDF}$ | $E_{\rm MBPT}$ | Components |
|---|---|---|---|---|---|
| 50 | $2s^22p^3(^2P)3p$ | $^3D_2$ | 15674341 | 15673498 | 0.79 ( 50) -0.41 ( 64) -0.36 ( 47) |
| 51 | $2s^22p^3(^2D)3d$ | $^3D_1$ | 15825954 | 15825294 | 0.69 ( 51) 0.53 ( 35) 0.37 ( 57) 0.31 ( 46) |
| 52 | $2s^22p^3(^2D)3d$ | $^3F_2$ | 15829031 | 15828356 | 0.69 ( 52) -0.54 ( 31) -0.34 ( 40) -0.34 ( 69) |
| 53 | $2s^22p^3(^2D)3d$ | $^1S_0$ | 15834911 | 15834224 | -0.68 ( 53) 0.58 ( 34) -0.37 ( 66) |
| 54 | $2s^22p^3(^2D)3d$ | $^3F_3$ | 15842304 | 15841671 | 0.69 ( 54) -0.59 ( 32) 0.36 ( 65) |
| 55 | $2s^22p^3(^2D)3d$ | $^3G_4$ | 15853221 | 15852522 | -0.62 ( 36) -0.59 ( 55) 0.44 ( 62) |
| 56 | $2s^22p^3(^2D)3d$ | $^3G_3$ | 15862369 | 15861528 | 0.67 ( 56) 0.61 ( 45) 0.39 ( 65) |
| 57 | $2s^22p^3(^2D)3d$ | $^1P_1$ | 15926840 | 15926023 | -0.58 ( 57) 0.50 ( 46) 0.46 ( 74) 0.44 ( 51) |
| 58 | $2s^22p^3(^2P)3p$ | $^3S_1$ | 15927895 | 15926936 | 0.58 ( 49) -0.56 ( 58) -0.50 ( 44) 0.33 ( 33) |
| 59 | $2s^22p^3(^2D)3d$ | $^3F_4$ | 15930286 | 15929502 | 0.73 ( 59) -0.54 ( 55) -0.42 ( 62) |
| 60 | $2s2p^4(^4P)3s$ | $^5P_3$ | 15934944 | 15935401 | 0.94 ( 60) 0.31 (105) |
| 61 | $2s^22p^3(^2D)3d$ | $^3P_2$ | 15943401 | 15942552 | -0.65 ( 61) 0.51 ( 40) -0.41 ( 52) 0.40 ( 72) |
| 62 | $2s^22p^3(^2D)3d$ | $^1G_4$ | 15951631 | 15950796 | 0.66 ( 62) 0.65 ( 59) 0.36 ( 55) |
| 63 | $2s^22p^3(^2D)3d$ | $^3G_5$ | 15959225 | 15958412 | 1.00 ( 63) |
| 64 | $2s^22p^3(^2P)3p$ | $^1D_2$ | 15965544 | 15964239 | 0.63 ( 64) 0.45 ( 50) 0.45 ( 47) 0.44 ( 26) |
| 65 | $2s^22p^3(^2D)3d$ | $^3D_3$ | 15977477 | 15976549 | -0.73 ( 65) 0.52 ( 54) 0.35 ( 45) |
| 66 | $2s^22p^3(^2D)3d$ | $^3P_0$ | 15991820 | 15990978 | 0.77 ( 66) -0.61 ( 53) |
| 67 | $2s^22p^3(^2P)3p$ | $^3D_3$ | 15998010 | 15997393 | 0.77 ( 67) 0.40 ( 27) -0.36 ( 29) -0.34 ( 17) |
| 68 | $2s^22p^3(^2P)3p$ | $^1P_1$ | 16003608 | 16002889 | -0.69 ( 68) -0.49 ( 25) -0.41 ( 19) -0.33 ( 58) |
| 69 | $2s^22p^3(^2D)3d$ | $^3D_2$ | 16004603 | 16003646 | -0.79 ( 69) 0.44 ( 40) 0.36 ( 61) |
| 70 | $2s^22p^3(^2D)3d$ | $^3P_1$ | 16005213 | 16004291 | -0.73 ( 70) -0.48 ( 57) 0.40 ( 51) |
| 71 | $2s2p^4(^4P)3s$ | $^3P_2$ | 16030394 | 16030140 | -0.83 ( 71) -0.41 ( 82) |
| 72 | $2s^22p^3(^2D)3d$ | $^1D_2$ | 16036511 | 16035805 | -0.56 ( 61) -0.52 ( 72) 0.48 ( 76) 0.43 ( 78) |
| 73 | $2s^22p^3(^2P)3p$ | $^3P_2$ | 16042236 | 16041716 | -0.72 ( 73) -0.42 ( 64) -0.40 ( 82) -0.38 ( 71) |
| 74 | $2s^22p^3(^2D)3d$ | $^3S_1$ | 16044729 | 16043966 | -0.80 ( 74) -0.43 ( 57) 0.40 ( 70) |
| 75 | $2s^22p^3(^2D)3d$ | $^1F_3$ | 16072723 | 16071614 | 0.82 ( 75) 0.41 ( 65) |
| 76 | $2s^22p^3(^2P)3d$ | $^3F_2$ | 16103864 | 16103220 | -0.76 ( 76) -0.46 ( 72) -0.34 ( 96) 0.32 ( 52) |
| 77 | $2s^22p^3(^2P)3d$ | $^3F_3$ | 16138249 | 16137600 | 0.74 ( 77) -0.47 ( 94) 0.43 ( 95) |
| 78 | $2s^22p^3(^2P)3d$ | $^1D_2$ | 16139285 | 16138607 | -0.59 ( 92) -0.56 ( 96) 0.43 ( 78) 0.40 ( 72) |
| 79 | $2s^22p^3(^2P)3d$ | $^3D_1$ | 16170616 | 16169845 | -0.71 ( 79) -0.55 (104) -0.39 ( 93) |
| 80 | $2s2p^4(^4P)3s$ | $^5P_1$ | 16204337 | 16204754 | -0.84 ( 80) -0.49 (113) |
| 81 | $2s^22p^3(^2P)3p$ | $^1S_0$ | 16212673 | 16211031 | 0.72 ( 81) 0.47 ( 30) -0.38 ( 23) -0.34 ( 48) |
| 82 | $2s2p^4(^4P)3s$ | $^5P_2$ | 16224157 | 16224251 | 0.76 ( 82) -0.48 ( 71) -0.32 (121) -0.30 (108) |
| 83 | $2s2p^4(^4P)3s$ | $^3P_1$ | 16275794 | 16275652 | -0.78 ( 83) -0.49 ( 99) |
| 84 | $2s2p^4(^4P)3p$ | $^5P_2$ | 16303367 | 16304212 | -0.75 ( 84) 0.48 (109) 0.34 (103) -0.31 ( 98) |
| 85 | $2s2p^4(^4P)3p$ | $^5P_3$ | 16316644 | 16317443 | -0.61 (106) 0.59 ( 85) -0.49 ( 88) |
| 86 | $2s2p^4(^4P)3s$ | $^3P_0$ | 16330254 | 16329674 | -0.78 ( 86) -0.57 (158) |
| 87 | $2s2p^4(^4P)3p$ | $^5D_4$ | 16422682 | 16423467 | 0.92 ( 87) 0.32 (133) |
| 88 | $2s2p^4(^4P)3p$ | $^3D_3$ | 16431303 | 16432069 | -0.73 ( 88) -0.61 ( 85) |
| 89 | $2s^22p^3(^2P)3d$ | $^3P_0$ | 16442472 | 16441775 | 0.76 ( 89) -0.46 ( 66) -0.32 ( 34) -0.32 ( 53) |
| 90 | $2s^22p^3(^2P)3d$ | $^3F_4$ | 16452083 | 16451488 | -0.77 ( 90) -0.39 ( 55) 0.36 ( 62) 0.35 ( 36) |
| 91 | $2s2p^4(^4P)3p$ | $^5P_1$ | 16455703 | 16455794 | 0.59 ( 93) 0.52 ( 91) 0.46 (112) -0.41 (100) |
| 92 | $2s^22p^3(^2P)3d$ | $^3P_2$ | 16468764 | 16468119 | 0.62 ( 92) 0.54 ( 78) 0.41 ( 69) 0.40 ( 61) |
| 93 | $2s^22p^3(^2P)3d$ | $^3P_1$ | 16468460 | 16468430 | 0.62 ( 93) -0.46 (112) 0.46 (100) -0.44 ( 91) |
| 94 | $2s^22p^3(^2P)3d$ | $^1F_3$ | 16501342 | 16500351 | 0.72 ( 94) 0.46 ( 56) -0.38 ( 45) 0.35 ( 77) |
| 95 | $2s^22p^3(^2P)3d$ | $^3D_3$ | 16510087 | 16509322 | -0.72 ( 95) 0.46 ( 75) 0.37 ( 77) -0.36 ( 54) |
| 96 | $2s^22p^3(^2P)3d$ | $^3D_2$ | 16517955 | 16517420 | 0.63 ( 96) 0.46 ( 78) 0.45 ( 52) 0.44 ( 72) |
| 97 | $2s2p^4(^2D)3s$ | $^3D_2$ | 16525545 | 16525615 | -0.70 ( 97) 0.47 ( 82) 0.42 (121) 0.33 (108) |
| 98 | $2s2p^4(^4P)3p$ | $^3P_2$ | 16537137 | 16537305 | -0.63 (111) 0.53 ( 98) 0.47 (109) -0.31 (103) |
| 99 | $2s2p^4(^2D)3s$ | $^3D_1$ | 16550894 | 16550795 | -0.73 ( 99) 0.58 ( 83) |
| 100 | $2s2p^4(^4P)3p$ | $^3S_1$ | 16566584 | 16567224 | -0.56 (102) 0.54 ( 91) 0.51 (100) 0.36 (146) |
| 101 | $2s2p^4(^4P)3p$ | $^5D_0$ | 16572950 | 16573694 | 0.74 (101) 0.56 (145) 0.34 (139) |
| 102 | $2s2p^4(^4P)3p$ | $^5D_1$ | 16583370 | 16584061 | 0.63 (102) 0.50 (189) 0.46 (100) 0.37 ( 91) |

**Table 1.** (*continued*)

| Key | Config. | *LS J* | $E_{\mathrm{MCDF}}$ | $E_{\mathrm{MBPT}}$ | Components |
|---|---|---|---|---|---|
| 103 | $2s2p^4(^4P)3p$ | $^5D_2$ | 16587433 | 16587922 | -0.66 (103) -0.62 ( 98) -0.31 (122) -0.31 (142) |
| 104 | $2s^22p^3(^2P)3d$ | $^1P_1$ | 16630156 | 16629028 | -0.73 (104) 0.41 ( 46) 0.41 ( 79) -0.35 ( 51) |
| 105 | $2s2p^4(^2D)3s$ | $^3D_3$ | 16629186 | 16629260 | -0.94 (105) 0.33 ( 60) |
| 106 | $2s2p^4(^4P)3p$ | $^5D_3$ | 16681334 | 16682085 | 0.72 (106) 0.46 ( 85) -0.37 ( 88) -0.35 (160) |
| 107 | $2s2p^4(^2D)3p$ | $^3P_0$ | 16687462 | 16688142 | 0.63 (139) -0.59 (107) -0.42 (101) |
| 108 | $2s2p^4(^2D)3s$ | $^1D_2$ | 16693164 | 16692839 | 0.76 (108) 0.51 ( 97) -0.36 ( 71) |
| 109 | $2s2p^4(^4P)3p$ | $^5S_2$ | 16704272 | 16704971 | -0.66 (109) -0.57 ( 84) -0.46 (154) |
| 110 | $2s2p^4(^4P)3p$ | $^3D_1$ | 16738159 | 16738719 | -0.79 (110) -0.47 (185) |
| 111 | $2s2p^4(^4P)3p$ | $^3D_2$ | 16738307 | 16738784 | 0.64 (111) -0.54 (103) 0.39 (122) 0.38 ( 98) |
| 112 | $2s2p^4(^4P)3p$ | $^3P_1$ | 16781492 | 16781867 | -0.65 (112) 0.52 ( 91) -0.40 (120) -0.38 (100) |
| 113 | $2s2p^4(^2S)3s$ | $^3S_1$ | 16803682 | 16803732 | -0.60 (113) -0.57 (155) 0.42 ( 80) 0.37 (123) |
| 114 | $2s2p^4(^4P)3d$ | $^5D_3$ | 16822844 | 16823269 | -0.81 (114) 0.40 (137) 0.35 (147) |
| 115 | $2s2p^4(^2P)3s$ | $^3P_0$ | 16829255 | 16829109 | 0.72 (115) 0.52 (158) -0.44 ( 86) |
| 116 | $2s2p^4(^4P)3d$ | $^5D_4$ | 16830517 | 16830950 | 0.75 (116) -0.58 (141) |
| 117 | $2s2p^4(^4P)3d$ | $^5D_2$ | 16831564 | 16831967 | -0.75 (117) 0.56 (143) |
| 118 | $2s2p^4(^4P)3d$ | $^5P_1$ | 16851264 | 16851646 | -0.73 (118) 0.58 (136) |
| 119 | $2s2p^4(^4P)3d$ | $^5F_5$ | 16863164 | 16863528 | -0.94 (119) -0.35 (170) |
| 120 | $2s2p^4(^2D)3p$ | $^3D_1$ | 16873271 | 16873727 | 0.60 (146) 0.48 (120) -0.46 (132) -0.44 (156) |
| 121 | $2s2p^4(^2P)3s$ | $^3P_2$ | 16892655 | 16892478 | 0.83 (121) -0.44 (108) 0.34 ( 97) |
| 122 | $2s2p^4(^2D)3p$ | $^3F_2$ | 16895817 | 16896257 | -0.77 (122) 0.43 (111) 0.35 ( 98) 0.32 (131) |
| 123 | $2s2p^4(^2P)3s$ | $^1P_1$ | 16899268 | 16899122 | 0.71 (123) 0.51 (155) 0.47 ( 99) |
| 124 | $2s2p^4(^4P)3d$ | $^3F_4$ | 16909573 | 16909631 | -0.85 (124) -0.34 (141) -0.30 (116) |
| 125 | $2s2p^4(^4P)3d$ | $^3P_0$ | 16930139 | 16930337 | -0.67 (125) 0.60 (140) 0.40 (162) |
| 126 | $2s2p^4(^4P)3d$ | $^3P_1$ | 16970941 | 16971097 | 0.60 (118) -0.60 (126) 0.38 (149) 0.36 (136) |
| 127 | $2s2p^4(^2D)3p$ | $^3F_3$ | 16983189 | 16983705 | -0.84 (127) 0.43 (106) |
| 128 | $2s2p^4(^4P)3d$ | $^3F_3$ | 16988985 | 16988974 | 0.66 (128) -0.56 (150) -0.36 (147) 0.33 (137) |
| 129 | $2s2p^4(^4P)3d$ | $^3D_2$ | 17004293 | 17004322 | 0.65 (129) 0.61 (143) -0.38 (153) |
| 130 | $2s2p^4(^2D)3p$ | $^1F_3$ | 17006092 | 17006508 | -0.75 (130) 0.50 (144) 0.31 ( 88) -0.30 (160) |
| 131 | $2s2p^4(^2D)3p$ | $^3D_2$ | 17020314 | 17020761 | -0.76 (131) 0.42 (159) 0.40 (111) |
| 132 | $2s2p^4(^2D)3p$ | $^3P_1$ | 17026187 | 17026561 | -0.66 (132) -0.65 (120) |
| 133 | $2s2p^4(^2D)3p$ | $^3F_4$ | 17099434 | 17099930 | -0.94 (133) 0.34 ( 87) |
| 134 | $2s2p^4(^2D)3p$ | $^3P_2$ | 17100874 | 17100658 | -0.86 (134) -0.31 ( 98) |
| 135 | $2s2p^4(^4P)3d$ | $^5F_2$ | 17108400 | 17108636 | 0.83 (135) 0.46 (201) |
| 136 | $2s2p^4(^4P)3d$ | $^5D_1$ | 17108832 | 17109015 | 0.53 (138) 0.52 (200) 0.49 (126) 0.46 (136) |
| 137 | $2s2p^4(^4P)3d$ | $^5F_3$ | 17111092 | 17111306 | 0.76 (137) 0.40 (184) 0.38 (150) 0.35 (114) |
| 138 | $2s2p^4(^4P)3d$ | $^5F_1$ | 17121286 | 17121475 | 0.77 (138) -0.44 (126) -0.36 (136) |
| 139 | $2s2p^4(^4P)3p$ | $^3P_0$ | 17123316 | 17123388 | 0.66 (139) 0.58 (181) 0.45 (107) |
| 140 | $2s2p^4(^4P)3d$ | $^5D_0$ | 17130062 | 17130147 | -0.70 (140) -0.60 (125) -0.31 (180) |
| 141 | $2s2p^4(^4P)3d$ | $^5F_4$ | 17131164 | 17131339 | 0.65 (141) 0.51 (116) -0.47 (124) -0.32 (192) |
| 142 | $2s2p^4(^2D)3p$ | $^1D_2$ | 17131826 | 17132255 | 0.78 (142) 0.42 (131) 0.36 (134) -0.31 ( 98) |
| 143 | $2s2p^4(^4P)3d$ | $^5P_2$ | 17132767 | 17132879 | 0.56 (117) 0.53 (153) 0.53 (143) -0.37 (129) |
| 144 | $2s2p^4(^2D)3p$ | $^3D_3$ | 17146708 | 17147082 | 0.81 (144) 0.49 (130) |
| 145 | $2s2p^4(^2S)3p$ | $^3P_0$ | 17148181 | 17148615 | 0.59 (145) -0.49 (161) -0.49 (101) -0.42 (181) |
| 146 | $2s2p^4(^2D)3p$ | $^1P_1$ | 17150404 | 17150694 | 0.67 (146) 0.44 (156) 0.43 (112) -0.42 (148) |
| 147 | $2s2p^4(^4P)3d$ | $^5P_3$ | 17156205 | 17156394 | -0.84 (147) -0.33 (128) 0.31 (190) |
| 148 | $2s2p^4(^2P)3p$ | $^3D_1$ | 17182579 | 17182956 | 0.61 (148) 0.51 (146) -0.47 (120) 0.38 (189) |
| 149 | $2s2p^4(^4P)3d$ | $^3D_1$ | 17190145 | 17190214 | 0.74 (149) -0.42 (136) -0.41 (163) -0.33 (174) |
| 150 | $2s2p^4(^4P)3d$ | $^3D_3$ | 17212006 | 17211865 | -0.62 (150) -0.51 (128) -0.47 (165) 0.37 (184) |
| 151 | $2s2p^4(^4P)3d$ | $^3F_2$ | 17215590 | 17215494 | -0.85 (151) -0.42 (202) |
| 152 | $2s2p^4(^2P)3p$ | $^3D_2$ | 17240920 | 17241145 | -0.66 (152) -0.50 (187) -0.40 (122) 0.39 (159) |
| 153 | $2s2p^4(^4P)3d$ | $^3P_2$ | 17278934 | 17278755 | -0.67 (153) -0.53 (129) -0.44 (202) |
| 154 | $2s2p^4(^2S)3p$ | $^3P_2$ | 17278443 | 17278926 | -0.65 (154) -0.51 (152) -0.41 (159) 0.38 (187) |
| 155 | $2s2p^4(^2P)3s$ | $^3P_1$ | 17301215 | 17301224 | -0.60 (155) 0.59 (113) 0.46 (123) |

**Table 1.** (*continued*)

| Key | Config. | *LS J* | $E_{\mathrm{MCDF}}$ | $E_{\mathrm{MBPT}}$ | Components |
|---|---|---|---|---|---|
| 156 | $2s2p^4(^2P)3p$ | $^3P_1$ | 17304350 | 17304699 | 0.54 (157) 0.53 (156) 0.49 (185) -0.43 (110) |
| 157 | $2s2p^4(^2P)3p$ | $^3S_1$ | 17339345 | 17339073 | 0.60 (157) -0.56 (156) 0.46 (132) -0.34 (146) |
| 158 | $2s2p^4(^2S)3s$ | $^1S_0$ | 17351957 | 17351610 | 0.68 (115) -0.63 (158) 0.36 ( 86) |
| 159 | $2s2p^4(^2P)3p$ | $^3P_2$ | 17357264 | 17357590 | -0.64 (159) -0.58 (187) -0.41 (131) |
| 160 | $2s2p^4(^2P)3p$ | $^3D_3$ | 17360676 | 17360977 | 0.86 (160) 0.36 (127) -0.33 (130) |
| 161 | $2s2p^4(^2P)3p$ | $^1S_0$ | 17417166 | 17417170 | -0.71 (161) -0.60 (107) 0.35 (181) |
| 162 | $2s2p^4(^2D)3d$ | $^3P_0$ | 17423893 | 17423747 | -0.64 (162) -0.49 (194) -0.45 (180) 0.39 (140) |
| 163 | $2s2p^4(^2D)3d$ | $^3D_1$ | 17431947 | 17431956 | 0.55 (163) 0.52 (179) -0.49 (193) 0.43 (136) |
| 164 | $2s2p^4(^2D)3d$ | $^3G_4$ | 17432172 | 17432109 | -0.72 (164) 0.42 (192) 0.41 (141) 0.36 (171) |
| 165 | $2s2p^4(^2D)3d$ | $^3G_3$ | 17439779 | 17439633 | -0.76 (165) 0.46 (128) 0.38 (150) |
| 166 | $2s2p^4(^2D)3d$ | $^3F_2$ | 17449888 | 17449772 | -0.71 (166) 0.45 (191) -0.40 (135) -0.37 (178) |
| 167 | $2s2p^4(^2P)3p$ | $^1P_1$ | 17465628 | 17465515 | 0.65 (167) -0.49 (148) 0.43 (157) 0.39 (132) |
| 168 | $2s2p^4(^2D)3d$ | $^3D_2$ | 17476541 | 17476377 | 0.69 (168) 0.51 (173) 0.42 (166) |
| 169 | $2s2p^4(^2D)3d$ | $^3F_3$ | 17481170 | 17481039 | 0.74 (169) -0.46 (190) -0.36 (147) 0.34 (137) |
| 170 | $2s2p^4(^2D)3d$ | $^3G_5$ | 17530304 | 17530206 | -0.94 (170) 0.35 (119) |
| 171 | $2s2p^4(^2D)3d$ | $^1G_4$ | 17539077 | 17538883 | 0.57 (164) 0.56 (171) -0.55 (176) |
| 172 | $2s2p^4(^2D)3d$ | $^3S_1$ | 17550732 | 17550789 | -0.84 (172) -0.33 (149) -0.31 (126) |
| 173 | $2s2p^4(^2D)3d$ | $^3P_2$ | 17577935 | 17577734 | 0.82 (173) -0.47 (168) |
| 174 | $2s2p^4(^2D)3d$ | $^3P_1$ | 17579181 | 17578939 | -0.81 (174) -0.38 (126) -0.32 (149) 0.32 (172) |
| 175 | $2s2p^4(^2D)3d$ | $^3D_3$ | 17582224 | 17582049 | 0.89 (175) -0.31 (169) |
| 176 | $2s2p^4(^2D)3d$ | $^3F_4$ | 17602193 | 17601966 | -0.74 (176) -0.58 (171) |
| 177 | $2s2p^4(^2D)3d$ | $^1F_3$ | 17622158 | 17621878 | 0.76 (177) 0.47 (169) -0.39 (150) |
| 178 | $2s2p^4(^2D)3d$ | $^1D_2$ | 17648896 | 17648589 | -0.76 (178) 0.45 (166) -0.37 (129) |
| 179 | $2s2p^4(^2D)3d$ | $^1P_1$ | 17658833 | 17658585 | -0.70 (179) 0.45 (163) 0.45 (149) 0.32 (182) |
| 180 | $2s2p^4(^2D)3d$ | $^1S_0$ | 17700067 | 17699363 | -0.76 (180) 0.48 (162) 0.42 (125) |
| 181 | $2s2p^4(^2P)3p$ | $^3P_0$ | 17706780 | 17706830 | 0.63 (145) 0.59 (181) 0.43 (161) |
| 182 | $2s2p^4(^2P)3d$ | $^3D_1$ | 17711165 | 17711013 | 0.62 (182) -0.53 (200) -0.46 (163) 0.34 (138) |
| 183 | $2s2p^4(^2P)3d$ | $^3F_2$ | 17726440 | 17726274 | 0.66 (183) 0.59 (201) -0.35 (191) -0.32 (153) |
| 184 | $2s2p^4(^2S)3d$ | $^3D_3$ | 17730476 | 17730376 | 0.65 (184) 0.49 (190) -0.43 (199) 0.40 (188) |
| 185 | $2s2p^4(^2S)3p$ | $^1P_1$ | 17732250 | 17732136 | -0.60 (148) 0.56 (185) -0.47 (167) 0.32 (189) |
| 186 | $2s2p^4(^2P)3d$ | $^3P_2$ | 17762886 | 17762638 | -0.64 (186) -0.54 (202) 0.40 (151) -0.37 (191) |
| 187 | $2s2p^4(^2P)3p$ | $^1D_2$ | 17779934 | 17780334 | -0.63 (154) 0.55 (152) -0.48 (187) |
| 188 | $2s2p^4(^2P)3d$ | $^3F_3$ | 17787710 | 17787331 | 0.71 (188) 0.46 (199) 0.38 (165) 0.37 (177) |
| 189 | $2s2p^4(^2S)3p$ | $^3P_1$ | 17801330 | 17801548 | -0.52 (156) -0.50 (157) -0.50 (189) 0.47 (167) |
| 190 | $2s2p^4(^2P)3d$ | $^3D_3$ | 17809331 | 17809006 | -0.62 (190) -0.58 (199) -0.38 (169) 0.37 (177) |
| 191 | $2s2p^4(^2P)3d$ | $^3D_2$ | 17819138 | 17818775 | 0.68 (191) -0.50 (186) 0.45 (178) |
| 192 | $2s2p^4(^2P)3d$ | $^3F_4$ | 17820430 | 17820077 | 0.85 (192) -0.38 (171) 0.31 (164) |
| 193 | $2s2p^4(^2P)3d$ | $^3P_1$ | 17842303 | 17841929 | 0.83 (193) 0.34 (179) 0.32 (163) |
| 194 | $2s2p^4(^2P)3d$ | $^3P_0$ | 17854907 | 17854343 | 0.83 (194) -0.46 (162) |
| 195 | $2s2p^4(^2P)3d$ | $^1D_2$ | 17900150 | 17899404 | 0.76 (195) -0.49 (183) 0.33 (168) |
| 196 | $2s2p^4(^2P)3d$ | $^1P_1$ | 17901727 | 17901304 | -0.78 (196) 0.39 (182) -0.37 (174) -0.31 (179) |
| 197 | $2p^5(^2P)3s$ | $^3P_2$ | 18058707 | 18059226 | -0.98 (197) |
| 198 | $2p^5(^2P)3s$ | $^1P_1$ | 18089057 | 18089401 | -0.77 (198) -0.61 (208) |
| 199 | $2s2p^4(^2P)3d$ | $^1F_3$ | 18226811 | 18226584 | 0.62 (184) -0.53 (188) 0.48 (199) -0.32 (190) |
| 200 | $2s2p^4(^2S)3d$ | $^3D_1$ | 18250135 | 18249803 | 0.61 (200) 0.54 (196) 0.47 (182) 0.32 (193) |
| 201 | $2s2p^4(^2S)3d$ | $^3D_2$ | 18256828 | 18256422 | 0.58 (186) 0.56 (201) -0.48 (195) 0.35 (191) |
| 202 | $2s2p^4(^2S)3d$ | $^1D_2$ | 18277093 | 18276672 | -0.66 (202) 0.63 (183) 0.31 (195) |
| 203 | $2p^5(^2P)3p$ | $^3S_1$ | 18382906 | 18383370 | -0.74 (203) 0.62 (218) |
| 204 | $2p^5(^2P)3p$ | $^3D_2$ | 18406738 | 18406984 | -0.73 (204) -0.56 (219) 0.38 (209) |
| 205 | $2p^5(^2P)3p$ | $^3D_3$ | 18506306 | 18506726 | -0.99 (205) |
| 206 | $2p^5(^2P)3p$ | $^1P_1$ | 18511986 | 18512349 | 0.76 (206) 0.47 (203) -0.38 (211) |
| 207 | $2p^5(^2P)3s$ | $^3P_0$ | 18512727 | 18513268 | 0.99 (207) |
| 208 | $2p^5(^2P)3s$ | $^3P_1$ | 18531960 | 18532378 | 0.78 (208) -0.61 (198) |

**Table 1.** (*continued*)

| Key | Config. | *LS J* | $E_{\rm MCDF}$ | $E_{\rm MBPT}$ | Components |
|---|---|---|---|---|---|
| 209 | $2p^5(^2P)3p$ | $^3P_2$ | 18548871 | 18549090 | -0.81 (209) -0.57 (219) |
| 210 | $2p^5(^2P)3p$ | $^3P_0$ | 18676441 | 18676152 | -0.84 (210) 0.53 (221) |
| 211 | $2p^5(^2P)3p$ | $^3D_1$ | 18851822 | 18852158 | -0.84 (211) -0.51 (206) |
| 212 | $2p^5(^2P)3d$ | $^3P_0$ | 18884956 | 18885600 | 0.99 (212) |
| 213 | $2p^5(^2P)3d$ | $^3P_1$ | 18904716 | 18905328 | 0.91 (213) -0.40 (222) |
| 214 | $2p^5(^2P)3d$ | $^3F_3$ | 18929439 | 18929847 | 0.76 (214) 0.59 (225) |
| 215 | $2p^5(^2P)3d$ | $^3F_4$ | 18936841 | 18937354 | -0.99 (215) |
| 216 | $2p^5(^2P)3d$ | $^3P_2$ | 18941406 | 18941948 | -0.69 (216) 0.68 (224) |
| 217 | $2p^5(^2P)3d$ | $^1D_2$ | 18965104 | 18965534 | -0.77 (217) 0.47 (223) -0.35 (216) |
| 218 | $2p^5(^2P)3p$ | $^3P_1$ | 18976494 | 18976862 | 0.75 (218) 0.47 (203) -0.36 (206) |
| 219 | $2p^5(^2P)3p$ | $^1D_2$ | 18984172 | 18984493 | -0.68 (204) 0.59 (219) -0.43 (209) |
| 220 | $2p^5(^2P)3d$ | $^3D_3$ | 18993339 | 18993740 | 0.82 (220) 0.54 (225) |
| 221 | $2p^5(^2P)3p$ | $^1S_0$ | 19034240 | 19032934 | 0.84 (221) 0.53 (210) |
| 222 | $2p^5(^2P)3d$ | $^3D_1$ | 19091624 | 19091714 | -0.70 (222) 0.65 (226) |
| 223 | $2p^5(^2P)3d$ | $^3F_2$ | 19384302 | 19384732 | -0.84 (223) -0.48 (217) |
| 224 | $2p^5(^2P)3d$ | $^3D_2$ | 19418844 | 19419338 | -0.64 (224) -0.63 (216) 0.41 (217) |
| 225 | $2p^5(^2P)3d$ | $^1F_3$ | 19427227 | 19427623 | 0.63 (214) -0.59 (225) 0.50 (220) |
| 226 | $2p^5(^2P)3d$ | $^1P_1$ | 19499126 | 19499086 | -0.75 (226) -0.59 (222) |
| 227 | $2s^22p^3(^4S)4s$ | $^5S_2$ | 19749161 | 19748169 | 0.70 (227) 0.59 (312) -0.32 (240) |
| 228 | $2s^22p^3(^4S)4s$ | $^3S_1$ | 19764533 | 19763518 | 0.68 (228) 0.48 (313) -0.44 (242) 0.35 (262) |
| 229 | $2s^22p^3(^4S)4p$ | $^5P_1$ | 19898904 | 19897675 | 0.72 (229) -0.47 (279) 0.36 (260) 0.36 (321) |
| 230 | $2s^22p^3(^4S)4p$ | $^5P_2$ | 19901688 | 19900478 | 0.65 (230) 0.48 (280) 0.46 (233) -0.38 (256) |
| 231 | $2s^22p^3(^4S)4p$ | $^5P_3$ | 19948690 | 19947497 | 0.70 (231) 0.59 (323) -0.31 (263) |
| 232 | $2s^22p^3(^4S)4p$ | $^3P_1$ | 19953404 | 19952136 | -0.67 (232) 0.48 (324) 0.42 (321) -0.38 (267) |
| 233 | $2s^22p^3(^4S)4p$ | $^3P_2$ | 19981539 | 19980134 | -0.59 (233) 0.48 (230) -0.47 (325) -0.44 (322) |
| 234 | $2s^22p^3(^4S)4p$ | $^3P_0$ | 20006087 | 20004476 | 0.71 (234) 0.45 (326) -0.39 (259) -0.38 (278) |
| 235 | $2s^22p^3(^4S)4d$ | $^5D_2$ | 20108555 | 20107573 | 0.64 (235) -0.48 (332) 0.43 (241) 0.41 (270) |
| 236 | $2s^22p^3(^4S)4d$ | $^5D_3$ | 20112293 | 20111285 | -0.71 (236) -0.48 (315) 0.40 (333) 0.32 (274) |
| 237 | $2s^22p^3(^4S)4d$ | $^5D_1$ | 20115937 | 20114970 | 0.74 (237) 0.50 (329) -0.35 (316) |
| 238 | $2s^22p^3(^4S)4d$ | $^5D_0$ | 20116187 | 20115186 | -0.71 (238) -0.58 (327) |
| 239 | $2s^22p^3(^4S)4d$ | $^5D_4$ | 20122708 | 20121688 | 0.71 (239) 0.59 (328) |
| 240 | $2s^22p^3(^2D)4s$ | $^3D_2$ | 20131176 | 20130100 | -0.61 (227) -0.55 (240) 0.41 (254) -0.40 (241) |
| 241 | $2s^22p^3(^4S)4d$ | $^3D_2$ | 20143025 | 20141931 | 0.53 (241) -0.50 (227) -0.49 (240) -0.48 (235) |
| 242 | $2s^22p^3(^2D)4s$ | $^3D_1$ | 20144713 | 20143559 | 0.73 (242) 0.65 (228) |
| 243 | $2s^22p^3(^4S)4d$ | $^3D_3$ | 20163574 | 20162432 | -0.67 (243) -0.50 (331) -0.41 (333) 0.35 (274) |
| 244 | $2s^22p^3(^4S)4d$ | $^3D_1$ | 20169558 | 20168388 | 0.74 (244) 0.49 (335) -0.33 (295) -0.31 (316) |
| 245 | $2s^22p^3(^4S)4f$ | $^5F_3$ | 20222982 | 20221693 | 0.60 (245) 0.51 (249) -0.46 (341) 0.42 (284) |
| 246 | $2s^22p^3(^4S)4f$ | $^5F_4$ | 20226540 | 20225205 | 0.72 (246) 0.47 (319) -0.41 (344) |
| 247 | $2s^22p^3(^4S)4f$ | $^5F_2$ | 20227164 | 20225887 | -0.71 (247) 0.47 (318) -0.40 (339) 0.34 (285) |
| 248 | $2s^22p^3(^4S)4f$ | $^5F_1$ | 20232460 | 20231172 | 0.71 (248) 0.60 (337) |
| 249 | $2s^22p^3(^4S)4f$ | $^3F_3$ | 20232591 | 20231262 | -0.60 (249) 0.52 (245) 0.45 (320) 0.42 (343) |
| 250 | $2s^22p^3(^2D)4f$ | $^1H_5$ | 20232694 | 20231310 | 0.70 (290) 0.59 (340) |
| 251 | $2s^22p^3(^4S)4f$ | $^3F_4$ | 20233004 | 20231532 | -0.71 (251) -0.50 (338) -0.37 (344) 0.32 (288) |
| 252 | $2s^22p^3(^2D)4s$ | $^3D_3$ | 20238980 | 20237859 | 1.00 (252) |
| 253 | $2s^22p^3(^4S)4f$ | $^3F_2$ | 20240673 | 20239278 | 0.70 (253) 0.48 (342) -0.41 (339) -0.35 (294) |
| 254 | $2s^22p^3(^2D)4s$ | $^1D_2$ | 20246543 | 20245433 | -0.79 (254) -0.61 (240) |
| 255 | $2s^22p^3(^2D)4p$ | $^1P_1$ | 20280163 | 20278801 | -0.62 (229) 0.55 (260) 0.46 (255) -0.32 (267) |
| 256 | $2s^22p^3(^2D)4p$ | $^3F_2$ | 20298424 | 20296997 | 0.67 (256) 0.49 (233) 0.46 (230) -0.30 (258) |
| 257 | $2s^22p^3(^2D)4p$ | $^1F_3$ | 20334010 | 20332706 | -0.64 (231) -0.57 (263) 0.45 (257) |
| 258 | $2s^22p^3(^2D)4p$ | $^3D_2$ | 20336294 | 20334926 | 0.63 (258) 0.50 (233) -0.48 (230) 0.34 (256) |
| 259 | $2s^22p^3(^2D)4p$ | $^3P_0$ | 20340695 | 20339303 | 0.76 (259) 0.60 (234) |
| 260 | $2s^22p^3(^2D)4p$ | $^3D_1$ | 20370577 | 20369033 | 0.62 (232) -0.56 (260) -0.40 (267) 0.39 (255) |
| 261 | $2s^22p^3(^2P)4s$ | $^3P_0$ | 20372746 | 20371610 | 0.99 (261) |

**Table 1.** (*continued*)

| Key | Config. | *LS J* | $E_{MCDF}$ | $E_{MBPT}$ | Components |
|---|---|---|---|---|---|
| 262 | $2s^22p^3(^2P)4s$ | $^3P_1$ | 20377097 | 20376014 | 0.82 (262) -0.57 (313) |
| 263 | $2s^22p^3(^2D)4p$ | $^3F_3$ | 20387238 | 20385928 | -0.62 (263) -0.55 (257) 0.55 (265) |
| 264 | $2s^22p^3(^2D)4p$ | $^3P_2$ | 20414024 | 20412438 | 0.75 (264) -0.52 (258) -0.39 (268) |
| 265 | $2s^22p^3(^2D)4p$ | $^3D_3$ | 20435203 | 20433882 | 0.80 (265) 0.56 (257) |
| 266 | $2s^22p^3(^2D)4p$ | $^3F_4$ | 20437076 | 20435780 | -1.00 (266) |
| 267 | $2s^22p^3(^2D)4p$ | $^3P_1$ | 20447319 | 20445800 | -0.70 (255) -0.65 (267) |
| 268 | $2s^22p^3(^2D)4p$ | $^1D_2$ | 20484393 | 20482743 | -0.75 (268) -0.57 (264) |
| 269 | $2s^22p^3(^2D)4d$ | $^3D_1$ | 20497287 | 20496184 | 0.64 (269) 0.57 (237) 0.32 (244) |
| 270 | $2s^22p^3(^2D)4d$ | $^3F_2$ | 20501658 | 20500483 | -0.65 (270) 0.61 (235) -0.34 (297) 0.31 (241) |
| 271 | $2s^22p^3(^2D)4d$ | $^3P_0$ | 20502120 | 20501020 | 0.62 (238) -0.56 (293) -0.49 (271) |
| 272 | $2s^22p^3(^2D)4d$ | $^1G_4$ | 20508536 | 20507371 | 0.65 (239) 0.55 (281) -0.47 (272) |
| 273 | $2s^22p^3(^2D)4d$ | $^3F_3$ | 20508760 | 20507581 | 0.63 (236) -0.60 (273) -0.39 (282) 0.30 (298) |
| 274 | $2s^22p^3(^2D)4d$ | $^3G_3$ | 20514654 | 20513383 | -0.72 (274) -0.65 (243) |
| 275 | $2s^22p^3(^2P)4p$ | $^3D_1$ | 20522040 | 20520760 | 0.85 (275) 0.48 (324) |
| 276 | $2s^22p^3(^2D)4p$ | $^3S_1$ | 20538765 | 20537583 | 0.61 (244) 0.53 (295) 0.48 (296) |
| 277 | $2s^22p^3(^2D)4d$ | $^3P_2$ | 20547363 | 20546078 | -0.66 (241) 0.46 (292) 0.44 (277) 0.40 (270) |
| 278 | $2s^22p^3(^2P)4p$ | $^3P_0$ | 20564782 | 20563055 | 0.82 (278) 0.57 (326) |
| 279 | $2s^22p^3(^2P)4p$ | $^3P_1$ | 20579100 | 20577758 | -0.71 (279) -0.54 (321) 0.34 (324) -0.31 (275) |
| 280 | $2s^22p^3(^2P)4p$ | $^3D_2$ | 20583019 | 20581674 | 0.73 (280) -0.55 (322) 0.40 (325) |
| 281 | $2s^22p^3(^2D)4d$ | $^3G_4$ | 20599704 | 20598556 | 0.64 (281) -0.60 (283) 0.47 (272) |
| 282 | $2s^22p^3(^2D)4d$ | $^3D_3$ | 20609290 | 20608083 | 0.73 (282) -0.63 (273) |
| 283 | $2s^22p^3(^2D)4d$ | $^3F_4$ | 20609403 | 20608250 | -0.74 (283) -0.62 (272) |
| 284 | $2s^22p^3(^2D)4f$ | $^3G_3$ | 20610109 | 20608616 | -0.63 (284) 0.56 (245) 0.39 (249) -0.38 (309) |
| 285 | $2s^22p^3(^2D)4f$ | $^3F_2$ | 20611819 | 20610386 | 0.59 (247) 0.59 (285) 0.43 (310) 0.35 (253) |
| 286 | $2s^22p^3(^2D)4d$ | $^3G_5$ | 20611731 | 20610587 | -1.00 (286) |
| 287 | $2s^22p^3(^2D)4f$ | $^1G_4$ | 20612761 | 20611209 | 0.61 (288) 0.59 (246) 0.39 (287) 0.35 (251) |
| 288 | $2s^22p^3(^2D)4f$ | $^3H_4$ | 20615122 | 20613601 | 0.62 (251) 0.53 (300) 0.44 (288) -0.38 (246) |
| 289 | $2s^22p^3(^2D)4f$ | $^3P_1$ | 20616798 | 20615375 | 0.65 (248) -0.50 (308) -0.46 (305) -0.34 (289) |
| 290 | $2s^22p^3(^4S)4f$ | $^5F_5$ | 20616951 | 20615413 | -0.66 (290) -0.53 (299) 0.48 (250) |
| 291 | $2s^22p^3(^2D)4f$ | $^3D_3$ | 20619528 | 20618016 | 0.58 (249) -0.50 (301) -0.50 (291) -0.40 (245) |
| 292 | $2s^22p^3(^2D)4d$ | $^3D_2$ | 20619504 | 20618321 | 0.74 (292) -0.56 (277) 0.30 (297) |
| 293 | $2s^22p^3(^2D)4d$ | $^1S_0$ | 20620871 | 20619763 | 0.71 (293) -0.70 (271) |
| 294 | $2s^22p^3(^2D)4f$ | $^3P_2$ | 20624082 | 20622594 | -0.62 (294) -0.58 (253) -0.41 (302) 0.33 (247) |
| 295 | $2s^22p^3(^2D)4d$ | $^3P_1$ | 20624156 | 20623015 | -0.63 (295) 0.50 (269) |
| 296 | $2s^22p^3(^2D)4d$ | $^3S_1$ | 20640964 | 20639859 | 0.78 (296) -0.39 (295) |
| 297 | $2s^22p^3(^2D)4d$ | $^1D_2$ | 20648594 | 20647363 | 0.76 (297) 0.59 (277) |
| 298 | $2s^22p^3(^2D)4d$ | $^1F_3$ | 20651518 | 20650176 | 0.81 (298) 0.48 (282) |
| 299 | $2s^22p^3(^2D)4f$ | $^3H_5$ | 20712411 | 20710767 | -0.71 (299) -0.67 (250) |
| 300 | $2s^22p^3(^2D)4f$ | $^3G_4$ | 20714509 | 20712991 | 0.73 (300) -0.46 (307) 0.43 (287) |
| 301 | $2s^22p^3(^2D)4f$ | $^3F_3$ | 20715441 | 20713993 | -0.74 (301) 0.43 (284) -0.37 (309) 0.36 (291) |
| 302 | $2s^22p^3(^2D)4f$ | $^3D_2$ | 20716980 | 20715561 | -0.69 (302) 0.60 (285) -0.33 (310) |
| 303 | $2s^22p^3(^2D)4f$ | $^3H_6$ | 20717639 | 20716008 | -1.00 (303) |
| 304 | $2s^22p^3(^2D)4f$ | $^3G_5$ | 20718396 | 20716873 | 0.92 (304) 0.38 (250) |
| 305 | $2s^22p^3(^2D)4f$ | $^3D_1$ | 20718539 | 20717139 | -0.75 (305) 0.60 (289) |
| 306 | $2s^22p^3(^2D)4f$ | $^3P_0$ | 20719674 | 20718285 | -1.00 (306) |
| 307 | $2s^22p^3(^2D)4f$ | $^3F_4$ | 20721756 | 20720223 | 0.73 (307) 0.66 (287) |
| 308 | $2s^22p^3(^2D)4f$ | $^1P_1$ | 20723534 | 20722156 | -0.71 (308) 0.65 (289) |
| 309 | $2s^22p^3(^2D)4f$ | $^1F_3$ | 20723739 | 20722252 | -0.70 (309) -0.66 (291) |
| 310 | $2s^22p^3(^2D)4f$ | $^1D_2$ | 20724126 | 20722693 | -0.70 (310) -0.56 (294) 0.37 (302) |
| 311 | $2s^22p^3(^2P)4d$ | $^3F_2$ | 20736636 | 20735568 | 0.85 (311) 0.47 (330) |
| 312 | $2s^22p^3(^2P)4s$ | $^3P_2$ | 20745352 | 20744084 | 0.76 (312) 0.41 (240) 0.37 (332) -0.35 (254) |
| 313 | $2s^22p^3(^2P)4s$ | $^1P_1$ | 20754528 | 20753111 | 0.64 (313) 0.54 (242) 0.44 (262) -0.34 (228) |
| 314 | $2s^22p^3(^2P)4d$ | $^3P_2$ | 20760269 | 20759097 | 0.64 (314) 0.56 (332) -0.38 (312) -0.37 (330) |

**Table 1.** (*continued*)

| Key | Config. | $LS\,J$ | $E_{\rm MCDF}$ | $E_{\rm MBPT}$ | Components |
|---|---|---|---|---|---|
| 315 | $2s^22p^3(^2P)4d$ | $^3F_3$ | 20761183 | 20760104 | -0.69 (315) 0.55 (331) -0.47 (333) |
| 316 | $2s^22p^3(^2P)4d$ | $^3D_1$ | 20767831 | 20766594 | -0.72 (316) -0.56 (335) -0.40 (329) |
| 317 | $2s^22p^3(^2P)4f$ | $^3G_3$ | 20848652 | 20847234 | 0.85 (317) 0.44 (343) |
| 318 | $2s^22p^3(^2P)4f$ | $^3F_2$ | 20851963 | 20850619 | -0.68 (318) -0.56 (342) -0.46 (339) |
| 319 | $2s^22p^3(^2P)4f$ | $^3G_4$ | 20855212 | 20853725 | 0.64 (319) -0.57 (338) 0.51 (344) |
| 320 | $2s^22p^3(^2P)4f$ | $^3D_3$ | 20855624 | 20854300 | 0.72 (320) 0.55 (341) -0.40 (343) |
| 321 | $2s^22p^3(^2P)4p$ | $^3S_1$ | 20907637 | 20905883 | -0.60 (279) 0.59 (321) 0.39 (267) -0.38 (255) |
| 322 | $2s^22p^3(^2P)4p$ | $^1D_2$ | 20915493 | 20913710 | -0.57 (280) -0.56 (322) -0.52 (256) 0.31 (325) |
| 323 | $2s^22p^3(^2P)4p$ | $^3D_3$ | 20941578 | 20939987 | 0.78 (323) 0.40 (263) -0.35 (257) -0.33 (231) |
| 324 | $2s^22p^3(^2P)4p$ | $^1P_1$ | 20943421 | 20941792 | 0.69 (324) 0.48 (260) 0.38 (321) 0.38 (232) |
| 325 | $2s^22p^3(^2P)4p$ | $^3P_2$ | 20957300 | 20955716 | -0.71 (325) -0.46 (322) -0.43 (258) 0.30 (268) |
| 326 | $2s^22p^3(^2P)4p$ | $^1S_0$ | 21014194 | 21011889 | 0.66 (326) 0.52 (259) -0.41 (278) -0.35 (234) |
| 327 | $2s^22p^3(^2P)4d$ | $^3P_0$ | 21109421 | 21107999 | -0.77 (327) 0.43 (271) 0.34 (293) 0.33 (238) |
| 328 | $2s^22p^3(^2P)4d$ | $^3F_4$ | 21114277 | 21112777 | -0.78 (328) -0.39 (281) 0.36 (272) 0.34 (239) |
| 329 | $2s^22p^3(^2P)4d$ | $^3P_1$ | 21116309 | 21114915 | -0.77 (329) 0.37 (316) 0.36 (237) |
| 330 | $2s^22p^3(^2P)4d$ | $^1D_2$ | 21120912 | 21119531 | -0.61 (314) -0.56 (330) -0.43 (292) -0.36 (277) |
| 331 | $2s^22p^3(^2P)4d$ | $^1F_3$ | 21126535 | 21124963 | -0.60 (331) -0.52 (315) -0.51 (274) 0.32 (243) |
| 332 | $2s^22p^3(^2P)4d$ | $^3D_2$ | 21134881 | 21133383 | -0.62 (332) -0.51 (270) -0.46 (330) 0.39 (311) |
| 333 | $2s^22p^3(^2P)4d$ | $^3D_3$ | 21135052 | 21133675 | -0.76 (333) -0.42 (273) 0.36 (298) -0.35 (331) |
| 334 | $2s2p^4(^4P)4s$ | $^5P_3$ | 21144170 | 21144127 | -0.94 (334) -0.34 (400) |
| 335 | $2s^22p^3(^2P)4d$ | $^1P_1$ | 21174971 | 21173255 | -0.71 (335) 0.45 (316) 0.39 (244) -0.38 (269) |
| 336 | $2s2p^4(^4P)4s$ | $^3P_2$ | 21177183 | 21176693 | 0.87 (336) 0.34 (351) |
| 337 | $2s^22p^3(^2P)4f$ | $^3D_1$ | 21217038 | 21215400 | -0.80 (337) 0.36 (308) 0.35 (248) 0.34 (305) |
| 338 | $2s^22p^3(^2P)4f$ | $^1G_4$ | 21220010 | 21218097 | 0.57 (338) 0.55 (319) 0.53 (288) -0.30 (251) |
| 339 | $2s^22p^3(^2P)4f$ | $^3D_2$ | 21222141 | 21220487 | -0.76 (339) 0.43 (294) -0.34 (310) 0.34 (247) |
| 340 | $2s^22p^3(^2P)4f$ | $^3G_5$ | 21223374 | 21221500 | -0.78 (340) -0.38 (299) 0.35 (250) 0.34 (290) |
| 341 | $2s^22p^3(^2P)4f$ | $^3F_3$ | 21230083 | 21228346 | -0.71 (341) 0.42 (320) -0.40 (284) -0.40 (309) |
| 342 | $2s^22p^3(^2P)4f$ | $^1D_2$ | 21230686 | 21228905 | 0.64 (342) -0.56 (318) 0.41 (285) 0.34 (302) |
| 343 | $2s^22p^3(^2P)4f$ | $^1F_3$ | 21232007 | 21230274 | -0.71 (343) -0.44 (320) -0.40 (301) -0.38 (249) |
| 344 | $2s^22p^3(^2P)4f$ | $^3F_4$ | 21235534 | 21233743 | 0.76 (344) 0.41 (300) 0.36 (338) -0.35 (287) |

**Table 2.** Excitation energies in $cm^{-1}$ for the $2s^22p^4$, $2s2p^5$, and $2p^6$ configurations of Kr XXIX as a function of increasing AS.

| Config. | *LS J* | MR | AS1 | AS2 | AS3 | AS4 | AS5 | AS5 (RCI) |
|---|---|---|---|---|---|---|---|---|
| $2s^22p^4$ | $^3P_2$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| $2s^22p^4$ | $^3P_0$ | 154792 | 155759 | 155045 | 154785 | 154687 | 154650 | 159993 |
| $2s^22p^4$ | $^3P_1$ | 427201 | 427335 | 428104 | 428184 | 428228 | 428244 | 424128 |
| $2s^22p^4$ | $^1D_2$ | 536485 | 535894 | 535403 | 535265 | 535204 | 535187 | 525261 |
| $2s^22p^4$ | $^1S_0$ | 1030242 | 1031165 | 1031265 | 1031055 | 1030987 | 1030962 | 1020259 |
| $2s2p^5$ | $^3P_2$ | 1694219 | 1690691 | 1684972 | 1684836 | 1685141 | 1685131 | 1674341 |
| $2s2p^5$ | $^3P_1$ | 1887081 | 1883357 | 1876112 | 1875858 | 1876135 | 1876114 | 1864481 |
| $2s2p^5$ | $^3P_0$ | 2159135 | 2156142 | 2150533 | 2150418 | 2150736 | 2150733 | 2134878 |
| $2s2p^5$ | $^1P_1$ | 2411520 | 2407399 | 2396471 | 2395962 | 2396178 | 2396131 | 2378285 |
| $2p^6$ | $^1S_0$ | 3833756 | 3804648 | 3800013 | 3799087 | 3798817 | 3798720 | 3779450 |

**Table 3.** Energy levels (in $cm^{-1}$) relative to the ground state for the lowest 344 states of Kr XXIX. For brevity, energies other than the present MCDF excitation energies are listed as differences from the latter ones in $cm^{-1}$. $E_{\mathrm{MCDF}}$, $\Delta E_{\mathrm{MBPT}}$–the present values; $\Delta E_{\mathrm{NIST}}$–Kramida et al. [12]; $\Delta E_{\mathrm{MCDF2}}$–Rynkun et al. [19]; $\Delta E_{\mathrm{MRMP}}$– Vilkas et al. [36]; $\Delta E_{\mathrm{GRASP1}}$, $\Delta E_{\mathrm{FAC}}$– Aggarwal et al. [20]. $\Delta E_x = \Delta E_x - E_{\mathrm{MCDF}}$. The NIST excitation energies have an uncertainty of ≤1 000 $cm^{-1}$ for the $n = 2$ levels except for the $2s^22p^4\ {}^3P_0$ and $2s2p^5\ {}^3P_0$ levels with 1 500 $cm^{-1}$ uncertainty. The NIST excitation energies have 1 900 $cm^{-1}$ - 2 500 $cm^{-1}$ uncertainty for the $n \geq 3$ levels [11].

| Key | Config. | LS J | $E_{\mathrm{MCDF}}$ | $\Delta E_{\mathrm{MBPT}}$ | $\Delta E_{\mathrm{NIST}}$ | $\Delta E_{\mathrm{MCDF2}}$ | $\Delta E_{\mathrm{MRMP}}$ | $\Delta E_{\mathrm{GRASP1}}$ | $\Delta E_{\mathrm{FAC}}$ |
|---|---|---|---|---|---|---|---|---|---|
| 1 | $2s^22p^4$ | $^3P_2$ | 0 | | | | | | |
| 2 | $2s^22p^4$ | $^3P_0$ | 159993 | -116 | 707 | 31 | 95 | 365 | 392 |
| 3 | $2s^22p^4$ | $^3P_1$ | 424128 | 166 | -308 | -228 | 57 | -1806 | -1510 |
| 4 | $2s^22p^4$ | $^1D_2$ | 525261 | -6 | -371 | -252 | -51 | 515 | 392 |
| 5 | $2s^22p^4$ | $^1S_0$ | 1020259 | 119 | | -394 | -27 | -2130 | -1660 |
| 6 | $2s2p^5$ | $^3P_2$ | 1674341 | 612 | 309 | 490 | 1941 | 11593 | 10949 |
| 7 | $2s2p^5$ | $^3P_1$ | 1864481 | 575 | -161 | 440 | 1978 | 13658 | 12687 |
| 8 | $2s2p^5$ | $^3P_0$ | 2134878 | 738 | -1078 | 250 | 1961 | 10174 | 9699 |
| 9 | $2s2p^5$ | $^1P_1$ | 2378285 | 523 | -585 | 282 | 1864 | 18563 | 16611 |
| 10 | $2p^6$ | $^1S_0$ | 3779450 | -67 | | 549 | 4791 | 39591 | 35588 |
| 11 | $2s^22p^3(^4S)3s$ | $^5S_2$ | 14524170 | -247 | | | | -11004 | -6958 |
| 12 | $2s^22p^3(^4S)3s$ | $^3S_1$ | 14570414 | -521 | | | | -9355 | -3753 |
| 13 | $2s^22p^3(^4S)3p$ | $^5P_1$ | 14883016 | -519 | | | | -9346 | -5280 |
| 14 | $2s^22p^3(^4S)3p$ | $^5P_2$ | 14892369 | -564 | | | | -9260 | -4787 |
| 15 | $2s^22p^3(^2D)3s$ | $^3D_2$ | 14912895 | -416 | | | | -9627 | -6044 |
| 16 | $2s^22p^3(^2D)3s$ | $^3D_1$ | 14942904 | -648 | | | | -8645 | -3524 |
| 17 | $2s^22p^3(^4S)3p$ | $^5P_3$ | 15007888 | -484 | | | | -9773 | -5551 |
| 18 | $2s^22p^3(^2D)3s$ | $^3D_3$ | 15015517 | -489 | | | | -7914 | -5058 |
| 19 | $2s^22p^3(^4S)3p$ | $^3P_1$ | 15015632 | -581 | | | | -8787 | -4953 |
| 20 | $2s^22p^3(^2D)3s$ | $^1D_2$ | 15043510 | -658 | | | | -7044 | -2994 |
| 21 | $2s^22p^3(^4S)3p$ | $^3P_2$ | 15090290 | -842 | | | | -6495 | -1359 |
| 22 | $2s^22p^3(^2P)3s$ | $^3P_0$ | 15151616 | -201 | | | | -12339 | -10994 |
| 23 | $2s^22p^3(^4S)3p$ | $^3P_0$ | 15159798 | -1073 | | | | -4738 | 570 |
| 24 | $2s^22p^3(^2P)3s$ | $^3P_1$ | 15164439 | -286 | | | | -11887 | -10016 |
| 25 | $2s^22p^3(^2D)3p$ | $^3D_1$ | 15259543 | -656 | | | | -8166 | -4802 |
| 26 | $2s^22p^3(^2D)3p$ | $^3F_2$ | 15300804 | -769 | | | | -6991 | -3395 |
| 27 | $2s^22p^3(^2D)3p$ | $^3F_3$ | 15375644 | -737 | | | | -6717 | -3602 |
| 28 | $2s^22p^3(^2D)3p$ | $^3D_2$ | 15389809 | -642 | | | | -8292 | -4904 |
| 29 | $2s^22p^3(^2D)3p$ | $^1F_3$ | 15396478 | -666 | | | | -8243 | -4517 |
| 30 | $2s^22p^3(^2D)3p$ | $^3P_0$ | 15415817 | -768 | | | | -6718 | -3175 |
| 31 | $2s^22p^3(^4S)3d$ | $^5D_2$ | 15428443 | -530 | | | | -7313 | -5160 |
| 32 | $2s^22p^3(^4S)3d$ | $^5D_3$ | 15438839 | -532 | | | | -7444 | -4954 |
| 33 | $2s^22p^3(^2D)3p$ | $^1P_1$ | 15439580 | -649 | | | | -7779 | -5885 |
| 34 | $2s^22p^3(^4S)3d$ | $^5D_0$ | 15451225 | -481 | | | | -8182 | -5628 |
| 35 | $2s^22p^3(^4S)3d$ | $^5D_1$ | 15451382 | -488 | | | | -8027 | -5453 |
| 36 | $2s^22p^3(^4S)3d$ | $^5D_4$ | 15464724 | -495 | | | | -7930 | -4648 |
| 37 | $2s^22p^3(^2D)3p$ | $^3P_2$ | 15488280 | -1432 | | | | 736 | 9405 |
| 38 | $2s^22p^3(^2D)3p$ | $^3D_3$ | 15492238 | -705 | | | | -6742 | 6213 |
| 39 | $2s^22p^3(^2D)3p$ | $^3F_4$ | 15501268 | -737 | | | | -6648 | -7062 |
| 40 | $2s^22p^3(^4S)3d$ | $^3D_2$ | 15501666 | -621 | | | | -6268 | -13442 |
| 41 | $2s^22p^3(^2P)3s$ | $^3P_2$ | 15524781 | -425 | | | | -11257 | -8452 |
| 42 | $2s^22p^3(^2P)3p$ | $^3D_1$ | 15526011 | -683 | | | | -8776 | -6086 |
| 43 | $2s^22p^3(^2P)3s$ | $^1P_1$ | 15547458 | -580 | | | | -10681 | -6887 |
| 44 | $2s^22p^3(^2D)3p$ | $^3P_1$ | 15570315 | -1063 | | | | -4388 | -92 |
| 45 | $2s^22p^3(^4S)3d$ | $^3D_3$ | 15575037 | -869 | | | | -3196 | -1293 |
| 46 | $2s^22p^3(^4S)3d$ | $^3D_1$ | 15589124 | -880 | | | | -4387 | -1847 |
| 47 | $2s^22p^3(^2D)3p$ | $^1D_2$ | 15630146 | -990 | | | | -5501 | -1918 |
| 48 | $2s^22p^3(^2P)3p$ | $^3P_0$ | 15651362 | -1256 | | | | -1845 | 1224 |

**Table 3.** (*continued*)

| Key | Config. | LS J | $E_{\rm MCDF}$ | $\Delta E_{\rm MBPT}$ | $\Delta E_{\rm NIST}$ | $\Delta E_{\rm MCDF2}$ | $\Delta E_{\rm MRMP}$ | $\Delta E_{\rm GRASP1}$ | $\Delta E_{\rm FAC}$ |
|---|---|---|---|---|---|---|---|---|---|
| 49 | $2s^22p^3(^2P)3p$ | $^3P_1$ | 15658815 | -633 | | | | -9275 | -6814 |
| 50 | $2s^22p^3(^2P)3p$ | $^3D_2$ | 15674341 | -843 | | | | -6310 | -3372 |
| 51 | $2s^22p^3(^2D)3d$ | $^3D_1$ | 15825954 | -660 | | | | -6308 | -4017 |
| 52 | $2s^22p^3(^2D)3d$ | $^3F_2$ | 15829031 | -675 | | | | -6026 | -3976 |
| 53 | $2s^22p^3(^2D)3d$ | $^1S_0$ | 15834911 | -687 | | | | -6121 | -3691 |
| 54 | $2s^22p^3(^2D)3d$ | $^3F_3$ | 15842304 | -633 | | | | -6290 | -4153 |
| 55 | $2s^22p^3(^2D)3d$ | $^3G_4$ | 15853221 | -699 | | | | -6358 | -4272 |
| 56 | $2s^22p^3(^2D)3d$ | $^3G_3$ | 15862369 | -841 | | | | -4810 | -2847 |
| 57 | $2s^22p^3(^2D)3d$ | $^1P_1$ | 15926840 | -817 | | | | -4833 | -2905 |
| 58 | $2s^22p^3(^2P)3p$ | $^3S_1$ | 15927895 | -959 | | | | -6736 | -2793 |
| 59 | $2s^22p^3(^2D)3d$ | $^3F_4$ | 15930286 | -784 | | | | -4400 | -3088 |
| 60 | $2s2p^4(^4P)3s$ | $^5P_3$ | 15934944 | 457 | | | | -9856 | -1967 |
| 61 | $2s^22p^3(^2D)3d$ | $^3P_2$ | 15943401 | -849 | | | | -4420 | -2903 |
| 62 | $2s^22p^3(^2D)3d$ | $^1G_4$ | 15951631 | -835 | | | | -4060 | -2820 |
| 63 | $2s^22p^3(^2D)3d$ | $^3G_5$ | 15959225 | -813 | | | | -4507 | -3456 |
| 64 | $2s^22p^3(^2P)3p$ | $^1D_2$ | 15965544 | -1305 | | | | -3258 | 1227 |
| 65 | $2s^22p^3(^2D)3d$ | $^3D_3$ | 15977477 | -928 | | | | -1678 | -875 |
| 66 | $2s^22p^3(^2D)3d$ | $^3P_0$ | 15991820 | -842 | | | | -3872 | -2159 |
| 67 | $2s^22p^3(^2P)3p$ | $^3D_3$ | 15998010 | -617 | | | | -9768 | -7155 |
| 68 | $2s^22p^3(^2P)3p$ | $^1P_1$ | 16003608 | -719 | | | | -9351 | -6513 |
| 69 | $2s^22p^3(^2D)3d$ | $^3D_2$ | 16004603 | -957 | | | | -2577 | -1222 |
| 70 | $2s^22p^3(^2D)3d$ | $^3P_1$ | 16005213 | -922 | | | | -3222 | -2049 |
| 71 | $2s2p^4(^4P)3s$ | $^3P_2$ | 16030394 | -254 | | | | -9370 | 10117 |
| 72 | $2s^22p^3(^2D)3d$ | $^1D_2$ | 16036511 | -706 | | | | -6113 | -5286 |
| 73 | $2s^22p^3(^2P)3p$ | $^3P_2$ | 16042236 | -520 | | | | -4192 | -12086 |
| 74 | $2s^22p^3(^2D)3d$ | $^3S_1$ | 16044729 | -763 | | | | -4836 | -3415 |
| 75 | $2s^22p^3(^2D)3d$ | $^1F_3$ | 16072723 | -1109 | | | | -1186 | -712 |
| 76 | $2s^22p^3(^2P)3d$ | $^3F_2$ | 16103864 | -644 | | | | -6172 | -6046 |
| 77 | $2s^22p^3(^2P)3d$ | $^3F_3$ | 16138249 | -649 | | | | -6014 | -6427 |
| 78 | $2s^22p^3(^2P)3d$ | $^1D_2$ | 16139285 | -678 | | | | -4852 | -5259 |
| 79 | $2s^22p^3(^2P)3d$ | $^3D_1$ | 16170616 | -771 | | | | -3856 | -4912 |
| 80 | $2s2p^4(^4P)3s$ | $^5P_1$ | 16204337 | 417 | | | | -7699 | -1201 |
| 81 | $2s^22p^3(^2P)3p$ | $^1S_0$ | 16212673 | -1642 | | | | 665 | 6219 |
| 82 | $2s2p^4(^4P)3s$ | $^5P_2$ | 16224157 | 94 | | | | -4773 | 2936 |
| 83 | $2s2p^4(^4P)3s$ | $^3P_1$ | 16275794 | -142 | | | | 23 | 6803 |
| 84 | $2s2p^4(^4P)3p$ | $^5P_2$ | 16303367 | 845 | | | | -7787 | 623 |
| 85 | $2s2p^4(^4P)3p$ | $^5P_3$ | 16316644 | 799 | | | | -7924 | 956 |
| 86 | $2s2p^4(^4P)3s$ | $^3P_0$ | 16330254 | -580 | | | | 1838 | 8596 |
| 87 | $2s2p^4(^4P)3p$ | $^5D_4$ | 16422682 | 785 | | | | -8961 | -542 |
| 88 | $2s2p^4(^4P)3p$ | $^3D_3$ | 16431303 | 766 | | | | -7889 | 1264 |
| 89 | $2s^22p^3(^2P)3d$ | $^3P_0$ | 16442472 | -697 | | | | -7644 | -5514 |
| 90 | $2s^22p^3(^2P)3d$ | $^3F_4$ | 16452083 | -595 | | | | -7211 | -6509 |
| 91 | $2s2p^4(^4P)3p$ | $^5P_1$ | 16455703 | 91 | | | | -11979 | -3031 |
| 92 | $2s^22p^3(^2P)3d$ | $^3P_2$ | 16468764 | -645 | | | | -8487 | -7266 |
| 93 | $2s^22p^3(^2P)3d$ | $^3P_1$ | 16468460 | -30 | | | | -1618 | -982 |
| 94 | $2s^22p^3(^2P)3d$ | $^1F_3$ | 16501342 | -991 | | | | -4842 | -3851 |
| 95 | $2s^22p^3(^2P)3d$ | $^3D_3$ | 16510087 | -765 | | | | -6218 | -5316 |
| 96 | $2s^22p^3(^2P)3d$ | $^3D_2$ | 16517955 | -535 | | | | -7884 | -2891 |
| 97 | $2s2p^4(^2D)3s$ | $^3D_2$ | 16525545 | 70 | | | | 427 | 5872 |
| 98 | $2s2p^4(^4P)3p$ | $^3P_2$ | 16537137 | 168 | | | | -802 | 4445 |
| 99 | $2s2p^4(^2D)3s$ | $^3D_1$ | 16550894 | -99 | | | | -132 | 6007 |
| 100 | $2s2p^4(^4P)3p$ | $^3S_1$ | 16566584 | 640 | | | | -4324 | 3315 |
| 101 | $2s2p^4(^4P)3p$ | $^5D_0$ | 16572950 | 744 | | | | -4929 | 1668 |

**Table 3.** (*continued*)

| Key | Config. | *LS J* | $E_{MCDF}$ | $\Delta E_{MBPT}$ | $\Delta E_{NIST}$ | $\Delta E_{MCDF2}$ | $\Delta E_{MRMP}$ | $\Delta E_{GRASP1}$ | $\Delta E_{FAC}$ |
|---|---|---|---|---|---|---|---|---|---|
| 102 | $2s2p^4(^4P)3p$ | $^5D_1$ | 16583370 | 691 | | | | -5282 | 2071 |
| 103 | $2s2p^4(^4P)3p$ | $^5D_2$ | 16587433 | 489 | | | | -2049 | 4780 |
| 104 | $2s^22p^3(^2P)3d$ | $^1P_1$ | 16630156 | -1128 | | | | -1284 | -1922 |
| 105 | $2s2p^4(^2D)3s$ | $^3D_3$ | 16629186 | 74 | | | | -688 | 4477 |
| 106 | $2s2p^4(^4P)3p$ | $^5D_3$ | 16681334 | 751 | | | | -5586 | 2127 |
| 107 | $2s2p^4(^2D)3p$ | $^3P_0$ | 16687462 | 680 | | | | -2375 | 4005 |
| 108 | $2s2p^4(^2D)3s$ | $^1D_2$ | 16693164 | -325 | | | | 3641 | 9311 |
| 109 | $2s2p^4(^4P)3p$ | $^5S_2$ | 16704272 | 699 | | | | -4687 | 2208 |
| 110 | $2s2p^4(^4P)3p$ | $^3D_1$ | 16738159 | 560 | | | | -4598 | 3518 |
| 111 | $2s2p^4(^4P)3p$ | $^3D_2$ | 16738307 | 477 | | | | -1727 | 5820 |
| 112 | $2s2p^4(^4P)3p$ | $^3P_1$ | 16781492 | 375 | | | | -1131 | 5702 |
| 113 | $2s2p^4(^2S)3s$ | $^3S_1$ | 16803682 | 50 | | | | 1652 | 6118 |
| 114 | $2s2p^4(^4P)3d$ | $^5D_3$ | 16822844 | 425 | | | | -8330 | -1400 |
| 115 | $2s2p^4(^2P)3s$ | $^3P_0$ | 16829255 | -146 | | | | 4591 | 8956 |
| 116 | $2s2p^4(^4P)3d$ | $^5D_4$ | 16830517 | 433 | | | | -8427 | -1384 |
| 117 | $2s2p^4(^4P)3d$ | $^5D_2$ | 16831564 | 403 | | | | -8061 | -1272 |
| 118 | $2s2p^4(^4P)3d$ | $^5P_1$ | 16851264 | 382 | | | | -7836 | -1085 |
| 119 | $2s2p^4(^4P)3d$ | $^5F_5$ | 16863164 | 364 | | | | -7719 | -1126 |
| 120 | $2s2p^4(^2D)3p$ | $^3D_1$ | 16873271 | 456 | | | | 1992 | 7394 |
| 121 | $2s2p^4(^2P)3s$ | $^3P_2$ | 16892655 | -177 | | | | 7504 | 12022 |
| 122 | $2s2p^4(^2D)3p$ | $^3F_2$ | 16895817 | 440 | | | | 929 | 7037 |
| 123 | $2s2p^4(^2P)3s$ | $^1P_1$ | 16899268 | -146 | | | | 7545 | 11556 |
| 124 | $2s2p^4(^4P)3d$ | $^3F_4$ | 16909573 | 58 | | | | -4867 | 1717 |
| 125 | $2s2p^4(^4P)3d$ | $^3P_0$ | 16930139 | 198 | | | | -4356 | 2137 |
| 126 | $2s2p^4(^4P)3d$ | $^3P_1$ | 16970941 | 156 | | | | -4493 | 1767 |
| 127 | $2s2p^4(^2D)3p$ | $^3F_3$ | 16983189 | 516 | | | | 934 | 6456 |
| 128 | $2s2p^4(^4P)3d$ | $^3F_3$ | 16988985 | -11 | | | | -3162 | 2515 |
| 129 | $2s2p^4(^4P)3d$ | $^3D_2$ | 17004293 | 29 | | | | -3210 | 2590 |
| 130 | $2s2p^4(^2D)3p$ | $^1F_3$ | 17006092 | 416 | | | | 1653 | 7714 |
| 131 | $2s2p^4(^2D)3p$ | $^3D_2$ | 17020314 | 447 | | | | 1647 | 7485 |
| 132 | $2s2p^4(^2D)3p$ | $^3P_1$ | 17026187 | 374 | | | | 4728 | 9808 |
| 133 | $2s2p^4(^2D)3p$ | $^3F_4$ | 17099434 | 496 | | | | 890 | 10284 |
| 134 | $2s2p^4(^2D)3p$ | $^3P_2$ | 17100874 | -216 | | | | 12228 | 16718 |
| 135 | $2s2p^4(^4P)3d$ | $^5F_2$ | 17108400 | 236 | | | | -4787 | -224 |
| 136 | $2s2p^4(^4P)3d$ | $^5D_1$ | 17108832 | 183 | | | | -3480 | 2644 |
| 137 | $2s2p^4(^4P)3d$ | $^5F_3$ | 17111092 | 214 | | | | -4612 | -5542 |
| 138 | $2s2p^4(^4P)3d$ | $^5F_1$ | 17121286 | 189 | | | | -3937 | 1136 |
| 139 | $2s2p^4(^4P)3p$ | $^3P_0$ | 17123316 | 72 | | | | 7701 | 12030 |
| 140 | $2s2p^4(^4P)3d$ | $^5D_0$ | 17130062 | 85 | | | | -3589 | 2011 |
| 141 | $2s2p^4(^4P)3d$ | $^5F_4$ | 17131164 | 175 | | | | -4725 | 989 |
| 142 | $2s2p^4(^2D)3p$ | $^1D_2$ | 17131826 | 429 | | | | 1757 | 7684 |
| 143 | $2s2p^4(^4P)3d$ | $^5P_2$ | 17132767 | 112 | | | | -2543 | 2532 |
| 144 | $2s2p^4(^2D)3p$ | $^3D_3$ | 17146708 | 374 | | | | 1815 | 10672 |
| 145 | $2s2p^4(^2S)3p$ | $^3P_0$ | 17148181 | 434 | | | | 4565 | 8716 |
| 146 | $2s2p^4(^2D)3p$ | $^1P_1$ | 17150404 | 290 | | | | 5819 | 9700 |
| 147 | $2s2p^4(^4P)3d$ | $^5P_3$ | 17156205 | 189 | | | | -4286 | -1875 |
| 148 | $2s2p^4(^2P)3p$ | $^3D_1$ | 17182579 | 377 | | | | 4071 | 11185 |
| 149 | $2s2p^4(^4P)3d$ | $^3D_1$ | 17190145 | 69 | | | | -1358 | 1257 |
| 150 | $2s2p^4(^4P)3d$ | $^3D_3$ | 17212006 | -141 | | | | 2659 | 6563 |
| 151 | $2s2p^4(^4P)3d$ | $^3F_2$ | 17215590 | -96 | | | | -1345 | 2205 |
| 152 | $2s2p^4(^2P)3p$ | $^3D_2$ | 17240920 | 225 | | | | 10537 | 14518 |
| 153 | $2s2p^4(^4P)3d$ | $^3P_2$ | 17278934 | -179 | | | | 1562 | 4974 |
| 154 | $2s2p^4(^2S)3p$ | $^3P_2$ | 17278443 | 483 | | | | 4339 | 8573 |

**Table 3.** (*continued*)

| Key | Config. | $LS\,J$ | $E_{\mathrm{MCDF}}$ | $\Delta E_{\mathrm{MBPT}}$ | $\Delta E_{\mathrm{NIST}}$ | $\Delta E_{\mathrm{MCDF2}}$ | $\Delta E_{\mathrm{MRMP}}$ | $\Delta E_{\mathrm{GRASP1}}$ | $\Delta E_{\mathrm{FAC}}$ |
|---|---|---|---|---|---|---|---|---|---|
| 155 | $2s2p^4(^2P)3s$ | $^3P_1$ | 17301215 | 9 | | | | 3071 | 6892 |
| 156 | $2s2p^4(^2P)3p$ | $^3P_1$ | 17304350 | 349 | | | | 5479 | 9794 |
| 157 | $2s2p^4(^2P)3p$ | $^3S_1$ | 17339345 | -272 | | | | 18106 | 22497 |
| 158 | $2s2p^4(^2S)3s$ | $^1S_0$ | 17351957 | -347 | | | | 5176 | 8980 |
| 159 | $2s2p^4(^2P)3p$ | $^3P_2$ | 17357264 | 326 | | | | 9043 | 12926 |
| 160 | $2s2p^4(^2P)3p$ | $^3D_3$ | 17360676 | 301 | | | | 9463 | 13217 |
| 161 | $2s2p^4(^2P)3p$ | $^1S_0$ | 17417166 | 4 | | | | 14074 | 17935 |
| 162 | $2s2p^4(^2D)3d$ | $^3P_0$ | 17423893 | -146 | | | | 6023 | 9095 |
| 163 | $2s2p^4(^2D)3d$ | $^3D_1$ | 17431947 | 9 | | | | 3728 | 5788 |
| 164 | $2s2p^4(^2D)3d$ | $^3G_4$ | 17432172 | -63 | | | | 2994 | 6489 |
| 165 | $2s2p^4(^2D)3d$ | $^3G_3$ | 17439779 | -146 | | | | 1821 | 4958 |
| 166 | $2s2p^4(^2D)3d$ | $^3F_2$ | 17449888 | -116 | | | | 4023 | 6642 |
| 167 | $2s2p^4(^2P)3p$ | $^1P_1$ | 17465628 | -113 | | | | 16120 | 19000 |
| 168 | $2s2p^4(^2D)3d$ | $^3D_2$ | 17476541 | -164 | | | | 5634 | 8160 |
| 169 | $2s2p^4(^2D)3d$ | $^3F_3$ | 17481170 | -131 | | | | 4154 | 6441 |
| 170 | $2s2p^4(^2D)3d$ | $^3G_5$ | 17530304 | -98 | | | | 2347 | 4592 |
| 171 | $2s2p^4(^2D)3d$ | $^1G_4$ | 17539077 | -194 | | | | 3397 | 6139 |
| 172 | $2s2p^4(^2D)3d$ | $^3S_1$ | 17550732 | 57 | | | | 465 | 4020 |
| 173 | $2s2p^4(^2D)3d$ | $^3P_2$ | 17577935 | -201 | | | | 5782 | 8288 |
| 174 | $2s2p^4(^2D)3d$ | $^3P_1$ | 17579181 | -242 | | | | 5902 | 8191 |
| 175 | $2s2p^4(^2D)3d$ | $^3D_3$ | 17582224 | -175 | | | | 5429 | 7543 |
| 176 | $2s2p^4(^2D)3d$ | $^3F_4$ | 17602193 | -227 | | | | 3286 | 5733 |
| 177 | $2s2p^4(^2D)3d$ | $^1F_3$ | 17622158 | -280 | | | | 5841 | 7967 |
| 178 | $2s2p^4(^2D)3d$ | $^1D_2$ | 17648896 | -307 | | | | 6526 | 8272 |
| 179 | $2s2p^4(^2D)3d$ | $^1P_1$ | 17658833 | -248 | | | | 5867 | 7608 |
| 180 | $2s2p^4(^2D)3d$ | $^1S_0$ | 17700067 | -704 | | | | 10787 | 11636 |
| 181 | $2s2p^4(^2P)3p$ | $^3P_0$ | 17706780 | 50 | | | | 10393 | 14482 |
| 182 | $2s2p^4(^2P)3d$ | $^3D_1$ | 17711165 | -152 | | | | 6770 | 7456 |
| 183 | $2s2p^4(^2P)3d$ | $^3F_2$ | 17726440 | -166 | | | | 7334 | 8125 |
| 184 | $2s2p^4(^2S)3d$ | $^3D_3$ | 17730476 | -100 | | | | 6070 | 6624 |
| 185 | $2s2p^4(^2S)3p$ | $^1P_1$ | 17732250 | -114 | | | | 12158 | 15554 |
| 186 | $2s2p^4(^2P)3d$ | $^3P_2$ | 17762886 | -248 | | | | 8813 | 9105 |
| 187 | $2s2p^4(^2P)3p$ | $^1D_2$ | 17779934 | 400 | | | | 5632 | 9008 |
| 188 | $2s2p^4(^2P)3d$ | $^3F_3$ | 17787710 | -379 | | | | 13016 | 13131 |
| 189 | $2s2p^4(^2S)3p$ | $^3P_1$ | 17801330 | 218 | | | | 9694 | 13203 |
| 190 | $2s2p^4(^2P)3d$ | $^3D_3$ | 17809331 | -325 | | | | 11604 | 11648 |
| 191 | $2s2p^4(^2P)3d$ | $^3D_2$ | 17819138 | -363 | | | | 13016 | 12622 |
| 192 | $2s2p^4(^2P)3d$ | $^3F_4$ | 17820430 | -353 | | | | 12685 | 12405 |
| 193 | $2s2p^4(^2P)3d$ | $^3P_1$ | 17842303 | -374 | | | | 14178 | 13703 |
| 194 | $2s2p^4(^2P)3d$ | $^3P_0$ | 17854907 | -564 | | | | 16788 | 16152 |
| 195 | $2s2p^4(^2P)3d$ | $^1D_2$ | 17900150 | -746 | | | | 19349 | 17561 |
| 196 | $2s2p^4(^2P)3d$ | $^1P_1$ | 17901727 | -423 | | | | 16958 | 15120 |
| 197 | $2p^5(^2P)3s$ | $^3P_2$ | 18058707 | 519 | | | | 23502 | 32399 |
| 198 | $2p^5(^2P)3s$ | $^1P_1$ | 18089057 | 344 | | | | 26154 | 33983 |
| 199 | $2s2p^4(^2P)3d$ | $^1F_3$ | 18226811 | -227 | | | | 8344 | 7762 |
| 200 | $2s2p^4(^2S)3d$ | $^3D_1$ | 18250135 | -332 | | | | 12100 | 11527 |
| 201 | $2s2p^4(^2S)3d$ | $^3D_2$ | 18256828 | -406 | | | | 10760 | 9907 |
| 202 | $2s2p^4(^2S)3d$ | $^1D_2$ | 18277093 | -421 | | | | 11370 | 11476 |
| 203 | $2p^5(^2P)3p$ | $^3S_1$ | 18382906 | 464 | | | | 22514 | 31488 |
| 204 | $2p^5(^2P)3p$ | $^3D_2$ | 18406738 | 246 | | | | 24469 | 33731 |
| 205 | $2p^5(^2P)3p$ | $^3D_3$ | 18506306 | 420 | | | | 22922 | 31952 |
| 206 | $2p^5(^2P)3p$ | $^1P_1$ | 18511986 | 363 | | | | 23438 | 32548 |
| 207 | $2p^5(^2P)3s$ | $^3P_0$ | 18512727 | 541 | | | | 21994 | 30379 |

**Table 3.** (*continued*)

| Key | Config. | $LS\,J$ | $E_{\mathrm{MCDF}}$ | $\Delta E_{\mathrm{MBPT}}$ | $\Delta E_{\mathrm{NIST}}$ | $\Delta E_{\mathrm{MCDF2}}$ | $\Delta E_{\mathrm{MRMP}}$ | $\Delta E_{\mathrm{GRASP1}}$ | $\Delta E_{\mathrm{FAC}}$ |
|---|---|---|---|---|---|---|---|---|---|
| 208 | $2p^5(^2P)3s$ | $^3P_1$ | 18531960 | 418 | | | | 23668 | 50894 |
| 209 | $2p^5(^2P)3p$ | $^3P_2$ | 18548871 | 219 | | | | 24624 | 14688 |
| 210 | $2p^5(^2P)3p$ | $^3P_0$ | 18676441 | -289 | | | | 32889 | 39771 |
| 211 | $2p^5(^2P)3p$ | $^3D_1$ | 18851822 | 336 | | | | 22543 | 31355 |
| 212 | $2p^5(^2P)3d$ | $^3P_0$ | 18884956 | 644 | | | | 24292 | 30150 |
| 213 | $2p^5(^2P)3d$ | $^3P_1$ | 18904716 | 612 | | | | 24756 | 30386 |
| 214 | $2p^5(^2P)3d$ | $^3F_3$ | 18929439 | 408 | | | | 26966 | 31140 |
| 215 | $2p^5(^2P)3d$ | $^3F_4$ | 18936841 | 513 | | | | 25712 | 30406 |
| 216 | $2p^5(^2P)3d$ | $^3P_2$ | 18941406 | 542 | | | | 25635 | 30671 |
| 217 | $2p^5(^2P)3d$ | $^1D_2$ | 18965104 | 430 | | | | 27424 | 31574 |
| 218 | $2p^5(^2P)3p$ | $^3P_1$ | 18976494 | 368 | | | | 22273 | 30761 |
| 219 | $2p^5(^2P)3p$ | $^1D_2$ | 18984172 | 321 | | | | 22559 | 31331 |
| 220 | $2p^5(^2P)3d$ | $^3D_3$ | 18993339 | 401 | | | | 27038 | 31307 |
| 221 | $2p^5(^2P)3p$ | $^1S_0$ | 19034240 | -1306 | | | | 48882 | 50663 |
| 222 | $2p^5(^2P)3d$ | $^3D_1$ | 19091624 | 90 | | | | 34363 | 36618 |
| 223 | $2p^5(^2P)3d$ | $^3F_2$ | 19384302 | 430 | | | | 25787 | 30125 |
| 224 | $2p^5(^2P)3d$ | $^3D_2$ | 19418844 | 494 | | | | 24967 | 28857 |
| 225 | $2p^5(^2P)3d$ | $^1F_3$ | 19427227 | 396 | | | | 25578 | 28995 |
| 226 | $2p^5(^2P)3d$ | $^1P_1$ | 19499126 | -40 | | | | 36479 | 37537 |
| 227 | $2s^22p^3(^4S)4s$ | $^5S_2$ | 19749161 | -992 | | | | | |
| 228 | $2s^22p^3(^4S)4s$ | $^3S_1$ | 19764533 | -1015 | | | | | |
| 229 | $2s^22p^3(^4S)4p$ | $^5P_1$ | 19898904 | -1229 | | | | | |
| 230 | $2s^22p^3(^4S)4p$ | $^5P_2$ | 19901688 | -1210 | | | | | |
| 231 | $2s^22p^3(^4S)4p$ | $^5P_3$ | 19948690 | -1193 | | | | | |
| 232 | $2s^22p^3(^4S)4p$ | $^3P_1$ | 19953404 | -1268 | | | | | |
| 233 | $2s^22p^3(^4S)4p$ | $^3P_2$ | 19981539 | -1405 | | | | | |
| 234 | $2s^22p^3(^4S)4p$ | $^3P_0$ | 20006087 | -1611 | | | | | |
| 235 | $2s^22p^3(^4S)4d$ | $^5D_2$ | 20108555 | -982 | | | | | |
| 236 | $2s^22p^3(^4S)4d$ | $^5D_3$ | 20112293 | -1008 | | | | | |
| 237 | $2s^22p^3(^4S)4d$ | $^5D_1$ | 20115937 | -967 | | | | | |
| 238 | $2s^22p^3(^4S)4d$ | $^5D_0$ | 20116187 | -1001 | | | | | |
| 239 | $2s^22p^3(^4S)4d$ | $^5D_4$ | 20122708 | -1020 | | | | | |
| 240 | $2s^22p^3(^2D)4s$ | $^3D_2$ | 20131176 | -1076 | | | | | |
| 241 | $2s^22p^3(^4S)4d$ | $^3D_2$ | 20143025 | -1094 | | | | | |
| 242 | $2s^22p^3(^2D)4s$ | $^3D_1$ | 20144713 | -1154 | | | | | |
| 243 | $2s^22p^3(^4S)4d$ | $^3D_3$ | 20163574 | -1142 | -21374 | | | | |
| 244 | $2s^22p^3(^4S)4d$ | $^3D_1$ | 20169558 | -1170 | -7258 | | | | |
| 245 | $2s^22p^3(^4S)4f$ | $^5F_3$ | 20222982 | -1289 | | | | | |
| 246 | $2s^22p^3(^4S)4f$ | $^5F_4$ | 20226540 | -1335 | | | | | |
| 247 | $2s^22p^3(^4S)4f$ | $^5F_2$ | 20227164 | -1277 | | | | | |
| 248 | $2s^22p^3(^4S)4f$ | $^5F_1$ | 20232460 | -1288 | | | | | |
| 249 | $2s^22p^3(^4S)4f$ | $^3F_3$ | 20232591 | -1329 | | | | | |
| 250 | $2s^22p^3(^2D)4f$ | $^1H_5$ | 20232694 | -1384 | | | | | |
| 251 | $2s^22p^3(^4S)4f$ | $^3F_4$ | 20233004 | -1472 | | | | | |
| 252 | $2s^22p^3(^2D)4s$ | $^3D_3$ | 20238980 | -1121 | | | | | |
| 253 | $2s^22p^3(^4S)4f$ | $^3F_2$ | 20240673 | -1395 | | | | | |
| 254 | $2s^22p^3(^2D)4s$ | $^1D_2$ | 20246543 | -1110 | | | | | |
| 255 | $2s^22p^3(^2D)4p$ | $^1P_1$ | 20280163 | -1362 | | | | | |
| 256 | $2s^22p^3(^2D)4p$ | $^3F_2$ | 20298424 | -1427 | | | | | |
| 257 | $2s^22p^3(^2D)4p$ | $^1F_3$ | 20334010 | -1304 | | | | | |
| 258 | $2s^22p^3(^2D)4p$ | $^3D_2$ | 20336294 | -1368 | | | | | |
| 259 | $2s^22p^3(^2D)4p$ | $^3P_0$ | 20340695 | -1392 | | | | | |
| 260 | $2s^22p^3(^2D)4p$ | $^3D_1$ | 20370577 | -1544 | | | | | |

**Table 3.** (*continued*)

| Key | Config. | *LS J* | $E_{\mathrm{MCDF}}$ | $\Delta E_{\mathrm{MBPT}}$ | $\Delta E_{\mathrm{NIST}}$ | $\Delta E_{\mathrm{MCDF2}}$ | $\Delta E_{\mathrm{MRMP}}$ | $\Delta E_{\mathrm{GRASP1}}$ | $\Delta E_{\mathrm{FAC}}$ |
|---|---|---|---|---|---|---|---|---|---|
| 261 | $2s^22p^3(^2P)4s$ | $^3P_0$ | 20372746 | -1136 | | | | | |
| 262 | $2s^22p^3(^2P)4s$ | $^3P_1$ | 20377097 | -1083 | | | | | |
| 263 | $2s^22p^3(^2D)4p$ | $^3F_3$ | 20387238 | -1310 | | | | | |
| 264 | $2s^22p^3(^2D)4p$ | $^3P_2$ | 20414024 | -1586 | | | | | |
| 265 | $2s^22p^3(^2D)4p$ | $^3D_3$ | 20435203 | -1321 | | | | | |
| 266 | $2s^22p^3(^2D)4p$ | $^3F_4$ | 20437076 | -1296 | | | | | |
| 267 | $2s^22p^3(^2D)4p$ | $^3P_1$ | 20447319 | -1519 | | | | | |
| 268 | $2s^22p^3(^2D)4p$ | $^1D_2$ | 20484393 | -1650 | | | | | |
| 269 | $2s^22p^3(^2D)4d$ | $^3D_1$ | 20497287 | -1103 | | | | | |
| 270 | $2s^22p^3(^2D)4d$ | $^3F_2$ | 20501658 | -1175 | | | | | |
| 271 | $2s^22p^3(^2D)4d$ | $^3P_0$ | 20502120 | -1100 | | | | | |
| 272 | $2s^22p^3(^2D)4d$ | $^1G_4$ | 20508536 | -1165 | | | | | |
| 273 | $2s^22p^3(^2D)4d$ | $^3F_3$ | 20508760 | -1179 | | | | | |
| 274 | $2s^22p^3(^2D)4d$ | $^3G_3$ | 20514654 | -1271 | | | | | |
| 275 | $2s^22p^3(^2P)4p$ | $^3D_1$ | 20522040 | -1280 | | | | | |
| 276 | $2s^22p^3(^2D)4p$ | $^3S_1$ | 20538765 | -1182 | | | | | |
| 277 | $2s^22p^3(^2D)4d$ | $^3P_2$ | 20547363 | -1285 | | | | | |
| 278 | $2s^22p^3(^2P)4p$ | $^3P_0$ | 20564782 | -1727 | | | | | |
| 279 | $2s^22p^3(^2P)4p$ | $^3P_1$ | 20579100 | -1342 | | | | | |
| 280 | $2s^22p^3(^2P)4p$ | $^3D_2$ | 20583019 | -1345 | | | | | |
| 281 | $2s^22p^3(^2D)4d$ | $^3G_4$ | 20599704 | -1148 | | | | | |
| 282 | $2s^22p^3(^2D)4d$ | $^3D_3$ | 20609290 | -1207 | | | | | |
| 283 | $2s^22p^3(^2D)4d$ | $^3F_4$ | 20609403 | -1153 | | | | | |
| 284 | $2s^22p^3(^2D)4f$ | $^3G_3$ | 20610109 | -1493 | | | | | |
| 285 | $2s^22p^3(^2D)4f$ | $^3F_2$ | 20611819 | -1433 | | | | | |
| 286 | $2s^22p^3(^2D)4d$ | $^3G_5$ | 20611731 | -1144 | | | | | |
| 287 | $2s^22p^3(^2D)4f$ | $^1G_4$ | 20612761 | -1552 | | | | | |
| 288 | $2s^22p^3(^2D)4f$ | $^3H_4$ | 20615122 | -1521 | | | | | |
| 289 | $2s^22p^3(^2D)4f$ | $^3P_1$ | 20616798 | -1423 | | | | | |
| 290 | $2s^22p^3(^4S)4f$ | $^5F_5$ | 20616951 | -1538 | | | | | |
| 291 | $2s^22p^3(^2D)4f$ | $^3D_3$ | 20619528 | -1512 | | | | | |
| 292 | $2s^22p^3(^2D)4d$ | $^3D_2$ | 20619504 | -1183 | | | | | |
| 293 | $2s^22p^3(^2D)4d$ | $^1S_0$ | 20620871 | -1108 | | | | | |
| 294 | $2s^22p^3(^2D)4f$ | $^3P_2$ | 20624082 | -1488 | | | | | |
| 295 | $2s^22p^3(^2D)4d$ | $^3P_1$ | 20624156 | -1141 | | | | | |
| 296 | $2s^22p^3(^2D)4d$ | $^3S_1$ | 20640964 | -1105 | | | | | |
| 297 | $2s^22p^3(^2D)4d$ | $^1D_2$ | 20648594 | -1231 | | | | | |
| 298 | $2s^22p^3(^2D)4d$ | $^1F_3$ | 20651518 | -1342 | | | | | |
| 299 | $2s^22p^3(^2D)4f$ | $^3H_5$ | 20712411 | -1644 | | | | | |
| 300 | $2s^22p^3(^2D)4f$ | $^3G_4$ | 20714509 | -1518 | | | | | |
| 301 | $2s^22p^3(^2D)4f$ | $^3F_3$ | 20715441 | -1448 | | | | | |
| 302 | $2s^22p^3(^2D)4f$ | $^3D_2$ | 20716980 | -1419 | | | | | |
| 303 | $2s^22p^3(^2D)4f$ | $^3H_6$ | 20717639 | -1631 | | | | | |
| 304 | $2s^22p^3(^2D)4f$ | $^3G_5$ | 20718396 | -1523 | | | | | |
| 305 | $2s^22p^3(^2D)4f$ | $^3D_1$ | 20718539 | -1400 | | | | | |
| 306 | $2s^22p^3(^2D)4f$ | $^3P_0$ | 20719674 | -1389 | | | | | |
| 307 | $2s^22p^3(^2D)4f$ | $^3F_4$ | 20721756 | -1533 | | | | | |
| 308 | $2s^22p^3(^2D)4f$ | $^1P_1$ | 20723534 | -1378 | | | | | |
| 309 | $2s^22p^3(^2D)4f$ | $^1F_3$ | 20723739 | -1487 | | | | | |
| 310 | $2s^22p^3(^2D)4f$ | $^1D_2$ | 20724126 | -1433 | | | | | |
| 311 | $2s^22p^3(^2P)4d$ | $^3F_2$ | 20736636 | -1068 | | | | | |
| 312 | $2s^22p^3(^2P)4s$ | $^3P_2$ | 20745352 | -1268 | | | | | |
| 313 | $2s^22p^3(^2P)4s$ | $^1P_1$ | 20754528 | -1417 | | | | | |

**Table 3.** (*continued*)

| Key | Config. | *LS J* | $E_{\mathrm{MCDF}}$ | $\Delta E_{\mathrm{MBPT}}$ | $\Delta E_{\mathrm{NIST}}$ | $\Delta E_{\mathrm{MCDF2}}$ | $\Delta E_{\mathrm{MRMP}}$ | $\Delta E_{\mathrm{GRASP1}}$ | $\Delta E_{\mathrm{FAC}}$ |
|---|---|---|---|---|---|---|---|---|---|
| 314 | $2s^22p^3(^2P)4d$ | $^3P_2$ | 20760269 | -1172 | | | | | |
| 315 | $2s^22p^3(^2P)4d$ | $^3F_3$ | 20761183 | -1079 | | | | | |
| 316 | $2s^22p^3(^2P)4d$ | $^3D_1$ | 20767831 | -1237 | | | | | |
| 317 | $2s^22p^3(^2P)4f$ | $^3G_3$ | 20848652 | -1418 | | | | | |
| 318 | $2s^22p^3(^2P)4f$ | $^3F_2$ | 20851963 | -1344 | | | | | |
| 319 | $2s^22p^3(^2P)4f$ | $^3G_4$ | 20855212 | -1487 | | | | | |
| 320 | $2s^22p^3(^2P)4f$ | $^3D_3$ | 20855624 | -1324 | | | | | |
| 321 | $2s^22p^3(^2P)4p$ | $^3S_1$ | 20907637 | -1754 | | | | | |
| 322 | $2s^22p^3(^2P)4p$ | $^1D_2$ | 20915493 | -1783 | | | | | |
| 323 | $2s^22p^3(^2P)4p$ | $^3D_3$ | 20941578 | -1591 | | | | | |
| 324 | $2s^22p^3(^2P)4p$ | $^1P_1$ | 20943421 | -1629 | | | | | |
| 325 | $2s^22p^3(^2P)4p$ | $^3P_2$ | 20957300 | -1584 | | | | | |
| 326 | $2s^22p^3(^2P)4p$ | $^1S_0$ | 21014194 | -2305 | | | | | |
| 327 | $2s^22p^3(^2P)4d$ | $^3P_0$ | 21109421 | -1422 | | | | | |
| 328 | $2s^22p^3(^2P)4d$ | $^3F_4$ | 21114277 | -1500 | | | | | |
| 329 | $2s^22p^3(^2P)4d$ | $^3P_1$ | 21116309 | -1394 | | | | | |
| 330 | $2s^22p^3(^2P)4d$ | $^1D_2$ | 21120912 | -1381 | | | | | |
| 331 | $2s^22p^3(^2P)4d$ | $^1F_3$ | 21126535 | -1572 | | | | | |
| 332 | $2s^22p^3(^2P)4d$ | $^3D_2$ | 21134881 | -1498 | | | | | |
| 333 | $2s^22p^3(^2P)4d$ | $^3D_3$ | 21135052 | -1377 | | | | | |
| 334 | $2s2p^4(^4P)4s$ | $^5P_3$ | 21144170 | -43 | | | | | |
| 335 | $2s^22p^3(^2P)4d$ | $^1P_1$ | 21174971 | -1716 | | | | | |
| 336 | $2s2p^4(^4P)4s$ | $^3P_2$ | 21177183 | -490 | -15383 | | | | |
| 337 | $2s^22p^3(^2P)4f$ | $^3D_1$ | 21217038 | -1638 | | | | | |
| 338 | $2s^22p^3(^2P)4f$ | $^1G_4$ | 21220010 | -1913 | | | | | |
| 339 | $2s^22p^3(^2P)4f$ | $^3D_2$ | 21222141 | -1654 | | | | | |
| 340 | $2s^22p^3(^2P)4f$ | $^3G_5$ | 21223374 | -1874 | | | | | |
| 341 | $2s^22p^3(^2P)4f$ | $^3F_3$ | 21230083 | -1737 | | | | | |
| 342 | $2s^22p^3(^2P)4f$ | $^1D_2$ | 21230686 | -1781 | | | | | |
| 343 | $2s^22p^3(^2P)4f$ | $^1F_3$ | 21232007 | -1733 | | | | | |
| 344 | $2s^22p^3(^2P)4f$ | $^3F_4$ | 21235534 | -1791 | | | | | |

**Table 4.** Wavelengths ($\lambda$, in vacuum, Å), transition rates ($A$, in $s^{-1}$), oscillator strengths ($gf$, dimensionless) and line strengths ($S$, in a.u.) for the transitions among the 344 levels listed in Table 1. The last column represent the estimated accuracies of the $A$-values using the terminologies of the NIST ASD.

| Upper | Lower | Type | $\lambda_{\rm MCDF}$ | $\lambda_{\rm MBPT}$ | $S_{\rm MCDF}$ | $gf_{\rm MCDF}$ | $A_{\rm MCDF}$ | $S_{\rm MBPT}$ | $gf_{\rm MBPT}$ | $A_{\rm MBPT}$ | Acc. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 1 | E2 | $6.2503E+02$ | $6.2548E+02$ | $5.288E-04$ | $3.636E-10$ | $6.208E+00$ | $5.272E-04$ | $3.617E-10$ | $6.168E+00$ | B |
| 3 | 1 | M1 | $2.3578E+02$ | $2.3569E+02$ | $1.953E+00$ | $3.349E-05$ | $1.340E+06$ | $1.949E+00$ | $3.344E-05$ | $1.339E+06$ | A |
| 3 | 1 | E2 | $2.3578E+02$ | $2.3569E+02$ | $5.519E-04$ | $7.069E-09$ | $2.827E+02$ | $5.498E-04$ | $7.051E-09$ | $2.822E+02$ | B |
| 3 | 2 | M1 | $3.7860E+02$ | $3.7819E+02$ | $1.023E+00$ | $1.093E-05$ | $1.695E+05$ | $1.021E+00$ | $1.092E-05$ | $1.697E+05$ | A |
| 4 | 1 | M1 | $1.9038E+02$ | $1.9038E+02$ | $1.247E+00$ | $2.648E-05$ | $9.746E+05$ | $1.245E+00$ | $2.645E-05$ | $9.736E+05$ | A |
| 4 | 1 | E2 | $1.9038E+02$ | $1.9038E+02$ | $8.142E-04$ | $1.981E-08$ | $7.292E+02$ | $8.124E-04$ | $1.977E-08$ | $7.275E+02$ | B |
| 4 | 2 | E2 | $2.7377E+02$ | $2.7369E+02$ | $2.477E-04$ | $2.027E-09$ | $3.608E+01$ | $2.471E-04$ | $2.024E-09$ | $3.605E+01$ | B |
| 4 | 3 | M1 | $9.8879E+02$ | $9.9048E+02$ | $5.385E-01$ | $2.202E-06$ | $3.005E+03$ | $5.383E-01$ | $2.198E-06$ | $2.989E+03$ | A |
| 4 | 3 | E2 | $9.8879E+02$ | $9.9048E+02$ | $1.576E-04$ | $2.738E-11$ | $3.735E-02$ | $1.572E-04$ | $2.716E-11$ | $3.693E-02$ | B |
| 5 | 3 | M1 | $1.6775E+02$ | $1.6776E+02$ | $9.599E-01$ | $2.314E-05$ | $5.485E+06$ | $9.585E-01$ | $2.311E-05$ | $5.476E+06$ | A |
| 5 | 4 | E2 | $2.0202E+02$ | $2.0197E+02$ | $7.701E-04$ | $1.568E-08$ | $2.563E+03$ | $7.676E-04$ | $1.564E-08$ | $2.558E+03$ | B |
| 6 | 1 | E1 | $5.9725E+01$ | $5.9703E+01$ | $4.524E-02$ | $2.301E-01$ | $8.606E+10$ | $4.508E-02$ | $2.294E-01$ | $8.585E+10$ | A |
| 6 | 1 | M2 | $5.9725E+01$ | $5.9703E+01$ | $9.243E-01$ | $9.698E-09$ | $3.627E+03$ | $9.232E-01$ | $9.697E-09$ | $3.629E+03$ | A |
| 6 | 2 | M2 | $6.6035E+01$ | $6.6003E+01$ | $3.129E-01$ | $2.429E-09$ | $7.431E+02$ | $3.125E-01$ | $2.430E-09$ | $7.440E+02$ | A |
| 6 | 3 | E1 | $7.9986E+01$ | $7.9958E+01$ | $1.861E-02$ | $7.068E-02$ | $1.474E+10$ | $1.855E-02$ | $7.047E-02$ | $1.471E+10$ | A |
| 6 | 4 | E1 | $8.7026E+01$ | $8.6979E+01$ | $1.181E-02$ | $4.124E-02$ | $7.263E+09$ | $1.179E-02$ | $4.116E-02$ | $7.258E+09$ | A |
| 6 | 4 | M2 | $8.7026E+01$ | $8.6979E+01$ | $1.444E-02$ | $4.898E-11$ | $8.628E+00$ | $1.434E-02$ | $4.872E-11$ | $8.590E+00$ | B+ |
| 6 | 5 | M2 | $1.5289E+02$ | $1.5277E+02$ | $2.681E-02$ | $1.677E-11$ | $9.570E-01$ | $2.672E-02$ | $1.675E-11$ | $9.575E-01$ | B+ |
| 7 | 1 | E1 | $5.3634E+01$ | $5.3618E+01$ | $2.882E-02$ | $1.632E-01$ | $1.262E+11$ | $2.874E-02$ | $1.628E-01$ | $1.259E+11$ | A |
| 7 | 1 | M2 | $5.3634E+01$ | $5.3618E+01$ | $2.611E-01$ | $3.782E-09$ | $2.924E+03$ | $2.608E-01$ | $3.782E-09$ | $2.925E+03$ | A |
| 7 | 2 | E1 | $5.8669E+01$ | $5.8645E+01$ | $1.249E-02$ | $6.468E-02$ | $4.178E+10$ | $1.246E-02$ | $6.451E-02$ | $4.171E+10$ | A |
| 7 | 3 | E1 | $6.9427E+01$ | $6.9408E+01$ | $8.774E-03$ | $3.839E-02$ | $1.771E+10$ | $8.742E-03$ | $3.826E-02$ | $1.766E+10$ | B+ |
| 7 | 3 | M2 | $6.9427E+01$ | $6.9408E+01$ | $8.203E-02$ | $5.479E-10$ | $2.527E+02$ | $8.186E-02$ | $5.472E-10$ | $2.526E+02$ | B+ |
| 7 | 4 | E1 | $7.4670E+01$ | $7.4638E+01$ | $3.475E-03$ | $1.414E-02$ | $5.638E+09$ | $3.470E-03$ | $1.412E-02$ | $5.637E+09$ | B+ |
| 7 | 4 | M2 | $7.4670E+01$ | $7.4638E+01$ | $1.203E-01$ | $6.457E-10$ | $2.575E+02$ | $1.198E-01$ | $6.442E-10$ | $2.571E+02$ | A |
| 7 | 5 | E1 | $1.1845E+02$ | $1.1839E+02$ | $1.852E-03$ | $4.748E-03$ | $7.524E+08$ | $1.843E-03$ | $4.729E-03$ | $7.502E+08$ | B+ |
| 7 | 6 | M1 | $5.2593E+02$ | $5.2603E+02$ | $1.925E+00$ | $1.480E-05$ | $1.190E+05$ | $1.921E+00$ | $1.476E-05$ | $1.186E+05$ | A |
| 7 | 6 | E2 | $5.2593E+02$ | $5.2603E+02$ | $5.461E-04$ | $6.303E-10$ | $5.067E+00$ | $5.440E-04$ | $6.276E-10$ | $5.043E+00$ | B |
| 8 | 1 | M2 | $4.6841E+01$ | $4.6825E+01$ | $5.287E-03$ | $1.150E-10$ | $3.496E+02$ | $5.272E-03$ | $1.148E-10$ | $3.492E+02$ | B |
| 8 | 3 | E1 | $5.8454E+01$ | $5.8434E+01$ | $1.537E-02$ | $7.985E-02$ | $1.559E+11$ | $1.531E-02$ | $7.961E-02$ | $1.555E+11$ | A |
| 8 | 4 | M2 | $6.2127E+01$ | $6.2098E+01$ | $2.573E-01$ | $2.399E-09$ | $4.145E+03$ | $2.569E-01$ | $2.398E-09$ | $4.149E+03$ | A |
| 8 | 6 | E2 | $2.1714E+02$ | $2.1708E+02$ | $3.042E-04$ | $4.989E-09$ | $7.058E+02$ | $3.032E-04$ | $4.976E-09$ | $7.044E+02$ | B |
| 8 | 7 | M1 | $3.6983E+02$ | $3.6960E+02$ | $1.544E+00$ | $1.689E-05$ | $8.235E+05$ | $1.541E+00$ | $1.686E-05$ | $8.230E+05$ | A |
| 9 | 1 | E1 | $4.2047E+01$ | $4.2038E+01$ | $3.104E-03$ | $2.242E-02$ | $2.820E+10$ | $3.094E-03$ | $2.236E-02$ | $2.813E+10$ | B+ |
| 9 | 1 | M2 | $4.2047E+01$ | $4.2038E+01$ | $1.202E-01$ | $3.615E-09$ | $4.546E+03$ | $1.198E-01$ | $3.604E-09$ | $4.535E+03$ | A |
| 9 | 2 | E1 | $4.5080E+01$ | $4.5067E+01$ | $4.297E-04$ | $2.896E-03$ | $3.168E+09$ | $4.291E-04$ | $2.892E-03$ | $3.166E+09$ | B |
| 9 | 3 | E1 | $5.1173E+01$ | $5.1164E+01$ | $2.623E-03$ | $1.557E-02$ | $1.322E+10$ | $2.617E-03$ | $1.554E-02$ | $1.320E+10$ | B+ |
| 9 | 3 | M2 | $5.1173E+01$ | $5.1164E+01$ | $3.169E-01$ | $5.287E-09$ | $4.489E+03$ | $3.166E-01$ | $5.284E-09$ | $4.488E+03$ | A |
| 9 | 4 | E1 | $5.3966E+01$ | $5.3950E+01$ | $6.130E-02$ | $3.451E-01$ | $2.634E+11$ | $6.109E-02$ | $3.439E-01$ | $2.627E+11$ | A |
| 9 | 4 | M2 | $5.3966E+01$ | $5.3950E+01$ | $2.778E-01$ | $3.951E-09$ | $3.017E+03$ | $2.776E-01$ | $3.952E-09$ | $3.019E+03$ | A |
| 9 | 5 | E1 | $7.3636E+01$ | $7.3614E+01$ | $9.798E-03$ | $4.042E-02$ | $1.657E+10$ | $9.773E-03$ | $4.033E-02$ | $1.655E+10$ | B+ |
| 9 | 6 | M1 | $1.4206E+02$ | $1.4208E+02$ | $5.555E-01$ | $1.581E-05$ | $1.742E+06$ | $5.549E-01$ | $1.580E-05$ | $1.740E+06$ | A |
| 9 | 6 | E2 | $1.4206E+02$ | $1.4208E+02$ | $1.496E-04$ | $8.763E-09$ | $9.655E+02$ | $1.493E-04$ | $8.741E-09$ | $9.628E+02$ | B |
| 9 | 7 | M1 | $1.9463E+02$ | $1.9465E+02$ | $2.565E-01$ | $5.330E-06$ | $3.129E+05$ | $2.563E-01$ | $5.326E-06$ | $3.125E+05$ | A |
| 9 | 7 | E2 | $1.9463E+02$ | $1.9465E+02$ | $3.873E-04$ | $8.821E-09$ | $5.177E+02$ | $3.861E-04$ | $8.791E-09$ | $5.159E+02$ | B |
| 9 | 8 | M1 | $4.1083E+02$ | $4.1120E+02$ | $4.498E-01$ | $4.427E-06$ | $5.832E+04$ | $4.496E-01$ | $4.422E-06$ | $5.815E+04$ | A |
| 10 | 6 | M2 | $4.7504E+01$ | $4.7519E+01$ | $4.628E-01$ | $9.650E-09$ | $2.853E+04$ | $4.619E-01$ | $9.622E-09$ | $2.842E+04$ | A |
| 10 | 7 | E1 | $5.2220E+01$ | $5.2238E+01$ | $1.145E-02$ | $6.662E-02$ | $1.629E+11$ | $1.142E-02$ | $6.643E-02$ | $1.624E+11$ | A |
| 10 | 9 | E1 | $7.1369E+01$ | $7.1399E+01$ | $3.983E-02$ | $1.695E-01$ | $2.220E+11$ | $3.967E-02$ | $1.688E-01$ | $2.209E+11$ | A |

Only transitions among the lowest 10 levels of the $n = 2$ configurations are shown here. Table 4 is available online in its entirety in the *JQSRT* website.

**Table 5.** Comparison between present transition rates ($A$ in $s^{-1}$) and available theoretical results, as well as the NIST values, for the transitions among the lowest 10 levels. MCDF, MBPT– the present values; MCDF2– Rynkun et al. [19]; GRASP1– Aggarwal et al. [20]; MCHF-BP– Froese Fischer and Saha [15]; NIST– Kramida et al. [12].

| Upper state | Lower state | Tpye | MCDF | MBPT | MCDF2 | GRASP1 | MCHF-BP | NIST |
|---|---|---|---|---|---|---|---|---|
| $2s^22p^4\ ^3P_0$ | $2s^22p^4\ ^3P_2$ | E2 | 6.208E+00 | 6.168E+00 | 6.214E+00 | | | |
| $2s^22p^4\ ^3P_1$ | $2s^22p^4\ ^3P_2$ | M1 | 1.340E+06 | 1.339E+06 | 1.338E+06 | | | 1.340E+06 |
| $2s^22p^4\ ^3P_1$ | $2s^22p^4\ ^3P_2$ | E2 | 2.827E+02 | 2.822E+02 | 2.820E+02 | | | |
| $2s^22p^4\ ^3P_1$ | $2s^22p^4\ ^3P_0$ | M1 | 1.695E+05 | 1.697E+05 | 1.691E+05 | | | |
| $2s^22p^4\ ^1D_2$ | $2s^22p^4\ ^3P_2$ | M1 | 9.746E+05 | 9.736E+05 | 9.732E+05 | | | 9.820E+05 |
| $2s^22p^4\ ^1D_2$ | $2s^22p^4\ ^3P_2$ | E2 | 7.292E+02 | 7.275E+02 | 7.274E+02 | | | |
| $2s^22p^4\ ^1D_2$ | $2s^22p^4\ ^3P_0$ | E2 | 3.608E+01 | 3.605E+01 | 3.593E+01 | | | |
| $2s^22p^4\ ^1D_2$ | $2s^22p^4\ ^3P_1$ | M1 | 3.005E+03 | 2.989E+03 | 3.019E+03 | | | |
| $2s^22p^4\ ^1D_2$ | $2s^22p^4\ ^3P_1$ | E2 | 3.735E-02 | 3.693E-02 | | | | |
| $2s^22p^4\ ^1S_0$ | $2s^22p^4\ ^3P_1$ | M1 | 5.485E+06 | 5.476E+06 | 5.479E+06 | | | |
| $2s^22p^4\ ^1S_0$ | $2s^22p^4\ ^1D_2$ | E2 | 2.563E+03 | 2.558E+03 | 2.560E+03 | | | |
| $2s2p^5\ ^3P^o_2$ | $2s^22p^4\ ^3P_2$ | E1 | 8.606E+10 | 8.585E+10 | 8.617E+10 | 9.070E+10 | 9.246E+10 | |
| $2s2p^5\ ^3P^o_2$ | $2s^22p^4\ ^3P_2$ | M2 | 3.627E+03 | 3.629E+03 | 3.630E+03 | 3.637E+03 | | |
| $2s2p^5\ ^3P^o_2$ | $2s^22p^4\ ^3P_0$ | M2 | 7.431E+02 | 7.440E+02 | 7.440E+02 | 7.500E+02 | | |
| $2s2p^5\ ^3P^o_2$ | $2s^22p^4\ ^3P_1$ | E1 | 1.474E+10 | 1.471E+10 | 1.477E+10 | 1.567E+10 | 1.584E+10 | |
| $2s2p^5\ ^3P^o_2$ | $2s^22p^4\ ^1D_2$ | E1 | 7.263E+09 | 7.258E+09 | 7.280E+09 | 7.610E+09 | 7.531E+09 | |
| $2s2p^5\ ^3P^o_2$ | $2s^22p^4\ ^1D_2$ | M2 | 8.628E+00 | 8.590E+00 | 8.669E+00 | 9.719E+00 | | |
| $2s2p^5\ ^3P^o_2$ | $2s^22p^4\ ^1S_0$ | M2 | 9.570E-01 | 9.575E-01 | | 1.052E+00 | | |
| $2s2p^5\ ^3P^o_1$ | $2s^22p^4\ ^3P_2$ | E1 | 1.262E+11 | 1.259E+11 | 1.263E+11 | 1.313E+11 | 1.348E+11 | |
| $2s2p^5\ ^3P^o_1$ | $2s^22p^4\ ^3P_2$ | M2 | 2.924E+03 | 2.925E+03 | 2.926E+03 | 2.940E+03 | | |
| $2s2p^5\ ^3P^o_1$ | $2s^22p^4\ ^3P_0$ | E1 | 4.178E+10 | 4.171E+10 | 4.183E+10 | 4.374E+10 | 4.510E+10 | |
| $2s2p^5\ ^3P^o_1$ | $2s^22p^4\ ^3P_1$ | E1 | 1.771E+10 | 1.766E+10 | 1.774E+10 | 1.904E+10 | 1.837E+10 | |
| $2s2p^5\ ^3P^o_1$ | $2s^22p^4\ ^3P_1$ | M2 | 2.527E+02 | 2.526E+02 | 2.533E+02 | 2.669E+02 | | |
| $2s2p^5\ ^3P^o_1$ | $2s^22p^4\ ^1D_2$ | E1 | 5.638E+09 | 5.637E+09 | 5.642E+09 | 5.515E+09 | 6.419E+09 | |
| $2s2p^5\ ^3P^o_1$ | $2s^22p^4\ ^1D_2$ | M2 | 2.575E+02 | 2.571E+02 | 2.583E+02 | 2.779E+02 | | |
| $2s2p^5\ ^3P^o_1$ | $2s^22p^4\ ^1S_0$ | E1 | 7.524E+08 | 7.502E+08 | 7.551E+08 | 8.559E+08 | | |
| $2s2p^5\ ^3P^o_1$ | $2s2p^5\ ^3P^o_2$ | M1 | 1.190E+05 | 1.186E+05 | 1.189E+05 | | | |
| $2s2p^5\ ^3P^o_1$ | $2s2p^5\ ^3P^o_2$ | E2 | 5.067E+00 | 5.043E+00 | 5.064E+00 | | | |
| $2s2p^5\ ^3P^o_0$ | $2s^22p^4\ ^3P_2$ | M2 | 3.496E+02 | 3.492E+02 | 3.496E+02 | 3.528E+02 | | |
| $2s2p^5\ ^3P^o_0$ | $2s^22p^4\ ^3P_1$ | E1 | 1.559E+11 | 1.555E+11 | 1.561E+11 | 1.639E+11 | 1.652E+11 | |
| $2s2p^5\ ^3P^o_0$ | $2s^22p^4\ ^1D_2$ | M2 | 4.145E+03 | 4.149E+03 | 4.150E+03 | 4.173E+03 | | |
| $2s2p^5\ ^3P^o_0$ | $2s2p^5\ ^3P^o_2$ | E2 | 7.058E+02 | 7.044E+02 | 7.044E+02 | | | |
| $2s2p^5\ ^3P^o_0$ | $2s2p^5\ ^3P^o_1$ | M1 | 8.235E+05 | 8.230E+05 | 8.220E+05 | | | |
| $2s2p^5\ ^1P^o_1$ | $2s^22p^4\ ^3P_2$ | E1 | 2.820E+10 | 2.813E+10 | 2.824E+10 | 3.044E+10 | 2.749E+10 | |
| $2s2p^5\ ^1P^o_1$ | $2s^22p^4\ ^3P_2$ | M2 | 4.546E+03 | 4.535E+03 | 4.551E+03 | 4.865E+03 | | |
| $2s2p^5\ ^1P^o_1$ | $2s^22p^4\ ^3P_0$ | E1 | 3.168E+09 | 3.166E+09 | 3.170E+09 | | 3.250E+9 | |
| $2s2p^5\ ^1P^o_1$ | $2s^22p^4\ ^3P_1$ | E1 | 1.322E+10 | 1.320E+10 | 1.323E+10 | 1.352E+10 | 1.421E+10 | |
| $2s2p^5\ ^1P^o_1$ | $2s^22p^4\ ^3P_1$ | M2 | 4.489E+03 | 4.488E+03 | 4.492E+03 | 4.568E+03 | | |
| $2s2p^5\ ^1P^o_1$ | $2s^22p^4\ ^1D_2$ | E1 | 2.634E+11 | 2.627E+11 | 2.638E+11 | 2.796E+11 | 2.737E+11 | |
| $2s2p^5\ ^1P^o_1$ | $2s^22p^4\ ^1D_2$ | M2 | 3.017E+03 | 3.019E+03 | 3.002E+03 | 3.008E+03 | | |
| $2s2p^5\ ^1P^o_1$ | $2s^22p^4\ ^1S_0$ | E1 | 1.657E+10 | 1.655E+10 | 1.660E+10 | 1.761E+10 | 1.773E+10 | |
| $2s2p^5\ ^1P^o_1$ | $2s2p^5\ ^3P^o_2$ | M1 | 1.742E+06 | 1.740E+06 | 1.740E+06 | | | |
| $2s2p^5\ ^1P^o_1$ | $2s2p^5\ ^3P^o_2$ | E2 | 9.655E+02 | 9.628E+02 | 9.640E+02 | | | |
| $2s2p^5\ ^1P^o_1$ | $2s2p^5\ ^3P^o_1$ | M1 | 3.129E+05 | 3.125E+05 | 3.125E+05 | | | |
| $2s2p^5\ ^1P^o_1$ | $2s2p^5\ ^3P^o_1$ | E2 | 5.177E+02 | 5.159E+02 | 5.170E+02 | | | |
| $2s2p^5\ ^1P^o_1$ | $2s2p^5\ ^3P^o_0$ | M1 | 5.832E+04 | 5.815E+04 | 5.830E+04 | | | |
| $2p^6\ ^1S_0$ | $2s2p^5\ ^3P^o_2$ | M2 | 2.853E+04 | 2.842E+04 | 2.852E+04 | 2.959E+04 | | |
| $2p^6\ ^1S_0$ | $2s2p^5\ ^3P^o_1$ | E1 | 1.629E+11 | 1.624E+11 | 1.629E+11 | 1.679E+11 | | |
| $2p^6\ ^1S_0$ | $2s2p^5\ ^1P^o_1$ | E1 | 2.220E+11 | 2.209E+11 | 2.223E+11 | 2.414E+11 | | |

**Table 6.** The present MCDF and MBPT lifetimes ($\tau$ in s), as well as the previous values [19, 20]. Hyperfine magnetic dipole constants $A_J(I/\mu_I)$ (MHz per unit of $\mu_N$ ), electric quadrupole constants $B_J/Q$ (MHz/barn), Landé $g_J$-factors, and the total energies $E_h$ (a.u.) from the present MCDF calculations. MCDF, MBPT– the present values; MCDF2– Rynkun et al. [19]; GRASP1– Aggarwal et al. [20]

| Key | level | $\tau_{\rm MCDF}$ | $\tau_{\rm MBPT}$ | $\tau_{\rm MCDF2}$ | $\tau_{\rm GRASP1}$ | MCDF | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | $E_h$ | $A_J$ | $B_J$ | $g_J$ |
| 1 | $2s^22p^4\ ^3P_2$ | | | | | -2104.36 | 7.483E+04 | 5.454E+04 | 1.386E+00 |
| 2 | $2s^22p^4\ ^3P_0$ | 1.611E-01 | 1.621E-01 | 1.609E-01 | 1.587E-01 | -2103.63 | | | |
| 3 | $2s^22p^4\ ^3P_1$ | 6.625E-07 | 6.629E-07 | 6.635E-07 | 6.698E-07 | -2102.43 | -1.311E+04 | -7.253E+04 | 1.494E+00 |
| 4 | $2s^22p^4\ ^1D_2$ | 1.022E-06 | 1.023E-06 | 1.024E-06 | 1.027E-06 | -2101.96 | 1.721E+05 | -2.005E+05 | 1.099E+00 |
| 5 | $2s^22p^4\ ^1S_0$ | 1.822E-07 | 1.825E-07 | 1.824E-07 | 1.833E-07 | -2099.71 | | | |
| 6 | $2s2p^5\ ^3P^o_2$ | 9.254E-12 | 9.276E-12 | 9.241E-12 | 8.774E-12 | -2096.73 | 4.175E+05 | -1.447E+05 | 1.492E+00 |
| 7 | $2s2p^5\ ^3P^o_1$ | 5.207E-12 | 5.217E-12 | 5.201E-12 | 4.989E-12 | -2095.86 | -4.204E+04 | 2.798E+04 | 1.380E+00 |
| 8 | $2s2p^5\ ^3P^o_0$ | 6.415E-12 | 6.430E-12 | 6.407E-12 | 6.103E-12 | -2094.63 | | | |
| 9 | $2s2p^5\ ^1P^o_1$ | 3.081E-12 | 3.089E-12 | 3.077E-12 | 2.901E-12 | -2093.52 | 7.179E+05 | -9.918E+04 | 1.103E+00 |
| 10 | $2p^6\ ^1S_0$ | 2.598E-12 | 2.609E-12 | 2.596E-12 | 2.443E-12 | -2087.14 | | | |
| 11 | $2s^22p^3(^4S)3s\ ^5S^o_2$ | 3.683E-13 | 3.697E-13 | | 3.649E-13 | -2038.18 | 1.380E+05 | 9.155E+04 | 1.687E+00 |
| 12 | $2s^22p^3(^4S)3s\ ^3S^o_1$ | 8.865E-14 | 8.898E-14 | | 8.657E-14 | -2037.97 | -1.256E+04 | 5.796E+04 | 1.367E+00 |
| 13 | $2s^22p^3(^4S)3p\ ^5P_1$ | 2.731E-11 | 2.760E-11 | | 2.150E-11 | -2036.55 | 4.602E+04 | 4.761E+04 | 1.722E+00 |
| 14 | $2s^22p^3(^4S)3p\ ^5P_2$ | 2.860E-11 | 2.886E-11 | | 2.468E-11 | -2036.50 | 7.287E+04 | 8.071E+04 | 1.397E+00 |
| 15 | $2s^22p^3(^2D)3s\ ^3D^o_2$ | 2.291E-13 | 2.299E-13 | | 2.235E-13 | -2036.41 | 1.066E+05 | 8.976E+04 | 1.481E+00 |
| 16 | $2s^22p^3(^2D)3s\ ^3D^o_1$ | 9.624E-14 | 9.666E-14 | | 9.425E-14 | -2036.27 | -7.483E+04 | 2.824E+04 | 1.199E+00 |
| 17 | $2s^22p^3(^4S)3p\ ^5P_3$ | 2.960E-11 | 2.993E-11 | | 2.506E-11 | -2035.98 | 3.905E+04 | 1.196E+05 | 1.457E+00 |
| 18 | $2s^22p^3(^2D)3s\ ^3D^o_3$ | 1.772E-13 | 1.779E-13 | | 1.724E-13 | -2035.94 | 1.918E+05 | -7.536E+02 | 1.326E+00 |
| 19 | $2s^22p^3(^4S)3p\ ^3P_1$ | 1.619E-11 | 1.643E-11 | | 1.211E-11 | -2035.94 | 4.259E+04 | -4.875E+04 | 1.495E+00 |
| 20 | $2s^22p^3(^2D)3s\ ^1D^o_2$ | 9.554E-14 | 9.596E-14 | | 9.342E-14 | -2035.81 | 1.227E+05 | -1.846E+04 | 1.051E+00 |
| 21 | $2s^22p^3(^4S)3p\ ^3P_2$ | 2.305E-11 | 2.327E-11 | | 1.955E-11 | -2035.60 | 4.630E+04 | 3.237E+04 | 1.342E+00 |
| 22 | $2s^22p^3(^2P)3s\ ^3P^o_0$ | 2.152E-13 | 2.161E-13 | | 2.121E-13 | -2035.32 | | | |
| 23 | $2s^22p^3(^4S)3p\ ^3P_0$ | 6.279E-12 | 6.305E-12 | | 5.411E-12 | -2035.28 | | | |
| 24 | $2s^22p^3(^2P)3s\ ^3P^o_1$ | 1.281E-13 | 1.286E-13 | | 1.252E-13 | -2035.26 | 4.133E+05 | -1.204E+04 | 1.333E+00 |
| 25 | $2s^22p^3(^2D)3p\ ^3D_1$ | 2.610E-11 | 2.655E-11 | | 1.707E-11 | -2034.83 | -3.107E+03 | 3.416E+04 | 1.481E+00 |
| 26 | $2s^22p^3(^2D)3p\ ^3F_2$ | 5.201E-11 | 5.234E-11 | | 4.650E-11 | -2034.64 | 9.692E+04 | 1.097E+04 | 1.160E+00 |
| 27 | $2s^22p^3(^2D)3p\ ^3F_3$ | 4.897E-11 | 4.916E-11 | | 4.597E-11 | -2034.30 | 1.384E+05 | -5.315E+03 | 1.151E+00 |
| 28 | $2s^22p^3(^2D)3p\ ^3D_2$ | 1.870E-11 | 1.905E-11 | | 1.406E-11 | -2034.24 | 4.468E+03 | 3.314E+04 | 1.350E+00 |
| 29 | $2s^22p^3(^2D)3p\ ^1F_3$ | 1.974E-11 | 1.999E-11 | | 1.619E-11 | -2034.21 | 3.371E+04 | 1.165E+05 | 1.296E+00 |
| 30 | $2s^22p^3(^2D)3p\ ^3P_0$ | 8.116E-12 | 8.245E-12 | | 5.593E-12 | -2034.12 | | | |
| 31 | $2s^22p^3(^4S)3d\ ^5D^o_2$ | 5.220E-13 | 5.266E-13 | | 4.750E-13 | -2034.06 | 3.683E+04 | 7.800E+02 | 1.122E+00 |
| 32 | $2s^22p^3(^4S)3d\ ^5D^o_3$ | 1.115E-12 | 1.128E-12 | | 1.093E-12 | -2034.01 | 3.094E+04 | 6.202E+04 | 1.278E+00 |
| 33 | $2s^22p^3(^2D)3p\ ^1P_1$ | 2.192E-11 | 2.210E-11 | | 1.645E-11 | -2034.01 | 2.595E+05 | -3.752E+04 | 8.940E-01 |
| 34 | $2s^22p^3(^4S)3d\ ^5D^o_0$ | 2.027E-12 | 2.031E-12 | | 1.915E-12 | -2033.96 | | | |
| 35 | $2s^22p^3(^4S)3d\ ^5D^o_1$ | 1.044E-13 | 1.046E-13 | | 1.028E-13 | -2033.96 | 2.956E+04 | -3.445E+04 | 1.302E+00 |
| 36 | $2s^22p^3(^4S)3d\ ^5D^o_4$ | 1.180E-10 | 1.187E-10 | | 1.135E-10 | -2033.90 | 2.306E+04 | 8.083E+04 | 1.343E+00 |
| 37 | $2s^22p^3(^2D)3p\ ^3P_2$ | 3.182E-12 | 3.236E-12 | | 2.290E-12 | -2033.79 | 1.074E+05 | 4.207E+04 | 1.360E+00 |
| 38 | $2s^22p^3(^2D)3p\ ^3D_3$ | 2.822E-11 | 2.846E-11 | | 2.308E-11 | -2033.77 | 1.187E+05 | -1.494E+04 | 1.206E+00 |
| 39 | $2s^22p^3(^2D)3p\ ^3F_4$ | 3.789E-11 | 3.810E-11 | | 3.682E-11 | -2033.73 | 1.037E+05 | 3.886E+04 | 1.244E+00 |
| 40 | $2s^22p^3(^4S)3d\ ^3D^o_2$ | 3.774E-14 | 3.782E-14 | | 3.721E-14 | -2033.73 | 8.422E+03 | -7.004E+04 | 1.278E+00 |
| 41 | $2s^22p^3(^2P)3s\ ^3P^o_2$ | 1.478E-13 | 1.485E-13 | | 1.441E-13 | -2033.62 | 1.594E+05 | -1.642E+05 | 1.420E+00 |
| 42 | $2s^22p^3(^2P)3p\ ^3D_1$ | 9.273E-12 | 9.339E-12 | | 7.541E-12 | -2033.62 | 2.300E+05 | -1.543E+04 | 8.145E-01 |
| 43 | $2s^22p^3(^2P)3s\ ^1P^o_1$ | 9.658E-14 | 9.702E-14 | | 9.465E-14 | -2033.52 | 1.193E+04 | -7.424E+04 | 1.069E+00 |
| 44 | $2s^22p^3(^2D)3p\ ^3P_1$ | 3.557E-12 | 3.598E-12 | | 2.779E-12 | -2033.41 | 6.267E+04 | 5.546E+04 | 1.343E+00 |
| 45 | $2s^22p^3(^4S)3d\ ^3D^o_3$ | 1.587E-14 | 1.592E-14 | | 1.548E-14 | -2033.39 | 2.766E+04 | 3.506E+04 | 1.157E+00 |
| 46 | $2s^22p^3(^4S)3d\ ^3D^o_1$ | 2.112E-14 | 2.121E-14 | | 2.017E-14 | -2033.33 | -2.537E+04 | 6.152E+03 | 8.188E-01 |
| 47 | $2s^22p^3(^2D)3p\ ^1D_2$ | 4.492E-12 | 4.509E-12 | | 3.987E-12 | -2033.14 | 1.520E+05 | 6.876E+04 | 1.167E+00 |
| 48 | $2s^22p^3(^2P)3p\ ^3P_0$ | 4.304E-12 | 4.355E-12 | | 3.159E-12 | -2033.04 | | | |
| 49 | $2s^22p^3(^2P)3p\ ^3P_1$ | 4.985E-12 | 5.086E-12 | | 3.621E-12 | -2033.01 | -6.803E+04 | -1.475E+04 | 1.482E+00 |
| 50 | $2s^22p^3(^2P)3p\ ^3D_2$ | 6.903E-12 | 7.074E-12 | | 4.929E-12 | -2032.94 | 1.361E+05 | -8.396E+04 | 1.123E+00 |
| 51 | $2s^22p^3(^2D)3d\ ^3D^o_1$ | 9.035E-14 | 9.045E-14 | | 8.780E-14 | -2032.25 | 4.083E+04 | -4.137E+04 | 8.779E-01 |
| 52 | $2s^22p^3(^2D)3d\ ^3F^o_2$ | 8.989E-14 | 9.016E-14 | | 8.590E-14 | -2032.24 | 5.896E+04 | -7.159E+04 | 1.032E+00 |
| 53 | $2s^22p^3(^2D)3d\ ^1S^o_0$ | 2.710E-13 | 2.715E-13 | | 2.699E-13 | -2032.21 | | | |
| 54 | $2s^22p^3(^2D)3d\ ^3F^o_3$ | 1.148E-13 | 1.150E-13 | | 1.135E-13 | -2032.17 | 9.047E+03 | -6.696E+03 | 1.258E+00 |
| 55 | $2s^22p^3(^2D)3d\ ^3G^o_4$ | 1.181E-10 | 1.189E-10 | | 1.133E-10 | -2032.13 | 1.569E+04 | 8.277E+04 | 1.224E+00 |
| 56 | $2s^22p^3(^2D)3d\ ^3G^o_3$ | 1.078E-13 | 1.079E-13 | | 1.027E-13 | -2032.08 | 4.942E+04 | 1.251E+04 | 1.065E+00 |
| 57 | $2s^22p^3(^2D)3d\ ^1P^o_1$ | 2.960E-14 | 2.973E-14 | | 2.836E-14 | -2031.79 | 7.134E+04 | 2.100E+04 | 1.132E+00 |
| 58 | $2s^22p^3(^2P)3p\ ^3S_1$ | 3.279E-12 | 3.355E-12 | | 2.330E-12 | -2031.78 | 7.252E+04 | -5.758E+04 | 1.627E+00 |
| 59 | $2s^22p^3(^2D)3d\ ^3F^o_4$ | 8.168E-11 | 8.211E-11 | | 7.952E-11 | -2031.77 | 9.255E+04 | 5.455E+03 | 1.143E+00 |
| 60 | $2s2p^4(^4P)3s\ ^5P_3$ | 1.540E-12 | 1.546E-12 | | 1.529E-12 | -2031.75 | 3.451E+05 | 9.632E+04 | 1.613E+00 |

**Table 6.** (*continued*)

| Key | level | $\tau_{\rm MCDF}$ | $\tau_{\rm MBPT}$ | $\tau_{\rm MCDF2}$ | $\tau_{\rm GRASP1}$ | MCDF | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | $E_h$ | $A_J$ | $B_J$ | $g_J$ |
| 61 | $2s^22p^3(^2D)3d\ ^3P^o_2$ | 1.733E-14 | 1.737E-14 | | 1.694E-14 | -2031.71 | 3.593E+04 | -2.960E+04 | 1.214E+00 |
| 62 | $2s^22p^3(^2D)3d\ ^1G^o_4$ | 1.054E-10 | 1.064E-10 | | 9.980E-11 | -2031.68 | 8.407E+04 | -7.562E+03 | 1.107E+00 |
| 63 | $2s^22p^3(^2D)3d\ ^3G^o_5$ | 1.185E-10 | 1.193E-10 | | 1.139E-10 | -2031.64 | 7.908E+04 | 8.232E+03 | 1.195E+00 |
| 64 | $2s^22p^3(^2P)3p\ ^1D_2$ | 6.136E-12 | 6.383E-12 | | 5.224E-12 | -2031.61 | 1.011E+05 | -1.684E+05 | 1.081E+00 |
| 65 | $2s^22p^3(^2D)3d\ ^3D^o_3$ | 1.248E-14 | 1.256E-14 | | 1.158E-14 | -2031.56 | 5.967E+04 | 3.434E+04 | 1.226E+00 |
| 66 | $2s^22p^3(^2D)3d\ ^3P^o_0$ | 2.879E-14 | 2.886E-14 | | 2.833E-14 | -2031.49 | | | |
| 67 | $2s^22p^3(^2P)3p\ ^3D_3$ | 3.086E-11 | 3.140E-11 | | 2.981E-11 | -2031.47 | 6.217E+04 | -1.016E+05 | 1.289E+00 |
| 68 | $2s^22p^3(^2P)3p\ ^1P_1$ | 5.813E-12 | 5.873E-12 | | 5.064E-12 | -2031.44 | 6.206E+04 | 1.279E+04 | 1.085E+00 |
| 69 | $2s^22p^3(^2D)3d\ ^3D^o_2$ | 1.298E-14 | 1.302E-14 | | 1.265E-14 | -2031.44 | 7.018E+04 | 3.372E+03 | 1.201E+00 |
| 70 | $2s^22p^3(^2D)3d\ ^3P^o_1$ | 1.481E-14 | 1.486E-14 | | 1.445E-14 | -2031.43 | 1.117E+05 | -4.134E+04 | 1.131E+00 |
| 71 | $2s2p^4(^4P)3s\ ^3P_2$ | 1.760E-13 | 1.806E-13 | | 9.312E-13 | -2031.32 | 2.921E+05 | 3.404E+04 | 1.448E+00 |
| 72 | $2s^22p^3(^2D)3d\ ^1D^o_2$ | 3.679E-14 | 3.673E-14 | | 3.792E-14 | -2031.29 | 7.870E+04 | 7.671E+04 | 1.089E+00 |
| 73 | $2s^22p^3(^2P)3p\ ^3P_2$ | 5.051E-13 | 4.688E-13 | | 1.479E-13 | -2031.26 | 1.288E+05 | -3.731E+03 | 1.369E+00 |
| 74 | $2s^22p^3(^2D)3d\ ^3S^o_1$ | 1.192E-14 | 1.197E-14 | | 1.140E-14 | -2031.25 | 1.121E+05 | 1.655E+04 | 1.687E+00 |
| 75 | $2s^22p^3(^2D)3d\ ^1F^o_3$ | 1.995E-14 | 1.989E-14 | | 2.122E-14 | -2031.12 | 9.479E+04 | 6.571E+04 | 1.074E+00 |
| 76 | $2s^22p^3(^2P)3d\ ^3F^o_2$ | 3.079E-14 | 3.092E-14 | | 2.950E-14 | -2030.98 | 8.903E+04 | 9.007E+04 | 8.747E-01 |
| 77 | $2s^22p^3(^2P)3d\ ^3F^o_3$ | 2.24E-14 | 2.261E-14 | | 1.957E-14 | -2030.83 | 8.180E+04 | -5.500E+04 | 1.086E+00 |
| 78 | $2s^22p^3(^2P)3d\ ^1D^o_2$ | 1.297E-14 | 1.308E-14 | | 1.162E-14 | -2030.82 | -3.304E+04 | -8.348E+04 | 1.220E+00 |
| 79 | $2s^22p^3(^2P)3d\ ^3D^o_1$ | 1.034E-14 | 1.040E-14 | | 9.699E-15 | -2030.68 | -8.349E+04 | 2.090E+04 | 8.096E-01 |
| 80 | $2s2p^4(^4P)3s\ ^5P_1$ | 5.756E-13 | 5.770E-13 | | 5.917E-13 | -2030.53 | 6.429E+05 | 3.211E+04 | 2.273E+00 |
| 81 | $2s^22p^3(^2P)3p\ ^1S_0$ | 7.003E-13 | 7.190E-13 | | 5.940E-13 | -2030.49 | | | |
| 82 | $2s2p^4(^4P)3s\ ^5P_2$ | 5.327E-13 | 5.381E-13 | | 4.675E-13 | -2030.43 | 1.303E+05 | -6.750E+04 | 1.612E+00 |
| 83 | $2s2p^4(^4P)3s\ ^3P_1$ | 9.205E-14 | 9.244E-14 | | 8.863E-14 | -2030.20 | 1.514E+04 | -9.510E+04 | 1.273E+00 |
| 84 | $2s2p^4(^4P)3p\ ^5P^o_2$ | 5.305E-13 | 5.296E-13 | | 5.332E-13 | -2030.07 | 3.823E+05 | 8.335E+04 | 1.720E+00 |
| 85 | $2s2p^4(^4P)3p\ ^5P^o_3$ | 2.616E-13 | 2.595E-13 | | 2.687E-13 | -2030.01 | 3.036E+05 | 7.339E+04 | 1.473E+00 |
| 86 | $2s2p^4(^4P)3s\ ^3P_0$ | 1.457E-13 | 1.460E-13 | | 1.373E-13 | -2029.95 | | | |
| 87 | $2s2p^4(^4P)3p\ ^5D^o_4$ | 2.600E-11 | 2.631E-11 | | 2.629E-11 | -2029.53 | 2.150E+05 | 1.215E+05 | 1.448E+00 |
| 88 | $2s2p^4(^4P)3p\ ^3D^o_3$ | 8.839E-14 | 8.859E-14 | | 8.425E-14 | -2029.49 | 2.693E+05 | 5.017E+04 | 1.426E+00 |
| 89 | $2s^22p^3(^2P)3d\ ^3P^o_0$ | 1.493E-14 | 1.498E-14 | | 1.443E-14 | -2029.44 | | | |
| 90 | $2s^22p^3(^2P)3d\ ^3F^o_4$ | 9.293E-11 | 9.204E-11 | | 6.809E-11 | -2029.40 | 4.677E+04 | -1.085E+05 | 1.224E+00 |
| 91 | $2s2p^4(^4P)3p\ ^5P^o_1$ | 2.927E-14 | 2.718E-14 | | 1.846E-14 | -2029.38 | 3.777E+05 | 2.908E+04 | 1.621E+00 |
| 92 | $2s^22p^3(^2P)3d\ ^3P^o_2$ | 3.668E-13 | 3.687E-13 | | 3.373E-13 | -2029.32 | 1.060E+04 | 1.156E+05 | 1.252E+00 |
| 93 | $2s^22p^3(^2P)3d\ ^3P^o_1$ | 2.700E-14 | 2.920E-14 | | 5.030E-14 | -2029.32 | 3.014E+05 | 3.112E+04 | 1.544E+00 |
| 94 | $2s^22p^3(^2P)3d\ ^1F^o_3$ | 1.652E-14 | 1.644E-14 | | 2.376E-14 | -2029.17 | 4.679E+04 | -1.080E+05 | 1.011E+00 |
| 95 | $2s^22p^3(^2P)3d\ ^3D^o_3$ | 4.329E-14 | 4.494E-14 | | 2.074E-14 | -2029.13 | 3.517E+04 | 1.458E+03 | 1.221E+00 |
| 96 | $2s^22p^3(^2P)3d\ ^3D^o_2$ | 1.58E-14 | 1.565E-14 | | 1.397E-14 | -2029.10 | 7.881E+04 | -2.194E+04 | 1.080E+00 |
| 97 | $2s2p^4(^2D)3s\ ^3D_2$ | 2.095E-13 | 2.108E-13 | | 1.992E-13 | -2029.06 | 1.829E+05 | -1.106E+05 | 1.352E+00 |
| 98 | $2s2p^4(^4P)3p\ ^3P^o_2$ | 6.237E-14 | 6.636E-14 | | 8.188E-14 | -2029.01 | 2.066E+05 | 3.117E+03 | 1.345E+00 |
| 99 | $2s2p^4(^2D)3s\ ^3D_1$ | 1.420E-13 | 1.428E-13 | | 1.372E-13 | -2028.95 | 9.312E+04 | -5.200E+04 | 9.883E-01 |
| 100 | $2s2p^4(^4P)3p\ ^3S^o_1$ | 7.361E-14 | 7.359E-14 | | 6.771E-14 | -2028.87 | 8.986E+04 | -5.866E+04 | 1.683E+00 |
| 101 | $2s2p^4(^4P)3p\ ^5D^o_0$ | 1.482E-12 | 1.475E-12 | | 1.482E-12 | -2028.85 | | | |
| 102 | $2s2p^4(^4P)3p\ ^5D^o_1$ | 1.427E-13 | 1.425E-13 | | 1.374E-13 | -2028.80 | 5.644E+05 | 3.567E+02 | 1.640E+00 |
| 103 | $2s2p^4(^4P)3p\ ^5D^o_2$ | 7.446E-14 | 7.521E-14 | | 7.053E-14 | -2028.78 | 7.879E+04 | -7.257E+04 | 1.351E+00 |
| 104 | $2s^22p^3(^2P)3d\ ^1P^o_1$ | 7.419E-15 | 7.458E-15 | | 7.035E-15 | -2028.59 | -2.924E+04 | 1.418E+04 | 8.990E-01 |
| 105 | $2s2p^4(^2D)3s\ ^3D_3$ | 1.463E-13 | 1.472E-13 | | 1.389E-13 | -2028.59 | 4.179E+05 | -2.511E+05 | 1.363E+00 |
| 106 | $2s2p^4(^4P)3p\ ^5D^o_3$ | 1.180E-13 | 1.184E-13 | | 1.196E-13 | -2028.35 | 3.168E+04 | -5.176E+04 | 1.416E+00 |
| 107 | $2s2p^4(^2D)3p\ ^3P^o_0$ | 2.073E-13 | 2.085E-13 | | 1.910E-13 | -2028.32 | | | |
| 108 | $2s2p^4(^2D)3s\ ^1D_2$ | 1.661E-13 | 1.671E-13 | | 1.589E-13 | -2028.30 | 4.291E+05 | -1.846E+05 | 1.121E+00 |
| 109 | $2s2p^4(^4P)3p\ ^5S^o_2$ | 5.587E-13 | 5.604E-13 | | 5.308E-13 | -2028.25 | 2.525E+05 | 9.594E+04 | 1.745E+00 |
| 110 | $2s2p^4(^4P)3p\ ^3D^o_1$ | 5.496E-14 | 5.510E-14 | | 5.429E-14 | -2028.09 | -2.732E+05 | 4.137E+04 | 8.025E-01 |
| 111 | $2s2p^4(^4P)3p\ ^3D^o_2$ | 1.771E-13 | 1.776E-13 | | 1.595E-13 | -2028.09 | 1.169E+05 | -8.982E+04 | 1.288E+00 |
| 112 | $2s2p^4(^4P)3p\ ^3P^o_1$ | 8.520E-14 | 8.567E-14 | | 8.048E-14 | -2027.90 | 9.448E+04 | 1.723E+04 | 1.532E+00 |
| 113 | $2s2p^4(^2S)3s\ ^3S_1$ | 2.067E-13 | 2.076E-13 | | 1.996E-13 | -2027.79 | 2.233E+05 | -8.190E+03 | 1.762E+00 |
| 114 | $2s2p^4(^4P)3d\ ^5D_3$ | 1.970E-11 | 1.984E-11 | | 1.961E-11 | -2027.71 | 2.314E+05 | 3.043E+04 | 1.442E+00 |
| 115 | $2s2p^4(^2P)3s\ ^3P_0$ | 1.115E-13 | 1.122E-13 | | 1.067E-13 | -2027.68 | | | |
| 116 | $2s2p^4(^4P)3d\ ^5D_4$ | 2.807E-11 | 2.841E-11 | | 2.524E-11 | -2027.67 | 1.978E+05 | 4.835E+04 | 1.415E+00 |
| 117 | $2s2p^4(^4P)3d\ ^5D_2$ | 2.003E-12 | 2.011E-12 | | 1.992E-12 | -2027.67 | 2.937E+05 | 2.119E+04 | 1.520E+00 |
| 118 | $2s2p^4(^4P)3d\ ^5P_1$ | 3.912E-13 | 3.937E-13 | | 3.759E-13 | -2027.58 | 5.246E+05 | 3.300E+04 | 1.935E+00 |
| 119 | $2s2p^4(^4P)3d\ ^5F_5$ | 3.563E-11 | 3.616E-11 | | 3.107E-11 | -2027.52 | 1.778E+05 | 1.074E+05 | 1.370E+00 |
| 120 | $2s2p^4(^2D)3p\ ^3D^o_1$ | 8.090E-14 | 8.135E-14 | | 7.572E-14 | -2027.48 | 9.037E+04 | -6.919E+04 | 1.315E+00 |
| 121 | $2s2p^4(^2P)3s\ ^3P_2$ | 2.366E-13 | 2.381E-13 | | 2.264E-13 | -2027.39 | 8.789E+04 | 2.931E+04 | 1.359E+00 |
| 122 | $2s2p^4(^2D)3p\ ^3F^o_2$ | 1.210E-13 | 1.213E-13 | | 1.212E-13 | -2027.37 | 1.260E+05 | -1.552E+05 | 1.005E+00 |
| 123 | $2s2p^4(^2P)3s\ ^1P_1$ | 9.910E-14 | 9.972E-14 | | 9.463E-14 | -2027.36 | -2.437E+04 | 2.846E+04 | 1.022E+00 |

**Table 6.** (*continued*)

| Key | level | $\tau_{\rm MCDF}$ | $\tau_{\rm MBPT}$ | $\tau_{\rm MCDF2}$ | $\tau_{\rm GRASP1}$ | MCDF | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | $E_h$ | $A_J$ | $B_J$ | $g_J$ |
| 124 | $2s2p^4(^4P)3d\ ^3F_4$ | 1.093E-11 | 1.100E-11 | | 1.034E-11 | -2027.31 | 2.167E+05 | 5.460E+04 | 1.249E+00 |
| 125 | $2s2p^4(^4P)3d\ ^3P_0$ | 1.687E-13 | 1.683E-13 | | 1.703E-13 | -2027.22 | | | |
| 126 | $2s2p^4(^4P)3d\ ^3P_1$ | 3.929E-14 | 3.939E-14 | | 3.859E-14 | -2027.03 | 3.035E+05 | -2.233E+04 | 1.627E+00 |
| 127 | $2s2p^4(^2D)3p\ ^3F^o_3$ | 8.105E-13 | 8.127E-13 | | 7.691E-13 | -2026.98 | 1.919E+05 | -1.519E+05 | 1.188E+00 |
| 128 | $2s2p^4(^4P)3d\ ^3F_3$ | 3.214E-14 | 3.225E-14 | | 3.112E-14 | -2026.95 | 1.474E+05 | 2.621E+04 | 1.222E+00 |
| 129 | $2s2p^4(^4P)3d\ ^3D_2$ | 2.421E-14 | 2.429E-14 | | 2.354E-14 | -2026.88 | 2.234E+05 | -1.176E+04 | 1.374E+00 |
| 130 | $2s2p^4(^2D)3p\ ^1F^o_3$ | 7.073E-14 | 7.081E-14 | | 6.912E-14 | -2026.87 | 2.437E+05 | -1.767E+05 | 1.177E+00 |
| 131 | $2s2p^4(^2D)3p\ ^3D^o_2$ | 1.762E-13 | 1.770E-13 | | 1.773E-13 | -2026.81 | 1.203E+05 | -2.538E+04 | 1.260E+00 |
| 132 | $2s2p^4(^2D)3p\ ^3P^o_1$ | 1.540E-13 | 1.540E-13 | | 1.567E-13 | -2026.78 | 4.572E+04 | 3.604E+04 | 1.154E+00 |
| 133 | $2s2p^4(^2D)3p\ ^3F^o_4$ | 9.045E-12 | 9.117E-12 | | 8.284E-12 | -2026.45 | 2.763E+05 | -2.093E+05 | 1.273E+00 |
| 134 | $2s2p^4(^2D)3p\ ^3P^o_2$ | 1.836E-13 | 1.834E-13 | | 1.966E-13 | -2026.44 | 4.296E+05 | -1.209E+05 | 1.487E+00 |
| 135 | $2s2p^4(^4P)3d\ ^5F_2$ | 3.431E-13 | 3.448E-13 | | 3.557E-13 | -2026.41 | 1.048E+05 | -4.831E+04 | 1.044E+00 |
| 136 | $2s2p^4(^4P)3d\ ^5D_1$ | 1.534E-13 | 1.539E-13 | | 1.559E-13 | -2026.40 | -6.901E+04 | 6.821E+03 | 8.318E-01 |
| 137 | $2s2p^4(^4P)3d\ ^5F_3$ | 9.565E-13 | 9.601E-13 | | 8.923E-13 | -2026.39 | 9.181E+04 | -4.008E+04 | 1.256E+00 |
| 138 | $2s2p^4(^4P)3d\ ^5F_1$ | 4.294E-13 | 4.428E-13 | | 2.476E-13 | -2026.35 | -2.330E+04 | 3.282E+04 | 6.780E-01 |
| 139 | $2s2p^4(^4P)3p\ ^3P^o_0$ | 4.217E-14 | 4.254E-14 | | 4.099E-14 | -2026.34 | | | |
| 140 | $2s2p^4(^4P)3d\ ^5D_0$ | 4.163E-14 | 4.178E-14 | | 4.057E-14 | -2026.31 | | | |
| 141 | $2s2p^4(^4P)3d\ ^5F_4$ | 8.000E-12 | 8.068E-12 | | 7.591E-12 | -2026.30 | 2.169E+04 | -6.409E+04 | 1.303E+00 |
| 142 | $2s2p^4(^2D)3p\ ^1D^o_2$ | 5.812E-14 | 5.855E-14 | | 5.354E-14 | -2026.30 | 3.996E+05 | -1.366E+05 | 1.124E+00 |
| 143 | $2s2p^4(^4P)3d\ ^5P_2$ | 8.237E-14 | 8.322E-14 | | 7.140E-14 | -2026.29 | 1.105E+05 | 3.684E+04 | 1.405E+00 |
| 144 | $2s2p^4(^2D)3p\ ^3D^o_3$ | 1.355E-13 | 1.361E-13 | | 1.352E-13 | -2026.23 | 3.034E+05 | -1.531E+05 | 1.262E+00 |
| 145 | $2s2p^4(^2S)3p\ ^3P^o_0$ | 6.941E-13 | 6.694E-13 | | 8.379E-13 | -2026.22 | | | |
| 146 | $2s2p^4(^2D)3p\ ^1P^o_1$ | 4.871E-14 | 4.889E-14 | | 4.645E-14 | -2026.21 | 3.122E+05 | 7.345E+03 | 1.166E+00 |
| 147 | $2s2p^4(^4P)3d\ ^5P_3$ | 2.564E-12 | 2.670E-12 | | 1.530E-12 | -2026.19 | 8.562E+04 | 8.341E+04 | 1.450E+00 |
| 148 | $2s2p^4(^2P)3p\ ^3D^o_1$ | 8.615E-14 | 8.657E-14 | | 8.426E-14 | -2026.07 | 3.743E+05 | -2.094E+04 | 9.899E-01 |
| 149 | $2s2p^4(^4P)3d\ ^3D_1$ | 2.764E-14 | 2.778E-14 | | 2.667E-14 | -2026.03 | -1.406E+05 | -1.759E+04 | 8.950E-01 |
| 150 | $2s2p^4(^4P)3d\ ^3D_3$ | 1.931E-14 | 1.940E-14 | | 1.818E-14 | -2025.93 | 7.665E+04 | -1.144E+05 | 1.139E+00 |
| 151 | $2s2p^4(^4P)3d\ ^3F_2$ | 3.001E-13 | 2.999E-13 | | 2.912E-13 | -2025.92 | -1.519E+05 | 5.992E+04 | 8.228E-01 |
| 152 | $2s2p^4(^2P)3p\ ^3D^o_2$ | 1.161E-13 | 1.166E-13 | | 1.124E-13 | -2025.80 | 6.908E+04 | 4.591E+04 | 1.094E+00 |
| 153 | $2s2p^4(^4P)3d\ ^3P_2$ | 1.875E-14 | 1.880E-14 | | 1.856E-14 | -2025.63 | 1.049E+05 | 4.434E+04 | 1.257E+00 |
| 154 | $2s2p^4(^2S)3p\ ^3P^o_2$ | 1.680E-13 | 1.678E-13 | | 1.853E-13 | -2025.63 | 4.017E+04 | 5.217E+04 | 1.397E+00 |
| 155 | $2s2p^4(^2P)3s\ ^3P_1$ | 9.601E-14 | 9.662E-14 | | 9.197E-14 | -2025.53 | 7.545E+05 | 5.491E+03 | 1.641E+00 |
| 156 | $2s2p^4(^2P)3p\ ^3P^o_1$ | 1.294E-13 | 1.303E-13 | | 1.195E-13 | -2025.51 | -1.798E+05 | -4.396E+03 | 1.307E+00 |
| 157 | $2s2p^4(^2P)3p\ ^3S^o_1$ | 1.586E-13 | 1.577E-13 | | 1.795E-13 | -2025.35 | -9.818E+04 | 1.615E+04 | 1.488E+00 |
| 158 | $2s2p^4(^2S)3s\ ^1S_0$ | 2.346E-13 | 2.374E-13 | | 2.254E-13 | -2025.30 | | | |
| 159 | $2s2p^4(^2P)3p\ ^3P^o_2$ | 2.008E-13 | 2.007E-13 | | 2.046E-13 | -2025.27 | 3.232E+04 | -9.491E+03 | 1.207E+00 |
| 160 | $2s2p^4(^2P)3p\ ^3D^o_3$ | 1.065E-13 | 1.067E-13 | | 1.062E-13 | -2025.26 | 2.959E+04 | 9.853E+04 | 1.261E+00 |
| 161 | $2s2p^4(^2P)3p\ ^1S^o_0$ | 2.650E-12 | 2.629E-12 | | 2.516E-12 | -2025.00 | | | |
| 162 | $2s2p^4(^2D)3d\ ^3P_0$ | 2.860E-14 | 2.872E-14 | | 2.563E-14 | -2024.97 | | | |
| 163 | $2s2p^4(^2D)3d\ ^3D_1$ | 4.058E-14 | 4.088E-14 | | 3.628E-14 | -2024.93 | 3.215E+04 | 1.748E+04 | 1.148E+00 |
| 164 | $2s2p^4(^2D)3d\ ^3G_4$ | 7.473E-12 | 7.564E-12 | | 6.519E-12 | -2024.93 | 4.686E+04 | -1.169E+05 | 1.161E+00 |
| 165 | $2s2p^4(^2D)3d\ ^3G_3$ | 6.732E-14 | 6.759E-14 | | 7.153E-14 | -2024.90 | 6.380E+04 | -1.598E+05 | 9.510E-01 |
| 166 | $2s2p^4(^2D)3d\ ^3F_2$ | 1.050E-13 | 1.053E-13 | | 1.134E-13 | -2024.85 | 3.671E+04 | -5.674E+04 | 9.814E-01 |
| 167 | $2s2p^4(^2P)3p\ ^1P^o_1$ | 2.245E-13 | 2.255E-13 | | 2.249E-13 | -2024.78 | 3.994E+05 | -3.656E+04 | 1.143E+00 |
| 168 | $2s2p^4(^2D)3d\ ^3D_2$ | 3.586E-14 | 3.604E-14 | | 3.122E-14 | -2024.73 | 5.694E+04 | 9.467E+04 | 1.179E+00 |
| 169 | $2s2p^4(^2D)3d\ ^3F_3$ | 1.083E-13 | 1.085E-13 | | 9.744E-14 | -2024.71 | 6.134E+04 | 2.645E+04 | 1.206E+00 |
| 170 | $2s2p^4(^2D)3d\ ^3G_5$ | 1.258E-11 | 1.276E-11 | | 1.079E-11 | -2024.48 | 2.184E+05 | -2.377E+05 | 1.219E+00 |
| 171 | $2s2p^4(^2D)3d\ ^1G_4$ | 7.622E-12 | 7.691E-12 | | 6.875E-12 | -2024.44 | 2.614E+05 | -2.194E+05 | 1.124E+00 |
| 172 | $2s2p^4(^2D)3d\ ^3S_1$ | 1.350E-14 | 1.356E-14 | | 1.301E-14 | -2024.39 | 3.521E+05 | -5.489E+03 | 1.625E+00 |
| 173 | $2s2p^4(^2D)3d\ ^3P_2$ | 1.396E-14 | 1.403E-14 | | 1.304E-14 | -2024.27 | 3.373E+05 | -2.270E+04 | 1.413E+00 |
| 174 | $2s2p^4(^2D)3d\ ^3P_1$ | 1.061E-14 | 1.065E-14 | | 1.002E-14 | -2024.26 | 3.216E+05 | -3.474E+04 | 1.384E+00 |
| 175 | $2s2p^4(^2D)3d\ ^3D_3$ | 2.308E-14 | 2.316E-14 | | 2.183E-14 | -2024.25 | 2.688E+05 | -6.807E+04 | 1.310E+00 |
| 176 | $2s2p^4(^2D)3d\ ^3F_4$ | 7.113E-12 | 7.189E-12 | | 6.421E-12 | -2024.16 | 2.147E+05 | -1.068E+05 | 1.169E+00 |
| 177 | $2s2p^4(^2D)3d\ ^1F_3$ | 5.203E-14 | 5.260E-14 | | 4.364E-14 | -2024.07 | 2.716E+05 | -7.528E+04 | 1.072E+00 |
| 178 | $2s2p^4(^2D)3d\ ^1D_2$ | 2.661E-14 | 2.678E-14 | | 2.427E-14 | -2023.94 | 1.637E+05 | 1.402E+04 | 9.885E-01 |
| 179 | $2s2p^4(^2D)3d\ ^1P_1$ | 1.899E-14 | 1.907E-14 | | 1.758E-14 | -2023.90 | 7.820E+04 | 1.964E+04 | 7.691E-01 |
| 180 | $2s2p^4(^2D)3d\ ^1S_0$ | 9.705E-15 | 9.742E-15 | | 9.191E-15 | -2023.71 | | | |
| 181 | $2s2p^4(^2P)3p\ ^3P^o_0$ | 3.177E-12 | 3.168E-12 | | 3.009E-12 | -2023.68 | | | |
| 182 | $2s2p^4(^2P)3d\ ^3D_1$ | 6.678E-14 | 6.733E-14 | | 6.655E-14 | -2023.66 | 5.010E+04 | 3.813E+04 | 5.806E-01 |
| 183 | $2s2p^4(^2P)3d\ ^3F_2$ | 9.591E-14 | 9.618E-14 | | 9.179E-14 | -2023.59 | 1.164E+05 | 4.667E+04 | 1.023E+00 |
| 184 | $2s2p^4(^2S)3d\ ^3D_3$ | 1.274E-13 | 1.278E-13 | | 1.118E-13 | -2023.57 | 1.385E+04 | 5.043E+04 | 1.266E+00 |
| 185 | $2s2p^4(^2S)3p\ ^1P^o_1$ | 5.167E-14 | 5.216E-14 | | 4.679E-14 | -2023.56 | 5.087E+05 | 2.641E+03 | 9.427E-01 |
| 186 | $2s2p^4(^2P)3d\ ^3P_2$ | 5.808E-14 | 5.835E-14 | | 5.424E-14 | -2023.42 | -1.074E+05 | 1.544E+04 | 1.115E+00 |
| 187 | $2s2p^4(^2P)3p\ ^1D^o_2$ | 6.060E-13 | 6.073E-13 | | 5.711E-13 | -2023.35 | 3.122E+05 | 5.680E+04 | 1.321E+00 |

**Table 6.** (*continued*)

| Key | level | $\tau_{\rm MCDF}$ | $\tau_{\rm MBPT}$ | $\tau_{\rm MCDF2}$ | $\tau_{\rm GRASP1}$ | MCDF $E_h$ | MCDF $A_J$ | MCDF $B_J$ | MCDF $g_J$ |
|---|---|---|---|---|---|---|---|---|---|
| 188 | $2s2p^4(^2P)3d\ ^3F_3$ | 4.767E-13 | 4.836E-13 | | 3.589E-13 | -2023.31 | 3.978E+04 | 6.987E+04 | 1.032E+00 |
| 189 | $2s2p^4(^2S)3p\ ^3P^o_1$ | 1.194E-13 | 1.181E-13 | | 1.556E-13 | -2023.25 | -1.274E+05 | 9.013E+03 | 1.397E+00 |
| 190 | $2s2p^4(^2P)3d\ ^3D_3$ | 9.673E-13 | 9.677E-13 | | 9.049E-13 | -2023.21 | -6.333E+03 | -2.099E+04 | 1.130E+00 |
| 191 | $2s2p^4(^2P)3d\ ^3D_2$ | 1.862E-14 | 1.874E-14 | | 1.686E-14 | -2023.17 | -8.032E+04 | -3.637E+04 | 1.195E+00 |
| 192 | $2s2p^4(^2P)3d\ ^3F_4$ | 2.959E-12 | 2.991E-12 | | 2.629E-12 | -2023.16 | 1.266E+04 | 6.394E+04 | 1.193E+00 |
| 193 | $2s2p^4(^2P)3d\ ^3P_1$ | 1.738E-14 | 1.748E-14 | | 1.598E-14 | -2023.06 | -1.249E+05 | -2.663E+04 | 1.254E+00 |
| 194 | $2s2p^4(^2P)3d\ ^3P_0$ | 1.562E-14 | 1.569E-14 | | 1.459E-14 | -2023.00 | | | |
| 195 | $2s2p^4(^2P)3d\ ^1D_2$ | 1.103E-14 | 1.108E-14 | | 1.056E-14 | -2022.80 | 1.771E+05 | -1.195E+04 | 9.797E-01 |
| 196 | $2s2p^4(^2P)3d\ ^1P_1$ | 9.616E-15 | 9.663E-15 | | 9.019E-15 | -2022.79 | 1.699E+05 | 1.415E+04 | 1.005E+00 |
| 197 | $2p^5(^2P)3s\ ^3P^o_2$ | 1.825E-12 | 1.854E-12 | | 1.456E-12 | -2022.08 | 1.416E+05 | -1.448E+05 | 1.493E+00 |
| 198 | $2p^5(^2P)3s\ ^1P^o_1$ | 1.586E-13 | 1.596E-13 | | 1.477E-13 | -2021.94 | 2.521E+03 | -6.159E+04 | 1.184E+00 |
| 199 | $2s2p^4(^2P)3d\ ^1F_3$ | 3.380E-12 | 3.396E-12 | | 3.070E-12 | -2021.31 | 2.002E+05 | 3.720E+04 | 1.209E+00 |
| 200 | $2s2p^4(^2S)3d\ ^3D_1$ | 1.343E-14 | 1.350E-14 | | 1.237E-14 | -2021.20 | -2.904E+05 | 9.482E+03 | 7.122E-01 |
| 201 | $2s2p^4(^2S)3d\ ^3D_2$ | 2.690E-14 | 2.669E-14 | | 3.867E-14 | -2021.17 | -9.489E+04 | 1.169E+04 | 1.194E+00 |
| 202 | $2s2p^4(^2S)3d\ ^1D_2$ | 2.198E-14 | 2.242E-14 | | 1.498E-14 | -2021.08 | 2.085E+05 | 4.504E+03 | 9.389E-01 |
| 203 | $2p^5(^2P)3p\ ^3S_1$ | 8.461E-14 | 8.489E-14 | | 8.230E-14 | -2020.60 | 5.410E+04 | -5.711E+04 | 1.697E+00 |
| 204 | $2p^5(^2P)3p\ ^3D_2$ | 9.864E-14 | 9.885E-14 | | 9.981E-14 | -2020.49 | 8.238E+04 | -1.433E+05 | 1.153E+00 |
| 205 | $2p^5(^2P)3p\ ^3D_3$ | 8.212E-14 | 8.240E-14 | | 8.180E-14 | -2020.04 | 4.516E+04 | -1.073E+05 | 1.328E+00 |
| 206 | $2p^5(^2P)3p\ ^1P_1$ | 6.816E-14 | 6.834E-14 | | 6.508E-14 | -2020.01 | 5.055E+04 | 2.224E+04 | 1.164E+00 |
| 207 | $2p^5(^2P)3s\ ^3P^o_0$ | 2.211E-12 | 2.246E-12 | | 1.752E-12 | -2020.01 | | | |
| 208 | $2p^5(^2P)3s\ ^3P^o_1$ | 1.913E-13 | 1.930E-13 | | 1.716E-13 | -2019.92 | 4.028E+05 | -1.245E+04 | 1.301E+00 |
| 209 | $2p^5(^2P)3p\ ^3P_2$ | 8.576E-14 | 8.606E-14 | | 8.653E-14 | -2019.84 | 4.478E+04 | -3.483E+03 | 1.331E+00 |
| 210 | $2p^5(^2P)3p\ ^3P_0$ | 7.313E-14 | 7.346E-14 | | 7.622E-14 | -2019.26 | | | |
| 211 | $2p^5(^2P)3p\ ^3D_1$ | 7.609E-14 | 7.630E-14 | | 7.435E-14 | -2018.46 | 2.806E+05 | 1.368E+03 | 6.596E-01 |
| 212 | $2p^5(^2P)3d\ ^3P^o_0$ | 1.516E-12 | 1.514E-12 | | 1.554E-12 | -2018.31 | | | |
| 213 | $2p^5(^2P)3d\ ^3P^o_1$ | 1.184E-12 | 1.183E-12 | | 1.185E-12 | -2018.22 | 2.168E+04 | 3.877E+04 | 1.336E+00 |
| 214 | $2p^5(^2P)3d\ ^3F^o_3$ | 1.567E-12 | 1.561E-12 | | 1.530E-12 | -2018.11 | 4.212E+04 | -1.396E+05 | 1.066E+00 |
| 215 | $2p^5(^2P)3d\ ^3F^o_4$ | 3.332E-12 | 3.367E-12 | | 2.929E-12 | -2018.08 | 3.050E+04 | -1.370E+05 | 1.245E+00 |
| 216 | $2p^5(^2P)3d\ ^3P^o_2$ | 1.554E-12 | 1.543E-12 | | 1.585E-12 | -2018.05 | 2.568E+04 | 3.007E+04 | 1.293E+00 |
| 217 | $2p^5(^2P)3d\ ^1D^o_2$ | 2.098E-12 | 2.099E-12 | | 1.973E-12 | -2017.95 | 2.432E+04 | 4.947E+04 | 9.941E-01 |
| 218 | $2p^5(^2P)3p\ ^3P_1$ | 7.480E-14 | 7.507E-14 | | 7.317E-14 | -2017.89 | -8.285E+04 | 2.293E+04 | 1.456E+00 |
| 219 | $2p^5(^2P)3p\ ^1D_2$ | 8.135E-14 | 8.165E-14 | | 8.171E-14 | -2017.86 | 1.257E+05 | 3.956E+04 | 1.164E+00 |
| 220 | $2p^5(^2P)3d\ ^3D^o_3$ | 1.480E-12 | 1.462E-12 | | 1.525E-12 | -2017.82 | 2.499E+04 | 3.359E+04 | 1.224E+00 |
| 221 | $2p^5(^2P)3p\ ^1S_0$ | 4.804E-14 | 4.857E-14 | | 4.788E-14 | -2017.63 | | | |
| 222 | $2p^5(^2P)3d\ ^3D^o_1$ | 1.302E-14 | 1.308E-14 | | 1.270E-14 | -2017.37 | -2.692E+04 | 7.256E+03 | 7.943E-01 |
| 223 | $2p^5(^2P)3d\ ^3F^o_2$ | 2.463E-12 | 2.480E-12 | | 2.213E-12 | -2016.04 | 1.191E+05 | 2.017E+04 | 7.734E-01 |
| 224 | $2p^5(^2P)3d\ ^3D^o_2$ | 1.715E-12 | 1.706E-12 | | 1.689E-12 | -2015.88 | -6.631E+04 | 2.008E+04 | 1.258E+00 |
| 225 | $2p^5(^2P)3d\ ^1F^o_3$ | 1.635E-12 | 1.626E-12 | | 1.604E-12 | -2015.84 | 7.837E+04 | 1.663E+04 | 1.113E+00 |
| 226 | $2p^5(^2P)3d\ ^1P^o_1$ | 9.608E-15 | 9.695E-15 | | 8.486E-15 | -2015.51 | -9.814E+04 | 1.125E+02 | 8.643E-01 |
| 227 | $2s^22p^3(^4S)4s\ ^5S^o_2$ | 3.137E-13 | 3.146E-13 | | | -2014.37 | 8.238E+04 | 9.535E+04 | 1.670E+00 |
| 228 | $2s^22p^3(^4S)4s\ ^3S^o_1$ | 1.615E-13 | 1.626E-13 | | | -2014.30 | 3.826E+04 | 5.148E+04 | 1.413E+00 |
| 229 | $2s^22p^3(^4S)4p\ ^5P_1$ | 3.598E-13 | 3.603E-13 | | | -2013.69 | 6.244E+04 | 4.809E+04 | 1.743E+00 |
| 230 | $2s^22p^3(^4S)4p\ ^5P_2$ | 3.588E-13 | 3.593E-13 | | | -2013.68 | 5.580E+04 | 9.027E+04 | 1.386E+00 |
| 231 | $2s^22p^3(^4S)4p\ ^5P_3$ | 3.915E-13 | 3.916E-13 | | | -2013.46 | 3.322E+04 | 1.077E+05 | 1.445E+00 |
| 232 | $2s^22p^3(^4S)4p\ ^3P_1$ | 3.835E-13 | 3.854E-13 | | | -2013.44 | 3.512E+04 | -4.344E+04 | 1.469E+00 |
| 233 | $2s^22p^3(^4S)4p\ ^3P_2$ | 3.953E-13 | 3.991E-13 | | | -2013.32 | 3.581E+04 | 1.129E+04 | 1.375E+00 |
| 234 | $2s^22p^3(^4S)4p\ ^3P_0$ | 4.138E-13 | 4.195E-13 | | | -2013.20 | | | |
| 235 | $2s^22p^3(^4S)4d\ ^5D^o_2$ | 1.617E-13 | 1.622E-13 | | | -2012.74 | 3.261E+04 | 1.094E+03 | 1.154E+00 |
| 236 | $2s^22p^3(^4S)4d\ ^5D^o_3$ | 1.822E-13 | 1.825E-13 | | | -2012.72 | 2.879E+04 | 7.025E+04 | 1.268E+00 |
| 237 | $2s^22p^3(^4S)4d\ ^5D^o_1$ | 1.197E-13 | 1.200E-13 | | | -2012.70 | 2.864E+04 | -3.644E+04 | 1.278E+00 |
| 238 | $2s^22p^3(^4S)4d\ ^5D^o_0$ | 1.974E-13 | 1.978E-13 | | | -2012.70 | | | |
| 239 | $2s^22p^3(^4S)4d\ ^5D^o_4$ | 1.969E-13 | 1.971E-13 | | | -2012.67 | 2.272E+04 | 9.230E+04 | 1.334E+00 |
| 240 | $2s^22p^3(^2D)4s\ ^3D^o_2$ | 8.061E-14 | 8.144E-14 | | | -2012.63 | 3.505E+04 | 1.933E+04 | 1.393E+00 |
| 241 | $2s^22p^3(^4S)4d\ ^3D^o_2$ | 1.100E-13 | 1.099E-13 | | | -2012.58 | 2.387E+04 | -1.279E+04 | 1.344E+00 |
| 242 | $2s^22p^3(^2D)4s\ ^3D^o_1$ | 1.729E-13 | 1.736E-13 | | | -2012.57 | -1.494E+04 | 3.298E+04 | 1.165E+00 |
| 243 | $2s^22p^3(^4S)4d\ ^3D^o_3$ | 2.688E-14 | 2.726E-14 | | | -2012.49 | 2.443E+04 | 1.079E+04 | 1.197E+00 |
| 244 | $2s^22p^3(^4S)4d\ ^3D^o_1$ | 3.719E-14 | 3.770E-14 | | | -2012.46 | -3.671E+04 | 8.005E+03 | 8.414E-01 |
| 245 | $2s^22p^3(^4S)4f\ ^5F_3$ | 9.546E-14 | 9.601E-14 | | | -2012.21 | 1.853E+04 | -2.437E+04 | 1.044E+00 |
| 246 | $2s^22p^3(^4S)4f\ ^5F_4$ | 9.614E-14 | 9.674E-14 | | | -2012.20 | 1.947E+04 | 4.934E+04 | 1.196E+00 |
| 247 | $2s^22p^3(^4S)4f\ ^5F_2$ | 9.556E-14 | 9.621E-14 | | | -2012.20 | 6.173E+03 | -6.780E+04 | 9.082E-01 |
| 248 | $2s^22p^3(^4S)4f\ ^5F_1$ | 9.524E-14 | 9.596E-14 | | | -2012.17 | -4.089E+04 | 8.675E+03 | 3.280E-01 |
| 249 | $2s^22p^3(^4S)4f\ ^3F_3$ | 9.703E-14 | 9.773E-14 | | | -2012.17 | 7.624E+02 | -8.078E+04 | 1.154E+00 |
| 250 | $2s^22p^3(^2D)4f\ ^1H_5$ | 9.709E-14 | 9.773E-14 | | | -2012.17 | 1.808E+04 | 9.246E+04 | 1.264E+00 |

**Table 6.** (*continued*)

| Key | level | $\tau_{\mathrm{MCDF}}$ | $\tau_{\mathrm{MBPT}}$ | $\tau_{\mathrm{MCDF2}}$ | $\tau_{\mathrm{GRASP1}}$ | MCDF | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | $E_h$ | $A_J$ | $B_J$ | $g_J$ |
| 251 | $2s^22p^3(^4S)4f\ ^3F_4$ | 1.000E-13 | 1.009E-13 | | | -2012.17 | 1.613E+04 | 5.327E+03 | 1.139E+00 |
| 252 | $2s^22p^3(^2D)4s\ ^3D^o_3$ | 3.601E-13 | 3.594E-13 | | | -2012.14 | 1.527E+05 | -9.911E+02 | 1.324E+00 |
| 253 | $2s^22p^3(^4S)4f\ ^3F_2$ | 9.823E-14 | 9.916E-14 | | | -2012.13 | -2.789E+04 | 2.479E+04 | 9.437E-01 |
| 254 | $2s^22p^3(^2D)4s\ ^1D^o_2$ | 1.756E-13 | 1.761E-13 | | | -2012.11 | 1.568E+05 | -7.078E+03 | 1.053E+00 |
| 255 | $2s^22p^3(^2D)4p\ ^1P_1$ | 3.569E-13 | 3.578E-13 | | | -2011.95 | 1.362E+04 | 3.487E+04 | 1.477E+00 |
| 256 | $2s^22p^3(^2D)4p\ ^3F_2$ | 3.607E-13 | 3.623E-13 | | | -2011.87 | 4.507E+04 | 4.879E+04 | 1.150E+00 |
| 257 | $2s^22p^3(^2D)4p\ ^1F_3$ | 3.916E-13 | 3.920E-13 | | | -2011.71 | 1.542E+04 | 8.934E+04 | 1.320E+00 |
| 258 | $2s^22p^3(^2D)4p\ ^3D_2$ | 3.919E-13 | 3.927E-13 | | | -2011.70 | 4.470E+02 | 1.960E+04 | 1.345E+00 |
| 259 | $2s^22p^3(^2D)4p\ ^3P_0$ | 3.900E-13 | 3.925E-13 | | | -2011.68 | | | |
| 260 | $2s^22p^3(^2D)4p\ ^3D_1$ | 4.029E-13 | 4.064E-13 | | | -2011.54 | 8.262E+04 | -4.504E+04 | 1.213E+00 |
| 261 | $2s^22p^3(^2P)4s\ ^3P^o_0$ | 2.569E-13 | 2.584E-13 | | | -2011.53 | | | |
| 262 | $2s^22p^3(^2P)4s\ ^3P^o_1$ | 2.128E-13 | 2.141E-13 | | | -2011.51 | 3.025E+05 | -4.359E+03 | 1.328E+00 |
| 263 | $2s^22p^3(^2D)4p\ ^3F_3$ | 3.559E-13 | 3.569E-13 | | | -2011.47 | 1.361E+05 | -3.463E+03 | 1.127E+00 |
| 264 | $2s^22p^3(^2D)4p\ ^3P_2$ | 3.784E-13 | 3.814E-13 | | | -2011.34 | 1.533E+05 | 1.751E+04 | 1.327E+00 |
| 265 | $2s^22p^3(^2D)4p\ ^3D_3$ | 3.895E-13 | 3.904E-13 | | | -2011.25 | 1.123E+05 | -5.806E+03 | 1.212E+00 |
| 266 | $2s^22p^3(^2D)4p\ ^3F_4$ | 3.926E-13 | 3.929E-13 | | | -2011.24 | 9.962E+04 | 1.539E+04 | 1.244E+00 |
| 267 | $2s^22p^3(^2D)4p\ ^3P_1$ | 4.009E-13 | 4.034E-13 | | | -2011.19 | 1.937E+05 | 2.236E+04 | 1.193E+00 |
| 268 | $2s^22p^3(^2D)4p\ ^1D_2$ | 4.172E-13 | 4.220E-13 | | | -2011.02 | 1.565E+05 | -1.083E+04 | 1.152E+00 |
| 269 | $2s^22p^3(^2D)4d\ ^3D^o_1$ | 1.133E-13 | 1.133E-13 | | | -2010.97 | 2.397E+04 | -3.405E+04 | 9.297E-01 |
| 270 | $2s^22p^3(^2D)4d\ ^3F^o_2$ | 8.023E-14 | 8.082E-14 | | | -2010.95 | 2.811E+04 | -2.635E+04 | 1.084E+00 |
| 271 | $2s^22p^3(^2D)4d\ ^3P^o_0$ | 1.254E-13 | 1.258E-13 | | | -2010.94 | | | |
| 272 | $2s^22p^3(^2D)4d\ ^1G^o_4$ | 1.972E-13 | 1.975E-13 | | | -2010.91 | 1.012E+04 | 7.616E+04 | 1.237E+00 |
| 273 | $2s^22p^3(^2D)4d\ ^3F^o_3$ | 9.028E-14 | 9.072E-14 | | | -2010.91 | 2.945E+03 | -5.132E+02 | 1.273E+00 |
| 274 | $2s^22p^3(^2D)4d\ ^3G^o_3$ | 7.515E-14 | 7.632E-14 | | | -2010.89 | 1.843E+04 | 4.730E+04 | 1.031E+00 |
| 275 | $2s^22p^3(^2P)4p\ ^3D_1$ | 3.471E-13 | 3.481E-13 | | | -2010.85 | 2.513E+05 | -2.024E+02 | 6.664E-01 |
| 276 | $2s^22p^3(^2D)4p\ ^3S^o_1$ | 4.633E-14 | 4.681E-14 | | | -2010.78 | 1.490E+04 | 1.089E+04 | 1.181E+00 |
| 277 | $2s^22p^3(^2D)4d\ ^3P^o_2$ | 3.169E-14 | 3.207E-14 | | | -2010.74 | 2.733E+03 | -4.201E+04 | 1.169E+00 |
| 278 | $2s^22p^3(^2P)4p\ ^3P_0$ | 3.710E-13 | 3.748E-13 | | | -2010.66 | | | |
| 279 | $2s^22p^3(^2P)4p\ ^3P_1$ | 3.855E-13 | 3.868E-13 | | | -2010.59 | -1.007E+05 | 8.670E+02 | 1.492E+00 |
| 280 | $2s^22p^3(^2P)4p\ ^3D_2$ | 3.802E-13 | 3.817E-13 | | | -2010.57 | 1.193E+05 | -4.705E+03 | 1.162E+00 |
| 281 | $2s^22p^3(^2D)4d\ ^3G^o_4$ | 1.980E-13 | 1.984E-13 | | | -2010.50 | 9.549E+04 | 1.543E+03 | 1.106E+00 |
| 282 | $2s^22p^3(^2D)4d\ ^3D^o_3$ | 5.332E-14 | 5.408E-14 | | | -2010.45 | 9.230E+04 | 1.155E+04 | 1.209E+00 |
| 283 | $2s^22p^3(^2D)4d\ ^3F^o_4$ | 1.970E-13 | 1.974E-13 | | | -2010.45 | 8.019E+04 | -2.867E+03 | 1.137E+00 |
| 284 | $2s^22p^3(^2D)4f\ ^3G_3$ | 9.652E-14 | 9.722E-14 | | | -2010.45 | 7.531E+03 | -2.464E+04 | 9.977E-01 |
| 285 | $2s^22p^3(^2D)4f\ ^3F_2$ | 9.511E-14 | 9.578E-14 | | | -2010.44 | 3.930E+02 | -5.309E+04 | 8.724E-01 |
| 286 | $2s^22p^3(^2D)4d\ ^3G^o_5$ | 1.975E-13 | 1.979E-13 | | | -2010.44 | 7.820E+04 | 3.058E+03 | 1.195E+00 |
| 287 | $2s^22p^3(^2D)4f\ ^1G_4$ | 9.771E-14 | 9.854E-14 | | | -2010.44 | 9.198E+03 | 5.012E+04 | 1.085E+00 |
| 288 | $2s^22p^3(^2D)4f\ ^3H_4$ | 9.720E-14 | 9.779E-14 | | | -2010.43 | 4.562E+03 | -1.453E+04 | 1.120E+00 |
| 289 | $2s^22p^3(^2D)4f\ ^3P_1$ | 9.488E-14 | 9.566E-14 | | | -2010.42 | -2.002E+04 | 6.959E+03 | 5.314E-01 |
| 290 | $2s^22p^3(^4S)4f\ ^5F_5$ | 9.760E-14 | 9.828E-14 | | | -2010.42 | 7.918E+03 | 6.882E+04 | 1.191E+00 |
| 291 | $2s^22p^3(^2D)4f\ ^3D_3$ | 9.783E-14 | 9.863E-14 | | | -2010.41 | -2.383E+03 | -6.255E+04 | 1.143E+00 |
| 292 | $2s^22p^3(^2D)4d\ ^3D^o_2$ | 3.579E-14 | 3.614E-14 | | | -2010.41 | 1.225E+05 | 3.299E+03 | 1.222E+00 |
| 293 | $2s^22p^3(^2D)4d\ ^1S^o_0$ | 6.080E-14 | 6.104E-14 | | | -2010.40 | | | |
| 294 | $2s^22p^3(^2D)4f\ ^3P_2$ | 9.721E-14 | 9.811E-14 | | | -2010.39 | -1.263E+04 | 1.860E+04 | 1.095E+00 |
| 295 | $2s^22p^3(^2D)4d\ ^3P^o_1$ | 3.807E-14 | 3.825E-14 | | | -2010.39 | 1.791E+05 | -1.236E+04 | 1.075E+00 |
| 296 | $2s^22p^3(^2D)4d\ ^3S^o_1$ | 2.956E-14 | 2.979E-14 | | | -2010.31 | 1.259E+05 | 4.256E+03 | 1.657E+00 |
| 297 | $2s^22p^3(^2D)4d\ ^1D^o_2$ | 3.119E-14 | 3.153E-14 | | | -2010.28 | 8.241E+04 | 9.886E+03 | 1.143E+00 |
| 298 | $2s^22p^3(^2D)4d\ ^1F^o_3$ | 3.121E-14 | 3.167E-14 | | | -2010.26 | 9.398E+04 | 7.966E+03 | 1.063E+00 |
| 299 | $2s^22p^3(^2D)4f\ ^3H_5$ | 9.813E-14 | 9.883E-14 | | | -2009.98 | 7.803E+04 | 5.332E+02 | 1.023E+00 |
| 300 | $2s^22p^3(^2D)4f\ ^3G_4$ | 9.659E-14 | 9.734E-14 | | | -2009.98 | 7.511E+04 | 7.475E+02 | 1.063E+00 |
| 301 | $2s^22p^3(^2D)4f\ ^3F_3$ | 9.561E-14 | 9.635E-14 | | | -2009.97 | 7.696E+04 | -1.153E+04 | 1.038E+00 |
| 302 | $2s^22p^3(^2D)4f\ ^3D_2$ | 9.501E-14 | 9.578E-14 | | | -2009.96 | 7.961E+04 | -1.093E+04 | 9.862E-01 |
| 303 | $2s^22p^3(^2D)4f\ ^3H_6$ | 9.858E-14 | 9.926E-14 | | | -2009.96 | 6.486E+04 | 7.504E+02 | 1.162E+00 |
| 304 | $2s^22p^3(^2D)4f\ ^3G_5$ | 9.682E-14 | 9.746E-14 | | | -2009.96 | 5.855E+04 | 1.185E+03 | 1.165E+00 |
| 305 | $2s^22p^3(^2D)4f\ ^3D_1$ | 9.482E-14 | 9.563E-14 | | | -2009.96 | 7.711E+04 | -2.005E+02 | 8.985E-01 |
| 306 | $2s^22p^3(^2D)4f\ ^3P_0$ | 9.508E-14 | 9.593E-14 | | | -2009.95 | | | |
| 307 | $2s^22p^3(^2D)4f\ ^3F_4$ | 9.801E-14 | 9.879E-14 | | | -2009.94 | 5.292E+04 | -1.323E+04 | 1.120E+00 |
| 308 | $2s^22p^3(^2D)4f\ ^1P_1$ | 9.468E-14 | 9.547E-14 | | | -2009.93 | -1.852E+05 | 1.364E+02 | 1.183E+00 |
| 309 | $2s^22p^3(^2D)4f\ ^1F_3$ | 9.738E-14 | 9.822E-14 | | | -2009.93 | 3.581E+04 | -1.133E+04 | 1.128E+00 |
| 310 | $2s^22p^3(^2D)4f\ ^1D_2$ | 9.598E-14 | 9.681E-14 | | | -2009.93 | -8.587E+03 | 5.820E+02 | 1.153E+00 |
| 311 | $2s^22p^3(^2P)4d\ ^3F^o_2$ | 1.110E-13 | 1.121E-13 | | | -2009.87 | 1.162E+05 | 1.479E+04 | 7.978E-01 |
| 312 | $2s^22p^3(^2P)4s\ ^3P^o_2$ | 1.323E-13 | 1.354E-13 | | | -2009.83 | 6.237E+04 | -1.052E+05 | 1.355E+00 |
| 313 | $2s^22p^3(^2P)4s\ ^1P^o_1$ | 1.892E-13 | 1.906E-13 | | | -2009.79 | 6.729E+04 | -8.059E+04 | 1.059E+00 |
| 314 | $2s^22p^3(^2P)4d\ ^3P^o_2$ | 7.948E-14 | 7.930E-14 | | | -2009.77 | -3.113E+04 | -5.897E+04 | 1.318E+00 |

**Table 6.** (*continued*)

| Key | level | $\tau_{\rm MCDF}$ | $\tau_{\rm MBPT}$ | $\tau_{\rm MCDF2}$ | $\tau_{\rm GRASP1}$ | MCDF | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | $E_h$ | $A_J$ | $B_J$ | $g_J$ |
| 315 | $2s^22p^3(^2P)4d\ ^3F^o_3$ | 5.984E-14 | 6.061E-14 | | | -2009.76 | 7.712E+04 | -1.362E+04 | 1.108E+00 |
| 316 | $2s^22p^3(^2P)4d\ ^3D^o_1$ | 3.037E-14 | 3.086E-14 | | | -2009.73 | -1.037E+05 | 8.420E+03 | 8.212E-01 |
| 317 | $2s^22p^3(^2P)4f\ ^3G_3$ | 9.696E-14 | 9.759E-14 | | | -2009.36 | 7.638E+04 | 2.120E+04 | 8.242E-01 |
| 318 | $2s^22p^3(^2P)4f\ ^3F_2$ | 9.716E-14 | 9.793E-14 | | | -2009.35 | -7.303E+04 | 1.537E+04 | 8.792E-01 |
| 319 | $2s^22p^3(^2P)4f\ ^3G_4$ | 9.825E-14 | 9.900E-14 | | | -2009.33 | 5.705E+04 | 2.090E+04 | 1.084E+00 |
| 320 | $2s^22p^3(^2P)4f\ ^3D_3$ | 9.633E-14 | 9.702E-14 | | | -2009.33 | -5.525E+04 | 1.809E+04 | 1.197E+00 |
| 321 | $2s^22p^3(^2P)4p\ ^3S_1$ | 3.592E-13 | 3.605E-13 | | | -2009.10 | 8.956E+04 | -7.037E+04 | 1.583E+00 |
| 322 | $2s^22p^3(^2P)4p\ ^1D_2$ | 3.528E-13 | 3.555E-13 | | | -2009.06 | 7.649E+04 | -1.664E+05 | 1.076E+00 |
| 323 | $2s^22p^3(^2P)4p\ ^3D_3$ | 3.806E-13 | 3.802E-13 | | | -2008.94 | 4.744E+04 | -1.455E+05 | 1.286E+00 |
| 324 | $2s^22p^3(^2P)4p\ ^1P_1$ | 3.730E-13 | 3.745E-13 | | | -2008.93 | 5.158E+04 | 4.282E+04 | 1.108E+00 |
| 325 | $2s^22p^3(^2P)4p\ ^3P_2$ | 3.908E-13 | 3.921E-13 | | | -2008.87 | 4.739E+04 | -2.832E+03 | 1.308E+00 |
| 326 | $2s^22p^3(^2P)4p\ ^1S_0$ | 4.210E-13 | 4.282E-13 | | | -2008.61 | | | |
| 327 | $2s^22p^3(^2P)4d\ ^3P^o_0$ | 3.892E-14 | 3.893E-14 | | | -2008.18 | | | |
| 328 | $2s^22p^3(^2P)4d\ ^3F^o_4$ | 1.964E-13 | 1.965E-13 | | | -2008.15 | 3.358E+04 | -1.536E+05 | 1.213E+00 |
| 329 | $2s^22p^3(^2P)4d\ ^3P^o_1$ | 4.284E-14 | 4.301E-14 | | | -2008.14 | 2.251E+04 | 4.658E+04 | 1.299E+00 |
| 330 | $2s^22p^3(^2P)4d\ ^1D^o_2$ | 1.613E-13 | 1.621E-13 | | | -2008.12 | 8.434E+03 | 1.183E+05 | 1.240E+00 |
| 331 | $2s^22p^3(^2P)4d\ ^1F^o_3$ | 4.033E-14 | 4.101E-14 | | | -2008.10 | 4.460E+04 | -1.579E+05 | 1.002E+00 |
| 332 | $2s^22p^3(^2P)4d\ ^3D^o_2$ | 4.252E-14 | 4.316E-14 | | | -2008.06 | 4.453E+04 | -4.455E+03 | 9.940E-01 |
| 333 | $2s^22p^3(^2P)4d\ ^3D^o_3$ | 1.577E-13 | 1.595E-13 | | | -2008.06 | 2.720E+04 | 4.070E+04 | 1.229E+00 |
| 334 | $2s2p^4(^4P)4s\ ^5P_3$ | 3.930E-13 | 3.929E-13 | | | -2008.02 | 3.189E+05 | 1.020E+05 | 1.622E+00 |
| 335 | $2s^22p^3(^2P)4d\ ^1P^o_1$ | 1.919E-14 | 1.948E-14 | | | -2007.88 | -3.977E+04 | 5.122E+03 | 8.970E-01 |
| 336 | $2s2p^4(^4P)4s\ ^3P_2$ | 1.872E-13 | 1.865E-13 | | | -2007.87 | 3.934E+05 | 7.149E+04 | 1.479E+00 |
| 337 | $2s^22p^3(^2P)4f\ ^3D_1$ | 9.434E-14 | 9.486E-14 | | | -2007.69 | -6.286E+04 | -1.445E+04 | 5.674E-01 |
| 338 | $2s^22p^3(^2P)4f\ ^1G_4$ | 9.835E-14 | 9.908E-14 | | | -2007.67 | 3.283E+04 | -1.559E+05 | 9.915E-01 |
| 339 | $2s^22p^3(^2P)4f\ ^3D_2$ | 9.511E-14 | 9.566E-14 | | | -2007.66 | -1.963E+04 | 3.027E+04 | 1.118E+00 |
| 340 | $2s^22p^3(^2P)4f\ ^3G_5$ | 9.728E-14 | 9.782E-14 | | | -2007.66 | 2.631E+04 | -1.583E+05 | 1.172E+00 |
| 341 | $2s^22p^3(^2P)4f\ ^3F_3$ | 9.720E-14 | 9.806E-14 | | | -2007.63 | 1.997E+04 | 6.367E+04 | 1.075E+00 |
| 342 | $2s^22p^3(^2P)4f\ ^1D_2$ | 9.883E-14 | 9.977E-14 | | | -2007.62 | -1.519E+04 | 4.816E+04 | 8.702E-01 |
| 343 | $2s^22p^3(^2P)4f\ ^1F_3$ | 9.657E-14 | 9.727E-14 | | | -2007.62 | 6.095E+03 | 1.217E+05 | 1.038E+00 |
| 344 | $2s^22p^3(^2P)4f\ ^3F_4$ | 9.759E-14 | 9.842E-14 | | | -2007.60 | 1.801E+04 | 6.638E+04 | 1.169E+00 |