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Atomic data and theoretical X-ray spectra of Ge-like through V-like W ions

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ABSTRACT

The atomic structure and spectra of ten tungsten ions have been calculated using the Flexible Atomic Code. The calculations yield energy levels, radiative lifetimes, spectral line positions, transition probability rates, and oscillator strengths for the tungsten ions isoelectronic to germanium, W^{42+}, through vanadium, W^{51+}. Collisional–radiative models for high-temperature, low-density plasmas have been implemented to produce line emissivities for X-ray transitions in the 1–4 keV (3–12 Å) spectral interval. The Ge-like through V-like W ions are important in nuclear fusion research where their spectra may provide diagnostic information on magnetically confined plasmas.

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1. Introduction

Tungsten is being implemented as an erosion-resistant construction material in magnetic fusion experiments for plasma-facing surfaces expected to receive high heat loads. As a result, small amounts of tungsten get sputtered off these surfaces and enter into the plasmas. The tungsten atoms will not become fully ionized even in the hottest part of a fusion reactor since energies in excess of 80 keV are required to strip the last of the seventy-four electrons. This ensures that line spectra from tungsten ions will be emitted from wherever the tungsten ions are located—from the cooler edge and divertor regions to the center of the hot plasmas. Present-day magnetic confinement experiments have core temperatures of a few keV, where tungsten ionizes to M-shell charge states. In future fusion devices, such as the ITER tokamak, the core plasmas may reach temperatures around 30 keV, and tungsten particles that enter into these high-temperature plasmas will ionize to L-shell charge states. Even so, under ohmic plasma operations, the ITER core plasmas will have a large fractional abundance of M-shell charge states. The spectra from these tungsten ions may therefore provide diagnostics for plasmas both in current fusion experiments and in the initial ohmic phase of ITER plasmas.

The diagnostics of nuclear fusion plasmas using tungsten spectroscopy require accurate atomic data. An effort to collect experimental and theoretical data on tungsten ions has therefore been initiated at the Lawrence Livermore National Laboratory—the WOLFRAM project aims to investigate the spectra of tungsten and identify fusion plasma diagnostics [1]. This paper presents *ab initio* atomic data and theoretical spectra for ten tungsten ions, from germanium-like tungsten, W^{42+}, through vanadium-like tungsten, W^{51+} (i.e., all the ions having ground configurations with $4p_{1/2}$, $4s_{1/2}$, and $3d_{5/2}$ valence electrons). The structures and kinetics are calculated using the fully relativistic Flexible Atomic Code (FAC) [2,3]. The calculations yield energy levels, transition energies, wavelengths, oscillator strengths, and transition probabilities. The spectra have been calculated using collisional–radiative models, and line emissivities for the strong lines in a typical Maxwell–Boltzmann tokamak plasma are presented.

There exist several theoretical studies on M-shell tungsten spectra (see e.g., Refs. [4–12]) of which the most comprehensive set of data is presented by Fournier, who modeled the spectra of Rb-like W^{37+} through Co-like W^{47+} [13]. There has also been numerous experimental investigations of the M-shell tungsten spectra, with measurements from the ASDEX Upgrade tokamak [4,5,11,12], the Z-pinches at the University of Nevada, Reno [7], and from the electron beam ion traps (EBITs) at the Lawrence Livermore National Laboratory [1,6,7,14–18] and the National Institute of Standards and Technology [8,19–21]. Further references may be found in the atomic data compilations of Kramida and Shirai [22] and Kramida [23]. This work extends the database on highly charged tungsten ions relevant to fusion plasma diagnostics. Comparisons with existing theoretical and experimental data are discussed.

2. Calculations

The atomic structure and spectral modeling calculations were performed using the Flexible Atomic Code, FAC v1.1.1 [2,3]. FAC is a fully relativistic package based on the Dirac equation for calculations of atomic radiative and collisional parameters. FAC calculates the atomic structure by diagonalizing the Dirac–Coulomb Hamiltonian, which, in atomic units, can be written

$$H = \sum_{i=1}^{N} H_D(i) + \sum_{i<j}^{N} \frac{1}{r_{ij}} \tag{1}$$

where $H_D(i)$ describes the one-electron Dirac Hamiltonian. Breit interactions in the zero-frequency limit for the exchange photon together with hydrogenic approximations for self-energy and vacuum polarization effects are also included. The configuration state functions Φ consist of antisymmetric sums of products of N one-electron Dirac spinors $\varphi_{n\kappa m}$

$$\varphi_{n\kappa m} = \begin{pmatrix} P_{n\kappa}(r)\chi_{\kappa m}(\theta,\phi,\sigma) \\ iQ_{n\kappa}(r)\chi_{-\kappa m}(\theta,\phi,\sigma) \end{pmatrix} \tag{2}$$

where $\chi_{\kappa m}$ is the spin-angular function. The radial orbitals, $P_{n\kappa}$ and $Q_{n\kappa}$ are obtained using a Dirac–Fock–Slater method. The configuration state functions used in the calculations are listed in Table A. The atomic state functions ψ are then constructed by summation of the configuration state functions of the same symmetry

$$\psi = \sum_{\nu} b_{\nu}\Phi_{\nu} \tag{3}$$

with b_ν being the mixing coefficients, which are derived by diagonalizing the Hamiltonian. These atomic state functions are then used to compute oscillator strengths and radiative transition rates. They are also used to calculate collisional excitation cross sections in the distorted-wave approximation. These radiative and collisional atomic data are then employed for collisional–radiative

Table A
Configuration state functions used in the FAC atomic structure calculations. The principal quantum number is denoted by $n = 4, 5, 6$, $n^* = 5, 6$, and $n^{**} = 4, 5$. The orbital angular momentum quantum number is denoted by $l = 0, 1, \ldots, n-1$ and $l^* = s, p$.

Ge-like W^{42+}	Ga-like W^{43+}	Zn-like W^{44+}	Cu-like W^{45+}	Ni-like W^{46+}
$3s^23p^63d^{10}4l^4$ $3s^23p^63d^{10}4l^{*3}n^*l$	$3s^23p^63d^{10}4l^2nl$	$3s^23p^63d^{10}4lnl$	$3s^23p^63d^{10}nl$	$3s^23p^63d^{10}$
$3s^23p^63d^94l^{*4}4l$ $3s^23p^63d^94s^24p^2n^*l$	$3s^23p^63d^94l^{*3}nl$	$3s^23p^63d^94l^3$ $3s^23p^63d^94l^{*2}n^*l$	$3s^23p^63d^94l^2$ $3s^23p^63d^94l^*n^*l$	$3s^23p^63d^9nl$
$3s^23p^53d^{10}4l^{*4}4l$ $3s^23p^53d^{10}4s^24p^2n^*l$	$3s^23p^53d^{10}4l^{*3}nl$	$3s^23p^53d^{10}4l^3$ $3s^23p^53d^{10}4l^{*2}n^*l$	$3s^23p^53d^{10}4l^2$ $3s^23p^53d^{10}4l^*n^*l$	$3s^23p^53d^{10}nl$
$3s3p^63d^{10}4l^{*4}4l$ $3s3p^63d^{10}4s^24p^2n^*l$	$3s3p^63d^{10}4l^{*3}nl$	$3s3p^63d^{10}4l^3$ $3s3p^63d^{10}4l^{*2}n^*l$	$3s3p^63d^{10}4l^2$ $3s3p^63d^{10}4l^*n^*l$	$3s3p^63d^{10}nl$
Co-like W^{47+}	**Fe-like W^{48+}**	**Mn-like W^{49+}**	**Cr-like W^{50+}**	**V-like W^{51+}**
$3s^23p^63d^9$ $3s^23p^63d^8nl$ $3s^23p^53d^{10}$ $3s^23p^53d^9nl$ $3s^23p^43d^{10}nl$	$3s^23p^63d^8$ $3s^23p^63d^7nl$ $3s^23p^53d^9$ $3s^23p^53d^8nl$ $3s^23p^43d^{10}$	$3s^23p^63d^7$ $3s^23p^63d^6nl$ $3s^23p^53d^8$ $3s^23p^53d^7nl$ $3s^23p^43d^9$ $3s^23p^33d^{10}$	$3s^23p^63d^6$ $3s^23p^63d^5n^{**}l$ $3s^23p^53d^7$ $3s^23p^53d^6n^{**}l$ $3s^23p^43d^8$ $3s^23p^33d^9$ $3s^23p^23d^{10}$	$3s^23p^63d^5$ $3s^23p^63d^4n^{**}l$ $3s^23p^53d^6$ $3s^23p^53d^5n^{**}l$ $3s^23p^43d^7$ $3s^23p^33d^8$ $3s^23p^23d^9$ $3s^23p3d^{10}$
$3s3p^63d^{10}$ $3s3p^63d^9nl$ $3s3p^53d^{10}nl$	$3s3p^63d^9$ $3s3p^63d^8nl$ $3s3p^53d^{10}$	$3s3p^63d^8$ $3s3p^63d^7nl$ $3s3p^53d^9$ $3s3p^43d^{10}$	$3s3p^63d^7$ $3s3p^63d^6n^{**}l$ $3s3p^53d^8$ $3s3p^43d^9$ $3s3p^33d^{10}$	$3s3p^63d^6$ $3s3p^63d^5n^{**}l$ $3s3p^53d^7$ $3s3p^43d^8$ $3s3p^33d^9$ $3s3p^23d^{10}$
$3p^63d^{10}nl$	$3p^63d^{10}$	$3p^63d^9$ $3p^53d^{10}$	$3p^63d^8$ $3p^53d^9$ $3p^43d^{10}$	$3p^63d^7$ $3p^53d^8$ $3p^43d^9$ $3p^33d^{10}$

models for the calculation of line emissivities under non-LTE conditions.

The energy levels of Ge-like W^{42+} through V-like W^{51+} are listed in Tables 1–10, where each level is presented with the electron configuration in *jj*-coupling, total angular momentum *J*, parity $\pi = (-1)^{\Sigma_i l_i}$, energy *E*, radiative lifetime τ_{rad}, and level lifetime τ_{level}. The radiative lifetime of a level *k* is calculated from the sum of transition probabilities A_{ki} from *k* to all lower levels *i* included in the model,

$$\tau_k = \frac{1}{\Sigma_i A_{ki}}. \tag{4}$$

The level lifetimes are determined from the radiative and collisional excitation and decay rates affecting the given level population for the plasma conditions in the collisional–radiative model. When the level lifetime does not match the radiative lifetime this is an indication that the level is density sensitive or affected by autoionization.

Tables 11–20 list the strong transitions for the ten tungsten spectra in the 1–4 keV soft X-ray interval. Each transition is presented with the indices *i* and *k* for the levels to which the transition connects, the transition energy ΔE and corresponding wavelength λ, weighted mixed-multipole absorption oscillator strength *gf*, and mixed-multipole radiative transition probability rate *A* (the dominant multipole may be deduced from selection rules). The transition tables also list line emissivities ϵ, which are obtained from the collisional–radiative models described below. For Ni-like W^{46+}, multipoles up to order three are explicitly included, since it is known that such high ranks are important for a correct interpretation of the X-ray spectrum [24,20,15].

To gauge the quality of the FAC atomic data, energy levels and oscillator strengths of Ni-like W^{46+} are compared with existing theoretical and experimental data. The W^{46+} ion is chosen because it has been the subject of a large number of investigations. The 106 energy levels with $3l4l'$ configurations are listed in Table B where the FAC energies are tabulated together with results from seven other calculations and measured energies. Only measured wavelengths going to the ground state have been used to infer level energies. The energies are presented according to the published level designations although it is clear that some codes assign different dominating basis functions. The comparison is not complete since only the General-purpose Relativistic Atomic Structure Program (GRASP) calculation of Aggarwal et al. [25] and the Dirac–Fock–Slater (DFS) calculation of Zhang et al. [26] present results for all 106 levels. Table C compares FAC oscillator strengths from the ground level in Ni-like W^{46+} to five previous calculations. The GRASP oscillator strengths f_{ik} by Ballance and Griffin and the Relativistic Many-Body Perturbation Theory (RMBPT) oscillator strengths by Safronova et al. have been converted from radiative transition probability rates A_{ki} according to (in metric units)

$$g_i f_{ik} = g_k \frac{\epsilon_0 m c \lambda^2}{2\pi e^2} A_{ki} \tag{5}$$

where $g_{i,k} = 2J_{i,k} + 1$ are the statistical weights of the lower and upper levels, respectively, ϵ_0 the vacuum permittivity, *m* and *e* the electron mass and charge, respectively, *c* the speed of light, and λ the wavelength. g_i is equal to one for the ground level. The oscillator strengths of Safronova et al. are listed based on transition energies and not level designations.

The large data set on tungsten ions presented by Fournier [13] was calculated using the RELAC code written by Klapisch [38,39]. RELAC calculates the atomic structure using a relativistic parametric potential method. The RELAC data listed in Table B have been rounded off from the nine significant digits listed in Ref. [13]. The agreement between FAC and RELAC is very good, with most energy levels within 1 eV. The largest deviations are for the lowest energy levels where the differences are 0.1%. The levels have the same designations (dominating basis functions) and only the order of the $(3p_{3/2}^{-1}4p_{1/2})_2$ and $(3d_{5/2}^{-1}4f_{7/2})_1$ levels are interchanged.

Aggarwal et al. calculated the structure and allowed transition rates of W^{46+} together with several other nickel-like ions [25] using GRASP. GRASP is a multiconfiguration Dirac–Fock code

Table B
Comparison of energy levels in Ni-like tungsten, W^{46+}. Units in eV.

Level	FAC[a]	RELAC[b]	GRASP[c]	GRASP[d]	GRASP[e]	DFS[f]	RMBPT[g]	Cowan[g]	Experiment
$(3d_{5/2}^{-1}4s_{1/2})_3$	1562.15	1560.55	1559.78		1560.31	1560.0	1562		1562.0(1)[h]
$(3d_{5/2}^{-1}4s_{1/2})_2$	1564.07	1562.42	1561.67	1561.11	1562.14	1561.9	1563.63	1566.49	1563.9(1)[h]
$(3d_{3/2}^{-1}4s_{1/2})_1$	1628.75	1627.15	1626.11	1625.54	1627.99	1626.4	1628.42	1633.09	
$(3d_{3/2}^{-1}4s_{1/2})_2$	1629.99	1628.49	1627.33	1626.77	1629.28	1627.7	1629.62	1634.19	1629.8(3)[i] 1630(1)[j]
$(3d_{5/2}^{-1}4p_{1/2})_2$	1658.59	1657.55	1656.96		1657.24	1657.2	1658		
$(3d_{5/2}^{-1}4p_{1/2})_3$	1659.78	1658.96	1658.13		1658.62	1658.4	1659		
$(3d_{3/2}^{-1}4p_{1/2})_2$	1725.20	1724.42	1723.30		1725.20	1723.7	1763		
$(3d_{3/2}^{-1}4p_{1/2})_1$	1728.69	1727.77	1726.72	1727.19	1728.49	1727.1	1728.13	1730.57	1728(1)[j] 1728.4(1)[k] 1729(1)[l] 1729(1)[m]
$(3d_{5/2}^{-1}4p_{3/2})_4$	1761.59	1760.75	1759.74		1761.41	1760.0			
$(3d_{5/2}^{-1}4p_{3/2})_2$	1763.58	1762.58	1761.72		1763.20	1762.0	1725		
$(3d_{5/2}^{-1}4p_{3/2})_1$	1764.83	1763.75	1762.83	1763.20	1764.30	1763.2	1764.28	1769.03	1764.6(3)[i] 1764(1)[j] 1764(1)[l] 1765(1)[m] 1750(15)[n]
$(3d_{5/2}^{-1}4p_{3/2})_3$	1766.79	1765.84	1764.91		1766.41	1765.3	1766		
$(3d_{3/2}^{-1}4p_{3/2})_0$	1824.86	1823.75	1822.76		1825.53	1823.1			
$(3d_{3/2}^{-1}4p_{3/2})_1$	1829.45	1828.51	1827.31	1827.68	1830.20	1827.7	1829.11	1835.58	1829.6(4)[i] 1827(1)[j] 1829(1)[l] 1830(1)[m]
$(3d_{3/2}^{-1}4p_{3/2})_3$	1829.69	1828.94	1827.55		1830.62	1828.0	1829		
$(3d_{3/2}^{-1}4p_{3/2})_2$	1832.38	1831.51	1830.25		1833.16	1830.7	1832		
$(3d_{5/2}^{-1}4d_{3/2})_1$	1904.93		1903.61	1904.04	1905.40	1903.6	1905.12	1906.70	
$(3d_{5/2}^{-1}4d_{3/2})_4$	1909.87	1909.42	1908.52		1910.72	1908.7			
$(3d_{5/2}^{-1}4d_{3/2})_2$	1911.28	1910.56	1909.95	1910.42	1911.89	1910.1	1911.15	1912.01	
$(3d_{5/2}^{-1}4d_{3/2})_3$	1913.62	1912.99	1912.29		1914.27	1912.5	1913		
$(3d_{5/2}^{-1}4d_{5/2})_1$	1928.92	1928.29	1927.54	1927.99	1930.16	1927.6	1928.93	1931.14	
$(3d_{5/2}^{-1}4d_{5/2})_5$	1930.53	1930.10	1929.14		1931.91	1929.3			
$(3d_{5/2}^{-1}4d_{5/2})_3$	1934.49	1933.83	1933.12		1935.63	1933.3	1934		
$(3d_{5/2}^{-1}4d_{5/2})_2$	1935.73	1934.91	1934.32	1934.79	1936.66	1934.5	1935.68	1936.68	
$(3d_{5/2}^{-1}4d_{5/2})_4$	1936.39	1935.80	1935.02		1937.55	1935.2			
$(3d_{5/2}^{-1}4d_{5/2})_0$	1950.97		1949.40	1950.30	1951.85	1949.4	1950.09	1951.18	
$(3d_{3/2}^{-1}4d_{3/2})_1$	1975.52	1974.95	1973.92	1974.37	1977.42	1974.1	1975.38	1978.41	
$(3d_{3/2}^{-1}4d_{3/2})_3$	1975.86	1975.42	1974.25		1977.85	1974.5	1976		
$(3d_{3/2}^{-1}4d_{3/2})_2$	1981.68	1981.07	1980.05	1980.53	1983.42	1980.4	1981.35	1983.41	
$(3d_{3/2}^{-1}4d_{5/2})_1$	1995.63	1994.76	1993.98	1994.43	1997.68	1994.2	1995.72	1999.19	
$(3d_{3/2}^{-1}4d_{5/2})_4$	1998.76	1998.40	1997.09		2001.23	1997.4			
$(3d_{3/2}^{-1}4d_{5/2})_2$	2000.54	1999.94	1998.89	1999.37	2002.79	1999.2	2000.47	2003.59	
$(3d_{3/2}^{-1}4d_{5/2})_3$	2002.43	2001.90	2000.80		2004.72	2001.1	2002		
$(3p_{3/2}^{-1}4s_{1/2})_2$	2014.09		2013.25		2016.40	2012.9	2158		
$(3p_{3/2}^{-1}4s_{1/2})_1$	2017.39	2017.16	2016.49	2016.34	2019.67	2016.3	2179.24	2179.98	2015.4(3)[i] 2014(1)[j] 2015(2)[m]
$(3d_{3/2}^{-1}4d_{3/2})_0$	2023.02		2020.82	2018.84	2023.44	2019.1	2014.93	2012.11	
$(3d_{5/2}^{-1}4f_{5/2})_0$	2080.57		2078.65		2081.09	2078.8			
$(3d_{5/2}^{-1}4f_{5/2})_1$	2083.49		2081.63	2082.36	2084.36	2081.8	2014.60	2008.01	2082(2)[m]
$(3d_{5/2}^{-1}4f_{5/2})_5$	2087.56	2086.79	2085.84		2089.11	2086.0			
$(3d_{5/2}^{-1}4f_{5/2})_2$	2088.32		2086.59		2089.41	2091.8	2011		
$(3d_{5/2}^{-1}4f_{5/2})_3$	2091.47		2089.86		2092.83	2090.1	2091		
$(3d_{5/2}^{-1}4f_{7/2})_6$	2091.83	2090.88	2089.97		2093.55	2090.1			
$(3d_{5/2}^{-1}4f_{5/2})_4$	2092.57		2091.01		2093.98	2091.2			
$(3d_{5/2}^{-1}4f_{7/2})_2$	2093.33	2092.08	2091.58		2094.72	2086.8	2088		
$(3d_{5/2}^{-1}4f_{7/2})_4$	2097.39	2096.35	2095.72		2099.05	2095.9			
$(3d_{5/2}^{-1}4f_{7/2})_5$	2098.85	2097.93	2097.24		2100.58	2097.5			
$(3d_{5/2}^{-1}4f_{7/2})_3$	2099.46	2098.44	2097.93		2101.07	2098.2	2099		
$(3p_{3/2}^{-1}4p_{1/2})_1$	2111.07		2110.94	2111.77	2113.96	2110.7	2108.29	2100.07	
$(3p_{3/2}^{-1}4p_{1/2})_2$	2112.04	2112.55	2111.90	2112.74	2115.20	2111.7	2109.42	2101.01	
$(3d_{5/2}^{-1}4f_{7/2})_1$	2112.57	2111.56	2111.25	2111.54	2114.56	2111.2	2082.89	2085.17	2112.2(3)[i]

(*continued on next page*)

Table B (*continued*)

Level	FAC[a]	RELAC[b]	GRASP[c]	GRASP[d]	GRASP[e]	DFS[f]	RMBPT[g]	Cowan[g]	Experiment
									2111(1)[j] 2112.4(2)[o] 2111.6(3)[p] 2112(2)[m] 2100(15)[n]
$(3d_{3/2}^{-1}4f_{5/2})_4$	2153.90		2151.84		2156.39	2152.1			
$(3d_{3/2}^{-1}4f_{5/2})_2$	2155.36	2154.16	2153.29		2157.71	2157.0	2093		
$(3d_{3/2}^{-1}4f_{7/2})_2$	2158.70		2156.68		2161.22	2153.6	2155		
$(3d_{3/2}^{-1}4f_{7/2})_5$	2160.84		2158.83		2163.69	2159.1			
$(3d_{3/2}^{-1}4f_{5/2})_3$	2160.93	2160.04	2159.11		2163.51	2162.4	2161		
$(3d_{3/2}^{-1}4f_{7/2})_3$	2163.93		2162.05		2166.72	2159.5	2164		
$(3d_{3/2}^{-1}4f_{7/2})_4$	2165.25		2163.39		2168.12	2163.7			
$(3d_{3/2}^{-1}4f_{5/2})_1$	2181.36	2181.55	2180.88	2180.36	2185.81	2180.3	2112.08	2112.57	2179.7(4)[i] 2179(1)[j] 2179.3(2)[o] 2178.5(3)[p] 2179(2)[m] 2160(15)[n]
$(3p_{3/2}^{-1}4p_{3/2})_3$	2213.58		2213.24		2217.76	2213.0	2211		
$(3p_{3/2}^{-1}4p_{3/2})_1$	2213.69		2213.34	2214.07	2217.63	2213.1	2211.16	2206.94	
$(3p_{3/2}^{-1}4p_{3/2})_2$	2218.82		2218.45	2219.18	2222.68	2218.3	2216.14	2211.26	
$(3p_{3/2}^{-1}4p_{3/2})_0$	2239.71		2238.60	2238.19	2242.37	2237.2	2317.37	2326.18	
$(3p_{1/2}^{-1}4s_{1/2})_0$	2321.22		2319.65		2326.08	2319.4			
$(3p_{1/2}^{-1}4s_{1/2})_1$	2323.64		2322.00	2321.55	2328.61	2321.9	2319.63	2328.54	2320.3(6)[i]
$(3p_{3/2}^{-1}4d_{3/2})_0$	2358.45		2358.57		2363.09	2358.2			
$(3p_{3/2}^{-1}4d_{3/2})_1$	2361.82		2361.97	2362.85	2366.61	2361.6	2359.39	2351.37	2360.7(7)[i] 2360.2(4)[o] 2359(1)[q]
$(3p_{3/2}^{-1}4d_{3/2})_3$	2362.53		2362.70		2367.57	2362.3	2360		
$(3p_{3/2}^{-1}4d_{3/2})_2$	2365.62		2365.81		2370.45	2365.5	2363		
$(3p_{3/2}^{-1}4d_{5/2})_4$	2383.45		2383.58		2388.94	2383.2			
$(3p_{3/2}^{-1}4d_{5/2})_2$	2385.43	2386.09	2385.58		2390.72	2385.2	2383		
$(3p_{3/2}^{-1}4d_{5/2})_1$	2386.03	2386.88	2386.10	2386.98	2391.43	2385.8	2383.71	2375.77	2384.2(4)[i] 2383(1)[j] 2384.1(4)[o] 2383(1)[q]
$(3p_{3/2}^{-1}4d_{5/2})_3$	2388.63	2389.38	2388.78		2393.99	2388.5	2386		
$(3p_{1/2}^{-1}4p_{1/2})_1$	2418.84		2417.94	2418.47	2424.79	2417.8	2414.80	2422.70	
$(3p_{1/2}^{-1}4p_{1/2})_0$	2435.61		2434.62	2434.60	2440.82	2433.5	2356.07	2348.76	
$(3p_{1/2}^{-1}4p_{3/2})_1$	2520.34		2519.32	2519.91	2526.92	2519.2	2515.94	2524.28	
$(3p_{1/2}^{-1}4p_{3/2})_2$	2523.83		2522.71	2523.16	2530.67	2522.6	2519.55	2528.01	
$(3p_{3/2}^{-1}4f_{5/2})_1$	2534.39		2534.18	2535.02	2539.95	2730.6	2531.52	2527.98	
$(3p_{3/2}^{-1}4f_{5/2})_2$	2539.17		2539.03	2539.92	2544.89	2721.8	2536.68	2532.10	
$(3p_{3/2}^{-1}4f_{5/2})_4$	2539.97		2539.93		2545.76	2721.0			
$(3p_{3/2}^{-1}4f_{7/2})_5$	2543.35		2543.15		2549.31	2731.2			
$(3p_{3/2}^{-1}4f_{5/2})_3$	2543.78		2543.81		2549.49	2732.9	2541		
$(3p_{3/2}^{-1}4f_{7/2})_3$	2547.29	2547.67	2547.23		2553.24	2722.7	2844		
$(3p_{3/2}^{-1}4f_{7/2})_4$	2551.01	2551.54	2551.06		2557.04	2733.7			
$(3p_{3/2}^{-1}4f_{7/2})_2$	2554.73	2555.61	2555.02	2555.80	2560.99	2733.3	2552.02	2543.59	2553.0(4)[i] 2553(1)[q] 2553[r]
$(3s_{1/2}^{-1}4s_{1/2})_1$	2565.06		2565.52	2568.24	2572.10	2565.3	2560.48	2563.93	
$(3s_{1/2}^{-1}4s_{1/2})_0$	2574.71		2574.91	2577.40	2581.20	2573.5	2566.74	2570.08	
$(3s_{1/2}^{-1}4p_{1/2})_1$	2655.04		2655.62	2658.89	2662.53	2717.3	2674.81	2679.58	2651.3(4)[i] 2649(1)[q]
$(3s_{1/2}^{-1}4p_{1/2})_0$	2659.22		2660.50		2666.70	2715.5			
$(3p_{1/2}^{-1}4d_{3/2})_2$	2671.08		2670.49		2680.35	2691.2	2667		
$(3p_{1/2}^{-1}4d_{3/2})_1$	2678.60		2678.64	2679.89	2686.23	2678.5	2649.66	2653.45	2673.7(6)[i] 2673(1)[q]
$(3p_{1/2}^{-1}4d_{5/2})_2$	2692.05		2691.45		2699.91	2718.6	2688		
$(3p_{1/2}^{-1}4d_{5/2})_3$	2694.08		2693.44		2701.63	2717.8	2692		
$(3s_{1/2}^{-1}4p_{3/2})_2$	2763.90		2764.93		2772.54	2804.2	2759		
$(3s_{1/2}^{-1}4p_{3/2})_1$	2765.65		2766.65	2770.49	2774.21	2814.9	2760.14	2765.51	2760.7(5)[i] 2759(1)[q]
$(3p_{1/2}^{-1}4f_{5/2})_3$	2848.83		2847.91		2857.14	2909.6	2545		
$(3p_{1/2}^{-1}4f_{5/2})_2$	2853.66		2853.03	2853.62	2863.02	2909.0	2850.36	2856.98	
$(3p_{1/2}^{-1}4f_{7/2})_3$	2854.06		2853.14		2863.29	2910.4	2846		

(*continued on next page*)

Table B (*continued*)

Level	FAC[a]	RELAC[b]	GRASP[c]	GRASP[d]	GRASP[e]	DFS[f]	RMBPT[g]	Cowan[g]	Experiment
$(3p_{1/2}^{-1}4f_{7/2})_4$	2856.17		2855.31		2864.84	2911.1			
$(3s_{1/2}^{-1}4d_{3/2})_1$	2910.52		2912.10	2916.03		2911.9	2905.76	2907.09	
$(3s_{1/2}^{-1}4d_{3/2})_2$	2911.83		2913.37	2917.27		2913.3	2907.15	2908.30	
$(3s_{1/2}^{-1}4d_{5/2})_3$	2933.06		2934.59			2934.4	2928		
$(3s_{1/2}^{-1}4d_{5/2})_2$	2933.97		2935.49	2939.44		2935.3	2929.26	2931.22	
$(3s_{1/2}^{-1}4f_{5/2})_2$	3087.27		3088.59			3087.8	3082		
$(3s_{1/2}^{-1}4f_{5/2})_3$	3088.49		3089.83			3089.1	3083		
$(3s_{1/2}^{-1}4f_{7/2})_4$	3092.88		3094.15			3093.4			
$(3s_{1/2}^{-1}4f_{7/2})_3$	3097.32		3098.81			3098.2	3092		

[a] This work.
[b] Fournier [13].
[c] Aggarwal et al. [25].
[d] Dong et al. [27].
[e] Ballance and Griffin [28].
[f] Zhang et al. [26].
[g] Safronova et al. [29].
[h] Clementson et al. [15].
[i] Clementson et al. [14].
[j] Ralchenko et al. [8].
[k] Beiersdorfer et al. [30] and Elliott et al. [31].
[l] Mandelbaum et al. [32].
[m] Zigler et al. [33].
[n] Burkhalter et al. [34].
[o] Neill/Kramida [6,23].
[p] Butzbach et al. [35].
[q] Tragin et al. [36].
[r] Wyart et al. [37].

developed by Dyall et al. [40] based on the program of Grant [41]. The energies presented by Aggarwal et al. are off from FAC by 1–2 eV except for the high-energy levels, which agree better. The orders of the levels are the same except for levels $(3p_{3/2}^{-1}4p_{1/2})_2$ and $(3d_{5/2}^{-1}4f_{7/2})_1$. Dong et al. [27] made use of a later GRASP version, GRASP92 by Parpia et al. [42], for the calculations of energy levels and transition probabilities in nickel-like ions with $74 \le Z \le 84$. Some of the W^{46+} energy levels differ by 5 eV from the FAC calculation. Levels $(3p_{3/2}^{-1}4p_{1/2})_{1,2}$ and $(3d_{5/2}^{-1}4f_{7/2})_1$ have a different order than the energy levels from FAC. Ballance and Griffin performed structure calculations of W^{46+} using a GRASP code [28]. These energy levels (especially the higher levels) are off with up to 5–10 eV from the FAC energies. In addition to the order of the levels $(3p_{3/2}^{-1}4p_{1/2})_2$ and $(3d_{5/2}^{-1}4f_{7/2})_1$ also the orders of $(3d_{3/2}^{-1}4f_{7/2})_5$ and $(3d_{3/2}^{-1}4f_{5/2})_3$ are interchanged as are the $(3p_{3/2}^{-1}4p_{3/2})_3$ and $(3p_{3/2}^{-1}4p_{3/2})_1$ levels.

Using the DFS program by Sampson et al. [43], which calculates the atomic structure using a Dirac–Fock–Slater potential and the continuum processes with the distorted-wave method, Zhang et al. calculated transition energies and collision strengths for nickel-like ions with $60 \le Z \le 92$ [26]. Most of the Ni-like W^{46+} energy levels differ from the FAC values by 1–2 eV. A few energy levels have a different order than FAC (i.e., the $(3p_{3/2}^{-1}4p_{1/2})_2$ and $(3d_{5/2}^{-1}4f_{7/2})_1$ levels around 2112 eV and the levels around 2090 eV, 2155 eV, and 2160 eV). Many of the 3*s* and 3*p* inner-shell excited levels are very different from the FAC energies, and the energies from the other codes in this comparison, with values from several tens eV to 200 eV higher.

Safronova et al. calculated multipole transitions in nickel-like ions with $30 \le Z \le 100$ [29] using RMBPT [44] and, for Ni-like tungsten, W^{46+}, using the Cowan code [45,46]. In addition to the energy levels listed in Ref. [29], the wavelengths for the transitions connecting the ground state have been used to infer additional energy levels albeit with fewer significant digits. There are many RMBPT and Cowan levels that differ considerably from the FAC levels, however this appears mainly to be due to different level designations. It is possible that, since the RMBPT and Cowan results are from the same reference, that the codes do not produce the same level designations but instead have been altered for consistency (as are results from other codes presented in Ref. [29]). Note that the Cowan code is not fully relativistic, which likely explains the larger differences from the results of the other codes.

The FAC theoretical energies are in excellent agreement with the experimental energies for the lower energy levels and in good agreement with the higher energy levels (see Table B). A measure of the overall quality may be achieved by comparing calculated values for the ten levels where data from all codes are available to high-precision experimental energies [15,14,31]. The RMBPT calculations by Safronova et al. [29] (the RMBPT values are compared based on energies and not on level labels) and FAC have a total energy difference of a few eV (4 eV and 9 eV, respectively), whereas the other codes are off by more than 15 eV [13,25,27] to several tens of eV [28,29,26] (although some individual values from these codes are in excellent agreement with experiment).

The oscillator strengths for the transitions connecting the 3*l*4*l* excited levels with the ground level in Ni-like tungsten, W^{46+}, are in good agreement between the codes (see Table C). Two of the oscillator strengths from the DFS code have values that differ from the other codes (the transitions originate from the $(3s_{1/2}^{-1}4p_{1/2})_1$ and $(3s_{1/2}^{-1}4p_{3/2})_1$ energy levels, which DFS predicted at energies with large offsets from the other codes). There is a large difference for the M1 transition at 2534.39 eV between FAC and RMBPT. Furthermore, the oscillator strengths for the E3 transitions from $(3d_{5/2}^{-1}4f_{5/2})_3$ at 2091.47 eV and $(3d_{3/2}^{-1}4f_{7/2})_3$ at 2163.93 eV and the oscillator strengths for the E3 transitions from $(3s_{1/2}^{-1}4f_{5/2})_3$ at 3088.49 eV and $(3s_{1/2}^{-1}4f_{7/2})_3$ at 3097.32 eV appear to be interchanged between FAC and RMBPT.

A test of the quality of the theoretical oscillator strengths is to compare calculated and experimental lifetimes. Although no such measurements exist for Ni-like tungsten, W^{46+}, lifetimes of the first excited level $(3d_{5/2}4s_{1/2})_3$ in the heavy nickel-like ions Xe^{26+}, Cs^{27+}, and Ba^{28+} have been measured by Träbert et al. [47]. A later detailed study of the hyperfine decay channels in Xe^{26+} revealed that the ^{132}Xe isotope, which does not have nuclear spin and thus no hyperfine structure, has a somewhat longer lifetime than

Table C
Comparison of E1, M1, E2, M2, E3, and M3 multipole (MP) absorption oscillator strengths from the ground state in Ni-like tungsten, W^{46+}, to all excited levels with $3l^{-1}4l$ configurations. Levels and transition energies according to FAC.

Upper level	ΔE (eV)	MP	FAC[a]	RELAC[b]	GRASP[c]	GRASP[e]	DFS[f]	RMBPT[g]
$(3d_{5/2}^{-1}4s_{1/2})_3$	1562.15	M3	6.05×10^{-10}					5.44×10^{-10}
$(3d_{5/2}^{-1}4s_{1/2})_2$	1564.07	E2	2.76×10^{-4}	2.794×10^{-4}				2.51×10^{-4}
$(3d_{3/2}^{-1}4s_{1/2})_1$	1628.75	M1	3.75×10^{-10}					4.25×10^{-10}
$(3d_{3/2}^{-1}4s_{1/2})_2$	1629.99	E2	1.93×10^{-4}	1.960×10^{-4}				1.75×10^{-4}
$(3d_{5/2}^{-1}4p_{1/2})_2$	1658.59	M2	1.90×10^{-7}					1.69×10^{-7}
$(3d_{5/2}^{-1}4p_{1/2})_3$	1659.78	E3	2.45×10^{-7}					2.23×10^{-7}
$(3d_{3/2}^{-1}4p_{1/2})_2$	1725.20	M2	5.29×10^{-9}					4.96×10^{-9}[*]
$(3d_{3/2}^{-1}4p_{1/2})_1$	1728.69	E1	1.43×10^{-1}	1.450×10^{-1}	1.5088×10^{-1}	1.49×10^{-1}	1.453×10^{-1}	1.54×10^{-1}
$(3d_{5/2}^{-1}4p_{3/2})_2$	1763.58	M2	5.72×10^{-7}					5.19×10^{-7}[*]
$(3d_{5/2}^{-1}4p_{3/2})_1$	1764.83	E1	2.58×10^{-1}	2.652×10^{-1}	2.7508×10^{-1}	2.73×10^{-1}	2.633×10^{-1}	2.82×10^{-1}
$(3d_{5/2}^{-1}4p_{3/2})_3$	1766.79	E3	2.27×10^{-7}					2.16×10^{-7}
$(3d_{3/2}^{-1}4p_{3/2})_1$	1829.45	E1	2.66×10^{-2}	2.749×10^{-2}	2.8329×10^{-2}	2.77×10^{-2}	2.68×10^{-2}	2.93×10^{-2}
$(3d_{3/2}^{-1}4p_{3/2})_3$	1829.69	E3	3.61×10^{-7}					3.42×10^{-7}
$(3d_{3/2}^{-1}4p_{3/2})_2$	1832.38	M2	1.45×10^{-10}					1.54×10^{-10}
$(3d_{5/2}^{-1}4d_{3/2})_1$	1904.93	M1	1.18×10^{-6}					1.32×10^{-6}
$(3d_{5/2}^{-1}4d_{3/2})_2$	1911.28	E2	1.39×10^{-4}					1.32×10^{-4}
$(3d_{5/2}^{-1}4d_{3/2})_3$	1913.62	M3	9.73×10^{-11}					7.62×10^{-11}
$(3d_{5/2}^{-1}4d_{5/2})_1$	1928.92	M1	3.90×10^{-7}					5.82×10^{-7}
$(3d_{5/2}^{-1}4d_{5/2})_3$	1934.49	M3	4.06×10^{-9}					3.73×10^{-9}
$(3d_{5/2}^{-1}4d_{5/2})_2$	1935.73	E2	7.56×10^{-4}					7.10×10^{-4}
$(3d_{3/2}^{-1}4d_{3/2})_1$	1975.52	M1	2.09×10^{-7}					2.52×10^{-7}
$(3d_{3/2}^{-1}4d_{3/2})_3$	1975.86	M3	7.98×10^{-11}					7.85×10^{-11}
$(3d_{3/2}^{-1}4d_{3/2})_2$	1981.68	E2	4.91×10^{-4}					4.58×10^{-4}
$(3d_{3/2}^{-1}4d_{5/2})_1$	1995.63	M1	3.90×10^{-7}					3.73×10^{-7}
$(3d_{3/2}^{-1}4d_{5/2})_2$	2000.54	E2	1.93×10^{-4}					1.78×10^{-4}
$(3d_{3/2}^{-1}4d_{5/2})_3$	2002.43	M3	2.52×10^{-11}					1.65×10^{-11}
$(3p_{3/2}^{-1}4s_{1/2})_2$	2014.09	M2	9.84×10^{-7}					8.97×10^{-7}[*]
$(3p_{3/2}^{-1}4s_{1/2})_1$	2017.39	E1	3.58×10^{-1}	3.544×10^{-1}	3.7413×10^{-1}	3.66×10^{-1}	3.681×10^{-1}	3.76×10^{-1}[*]
$(3d_{5/2}^{-1}4f_{5/2})_1$	2083.49	E1	4.41×10^{-3}	4.4360×10^{-3}	4.55×10^{-3}	4.5×10^{-3}		3.84×10^{-3}[*]
$(3d_{5/2}^{-1}4f_{5/2})_2$	2088.32	M2	4.51×10^{-6}					4.39×10^{-6}[*]
$(3d_{5/2}^{-1}4f_{5/2})_3$	2091.47	E3	1.65×10^{-7}					1.78×10^{-6}
$(3d_{5/2}^{-1}4f_{7/2})_2$	2093.33	M2	2.41×10^{-5}					2.29×10^{-5}[*]
$(3d_{5/2}^{-1}4f_{7/2})_3$	2099.46	E3	1.99×10^{-6}					8.05×10^{-7}
$(3p_{3/2}^{-1}4p_{1/2})_1$	2111.07	M1	6.43×10^{-6}					6.61×10^{-6}
$(3p_{3/2}^{-1}4p_{1/2})_2$	2112.04	E2	7.62×10^{-4}					7.04×10^{-4}
$(3d_{5/2}^{-1}4f_{7/2})_1$	2112.57	E1	1.98	1.893	1.9489	1.95	1.9001	1.83[*]
$(3d_{3/2}^{-1}4f_{5/2})_2$	2155.36	M2	1.81×10^{-7}					1.74×10^{-7}[*]
$(3d_{3/2}^{-1}4f_{7/2})_2$	2158.70	M2	5.41×10^{-6}					5.17×10^{-6}[*]
$(3d_{3/2}^{-1}4f_{5/2})_3$	2160.93	E3	8.18×10^{-7}					1.31×10^{-6}
$(3d_{3/2}^{-1}4f_{7/2})_3$	2163.93	E3	9.34×10^{-7}					1.37×10^{-7}
$(3d_{3/2}^{-1}4f_{5/2})_1$	2181.36	E1	5.89	5.875	6.2182	6.19	5.8147	5.41[*]
$(3p_{3/2}^{-1}4p_{3/2})_3$	2213.58	M3	4.94×10^{-9}					4.36×10^{-9}
$(3p_{3/2}^{-1}4p_{3/2})_1$	2213.69	M1	1.82×10^{-7}					2.69×10^{-7}
$(3p_{3/2}^{-1}4p_{3/2})_2$	2218.82	E2	6.85×10^{-4}					6.43×10^{-4}
$(3p_{1/2}^{-1}4s_{1/2})_1$	2323.64	E1	5.98×10^{-2}		6.0600×10^{-2}	6.09×10^{-2}	6.15×10^{-2}	7.30×10^{-2}
$(3p_{3/2}^{-1}4d_{3/2})_1$	2361.82	E1	6.51×10^{-2}		6.6563×10^{-2}	6.89×10^{-2}	6.49×10^{-2}	6.48×10^{-2}
$(3p_{3/2}^{-1}4d_{3/2})_3$	2362.53	E3	2.53×10^{-6}					2.46×10^{-6}
$(3p_{3/2}^{-1}4d_{3/2})_2$	2365.62	M2	2.67×10^{-8}					2.31×10^{-8}
$(3p_{3/2}^{-1}4d_{5/2})_2$	2385.43	M2	5.15×10^{-6}					4.71×10^{-6}
$(3p_{3/2}^{-1}4d_{5/2})_1$	2386.03	E1	1.16	1.160	1.2043	1.21	1.1781	1.14
$(3p_{3/2}^{-1}4d_{5/2})_3$	2388.63	E3	1.61×10^{-6}					1.40×10^{-6}
$(3p_{1/2}^{-1}4p_{1/2})_1$	2418.84	M1	3.94×10^{-8}					4.34×10^{-8}
$(3p_{1/2}^{-1}4p_{3/2})_1$	2520.34	M1	4.30×10^{-6}					4.31×10^{-6}
$(3p_{1/2}^{-1}4p_{3/2})_2$	2523.83	E2	1.12×10^{-3}					9.06×10^{-4}
$(3p_{3/2}^{-1}4f_{5/2})_1$	2534.39	M1	3.39×10^{-12}					2.17×10^{-9}
$(3p_{3/2}^{-1}4f_{5/2})_2$	2539.17	E2	1.02×10^{-5}					1.23×10^{-5}
$(3p_{3/2}^{-1}4f_{5/2})_3$	2543.78	M3	2.48×10^{-9}					2.04×10^{-9}
$(3p_{3/2}^{-1}4f_{7/2})_3$	2547.29	M3	4.49×10^{-8}					3.91×10^{-8}[*]
$(3p_{3/2}^{-1}4f_{7/2})_2$	2554.73	E2	9.61×10^{-3}					9.18×10^{-3}
$(3s_{1/2}^{-1}4s_{1/2})_1$	2565.06	M1	6.54×10^{-7}					6.94×10^{-7}
$(3s_{1/2}^{-1}4p_{1/2})_1$	2655.04	E1	4.28×10^{-1}	4.015×10^{-1}	4.9737×10^{-1}	4.06×10^{-1}	9.7×10^{-3}	4.82×10^{-1}[*]
$(3p_{1/2}^{-1}4d_{3/2})_2$	2671.08	M2	7.70×10^{-8}					5.75×10^{-8}

(*continued on next page*)

Table C (*continued*)

Upper level	ΔE (eV)	MP	FAC[a]	RELAC[b]	GRASP[c]	GRASP[e]	DFS[f]	RMBPT[g]
$(3p_{1/2}^{-1}4d_{3/2})_1$	2678.60	E1	1.62×10^{-1}		1.1432×10^{-1}	1.65×10^{-1}	1.080×10^{-1}	1.16×10^{-1}*
$(3p_{1/2}^{-1}4d_{5/2})_2$	2692.05	M2	9.45×10^{-7}					7.81×10^{-7}
$(3p_{1/2}^{-1}4d_{5/2})_3$	2694.08	E3	2.53×10^{-6}					2.36×10^{-6}
$(3s_{1/2}^{-1}4p_{3/2})_2$	2763.90	M2	5.74×10^{-7}					3.41×10^{-7}
$(3s_{1/2}^{-1}4p_{3/2})_1$	2765.65	E1	1.31×10^{-1}		1.3775×10^{-1}	1.38×10^{-1}	9.169×10^{-1}	2.98×10^{-1}
$(3p_{1/2}^{-1}4f_{5/2})_3$	2848.83	M3	6.43×10^{-10}					1.55×10^{-10}*
$(3p_{1/2}^{-1}4f_{5/2})_2$	2853.66	E2	6.27×10^{-3}					6.61×10^{-3}
$(3p_{1/2}^{-1}4f_{7/2})_3$	2854.06	M3	2.20×10^{-8}					9.72×10^{-9}
$(3s_{1/2}^{-1}4d_{3/2})_1$	2910.52	M1	4.90×10^{-10}					2.57×10^{-10}
$(3s_{1/2}^{-1}4d_{3/2})_2$	2911.83	E2	8.78×10^{-4}					6.04×10^{-4}
$(3s_{1/2}^{-1}4d_{5/2})_3$	2933.06	M3	1.33×10^{-8}					1.39×10^{-8}
$(3s_{1/2}^{-1}4d_{5/2})_2$	2933.97	E2	2.34×10^{-3}					2.10×10^{-3}
$(3s_{1/2}^{-1}4f_{5/2})_2$	3087.27	M2	1.30×10^{-11}					6.13×10^{-10}
$(3s_{1/2}^{-1}4f_{5/2})_3$	3088.49	E3	2.73×10^{-6}					1.90×10^{-5}
$(3s_{1/2}^{-1}4f_{7/2})_3$	3097.32	E3	1.85×10^{-5}					3.44×10^{-6}

* The energy level label is different from FAC.
[a] This work.
[b] Fournier [13].
[c] Aggarwal et al. [25].
[e] Ballance and Griffin [28].
[f] Zhang et al. [26].
[g] Safronova et al. [29].

Table D
Comparison of lifetimes of the $(3d_{5/2}4s_{1/2})_3$ level in nickel-like ions.

Ion	FAC[a]	RMBPT[b]	Experiment
Xe^{26+}	15.4 ms	18.6 ms	11.5±0.5 ms[c] (multiple isotopes) 15.06±0.24 ms[d] (single isotope)
Cs^{27+}	11.1 ms	13.2 ms	8.2±2.0 ms[c]
Ba^{28+}	8.1 ms	9.6 ms	4.3±3.6 ms[c]
W^{46+}	109.3 µs	121.7 µs	

[a] This work.
[b] Safronova et al. [29].
[c] Träbert et al. [47].
[d] Träbert et al. [48].

what was deduced from the mixed-isotope measurement [48]. The experimental lifetimes of the $(3d_{5/2}4s_{1/2})_3$ level, which can only radiatively decay by an M3 transition, are listed for Xe^{26+}, Cs^{27+}, and Ba^{28+} in Table D together with the FAC calculated radiative lifetimes using the same atomic structure model as for W^{46+}. Note that hyperfine interactions are not included in the FAC calculations. This level is suitable for assessing the quality of the lifetime calculations as it is the first excited level in the nickel-like spectrum and thus, the radiative lifetime is simply the inverse of the transition probability rate to the ground state. In addition to the FAC calculated lifetimes the RMBPT values from Safronova et al. [29] are listed. The other codes used for the comparison of the tungsten oscillator strengths did not list the corresponding transition probabilities for Xe^{26+}, Cs^{27+}, or Ba^{28+}. The FAC lifetimes are in good agreement with the experimental data.

The spectral emissions from the ten tungsten ions are modeled for plasma conditions of relevance to magnetic fusion experiments. All spectra are modeled with $N_e = 10^{14}$ cm^{-3}, which is the predicted density for ITER core plasmas. The electron temperatures T_{CRM}, for which the collisional–radiative models have been implemented, are listed in Table E. These temperatures are approximately 50% above T_{max}, the temperatures where the fractional abundances peak according to the charge-balance calculation of Pütterich et al. [12]. T_{max} are also listed in Table E together with semi-empirical ionization energies IE_{SE} of the ions according to Kramida and Reader [49] and theoretical ionization energies IE_{RAC} of Beiersdorfer et al. [50] calculated using the Relativistic Atomic Code (RAC) of Scofield [51]. The relative values of IE and

Table E
Electron temperatures T_{CRM} used in the collisional–radiative models for the tungsten ions. The T_{CRM} values are approximately 50% above the maximum abundance temperatures T_{max}, estimated from the charge-balance calculations of Pütterich et al. [12]. Also listed are the semi-empirical ionization energies IE_{SE} of Kramida and Reader [49] and the theoretical ionization energies IE_{RAC} of Beiersdorfer et al. [50].

Seq.	Ion	IE_{SE} (eV)	IE_{RAC} (eV)	T_{max}(eV)	T_{CRM}(eV)
Ge	W^{42+}	2149.2±2.1	2144.780	2650	3975
Ga	W^{43+}	2210.0±1.5	2206.134	3000	4500
Zn	W^{44+}	2354.5±1.4	2351.894	3180	4770
Cu	W^{45+}	2414.1±0.4	2413.505	3550	5325
Ni	W^{46+}	4057±3	4051.665	4250	6375
Co	W^{47+}	4180±4	4187.704	5180	7770
Fe	W^{48+}	4309±4	4302.636	5830	8745
Mn	W^{49+}	4446±4	4445.113	6400	9600
Cr	W^{50+}	4578±4	4562.794	7000	10500
V	W^{51+}	4709±4	4705.143	7360	11040

T_{max} disagree with the trend discussed by Ralchenko et al. [52], since the break where T_{max} is higher than IE occurs sooner, around In-like W^{25+}, according to the calculations of Pütterich et al. [12] rather than at Ni-like tungsten, W^{46+}, as suggested in Ref. [52].

Collisional excitation and quenching are considered only from the lower configurations that, due to the low plasma density, should be a valid approximation. Radiative transitions are included between all levels in the models. Autoionization is considered for the N-shell W ions. The collisional–radiative emissivities are listed in the transition tables (Tables 11–20), where all transitions with line emissivities larger than 1% of the strongest line are included.

Constants and conversion factors used in the paper are $e = 1.60217657 \times 10^{-19}$ C, $m = 9.10938291 \times 10^{-31}$ kg, $c = 2.99792458 \times 10^{8}$ m/s, $\epsilon_o = 8.85418782 \times 10^{-12}$ C^2/(N m^2), $h = 6.62606957 \times 10^{-34}$ J s, $hc = 12398.41929$ Å eV = 1/8065.544296 eV cm^{-1}, and 1 Ry = 13.60569253 eV.

3. Results and discussion

The calculated energy levels are listed in Tables 1–10. Each level is described by an identifier, the purity of the major basis-function composition (mixing coefficient squared, b_ν^2), the configuration in *jj*-coupling including intermediate angular momenta, the total angular momentum, the energy, the radiative lifetime, and the predicted level lifetime (where different from the radiative lifetime) for the given plasma conditions. The radiative transitions are listed in Tables 11–20. Each transition is described by the indices of the levels the transition connects, the transition energy, the wavelength, the weighted oscillator strength, the radiative transition probability rate, and the emissivity for the given plasma conditions.

The ten calculated tungsten spectra are shown in Fig. 1, where they are displayed in the 1–4 keV X-ray interval with a resolution of 2 eV full width half maximum. The strongest line in each spectrum is consistently from a $3d_{3/2}$–$4f_{5/2}$ transition. This line is particularly strong in the Ni-like tungsten, W XLVII, spectrum with an emissivity of more than 13 000 γ/ion/s at 2181.36 eV for the collisional–radiative model parameters of $T_e = 6375$ eV and $N_e = 10^{14}$ cm^{-3}. Centered around this line, the $3d_{3/2}$–$4f_{5/2}$ transitions in the ten tungsten spectra fall within a $\Delta E = 300$ eV region ($\Delta\lambda = 0.7$ Å). This interval should be very well suited to infer the tungsten charge balance in moderate-temperature tokamak plasmas.

Below, the results for each ion are discussed in more detail. Comparisons are made for the calculated data with some existing experimental data. A fairly large number of measurements of spectral lines from the N-shell tungsten ions considered in this work has been performed. The situation is less satisfactory for the open $3d$ ions, where very few X-ray measurements exist. To further validate the quality of the structure calculations comparisons are therefore extended to also include available experimental EUV data for $\Delta n = 0$ M- and N-shell transitions. Since most reported transitions are presented in wavelengths this is the quantity used in the comparisons, except for the Ni-like tungsten, W LXVII, spectrum that has already been discussed in Table B. Calculated wavelengths are given with the same number of significant digits as the highest-precision experimental value. For lines that consist of two or more transitions the calculated wavelengths are weighted by the line emissivities. Levels are designated by kets for brevity. The emissivities of the strongest $3d_{3/2}$–$4f_{5/2}$ transitions are stated in each text section, and make a good measure of the ion's spectral intensity as it is the strongest line in each of the ten spectra. Further discussions on tungsten spectroscopy may be found in the atomic data compilations by Kramida and Shirai [22] and Kramida [23].

Neill et al. [6] have measured a large number of spectral lines from the tungsten ions considered in this work at the Livermore EBIT-II. However, they do not state experimental uncertainties and, as noted by Kramida [23], the wavelength scale used in their work does not seem to be well determined. In addition to them not providing level identifications this makes data comparisons rather difficult. The work of Neill et al. is therefore used in the interpretation of Kramida [23] and is referenced as Neill/Kramida [6,23].

The recent work of Osborne et al. [17] at the Livermore EBIT-I lists wavelengths of a large number of transitions in tungsten ions isoelectronic to Co through Se. However, except for three unidentified lines, no new lines are presented and the line identifications are those of Kramida and Shirai [22]. The line-position uncertainties are not explicitly stated, but the wavelength scale in the 4.31–7.93 Å interval, based on the RMBPT calculations for Ni-like tungsten, W^{46+}, by Safronova et al. [29], is estimated to be accurate to 9–17 mÅ. Apparently, the presented lines also include the calibration lines and so the linelists only serve to identify the observed spectral features and are not appropriate for benchmarking of the present atomic calculations.

3.1. Ge-like tungsten, W^{42+}

Forty-two times ionized, germanium-like tungsten, W^{42+}, has a $(4s^2 4p_{1/2}^2)_0$ ground state. The calculations include a total of 14 454 energy levels, of which 122 are listed in Table 1. Out of these, there are twenty-two levels with a $3l^{18}4l^4$ superconfiguration, three with a $3l^{18}4l^3 5l$, twelve with a $3l^{18}4l^3 6l$, seventy-four with a $3l^{17}4l^5$, eight with a $3l^{17}4l^4 5l$, and three levels with a $3l^{17}4l^4 6l$ superconfiguration. The spectrum, which is modeled for $T_{CRM} = 3975$ eV, has 123 lines with intensities greater than 1% of the $3d_{3/2}$–$4f_{5/2}$ transition ($|0\rangle$–$|5911\rangle$) at 2126.75 eV with 2989 γ/ion/s. The radiative transitions are listed in Table 11. The spectral model shows that nearly all of the listed energy levels above the ionization limit are affected by autoionization, thus decreasing the line intensities for the radiative transitions proceeding from these levels.

Features from the Ge-like tungsten ion, W XLIII, spectrum have been observed in laser-produced plasmas by Klapisch et al. [53], Zigler et al. [54], and by Tragin et al. [36]; in EBITs by Radtke et al. [55], Utter et al. [56], Neill et al. [6], Pütterich et al. [11], Ralchenko et al. [20], Kramida [23], and Osborne et al. [17]; and in tokamak plasmas by Neu et al. [4], Asmussen et al. [57], and by Pütterich et al. [11,12].

A number of resolved Ge-like tungsten, W^{42+}, lines has been observed in the 1–4 keV X-ray interval. Zigler et al. [54] measured four $3d$–nf, $n = 5, 6$ transitions with unknown uncertainties. These were later remeasured by Tragin et al. [36] with experimental uncertainties of 2–5 mÅ. The transition $|0\rangle$–$|12237\rangle$ is calculated to have a wavelength of 4.020 Å and measured at 4.017(5) Å by Tragin et al. (where it was reported to be blended with a Ga-like tungsten, W^{43+}, line). The calculated wavelength of $|0\rangle$–$|12059\rangle$ is 4.106 Å and the measured 4.104(2) Å by Tragin et al. The $|0\rangle$–$|10381\rangle$ transition is predicted at 4.506 Å and measured at 4.507(5) Å by Tragin et al. (with a blend from a Zn-like W^{42+} line). The $|0\rangle$–$|10262\rangle$ transition, calculated at 4.610 Å, was measured at 4.620(2) Å by Tragin et al.

An observed line at 5.83(1) Å by Pütterich et al. at the ASDEX Upgrade tokamak [12] is likely a combination of the ground-state transitions from $|5897\rangle$, $|5907\rangle$, and $|5911\rangle$. These are probably the lines resolved by Neill/Kramida [6,23], who measured three lines at 5.8489(10) Å, 5.8398(6) Å, and 5.8326(9) Å. Due to level mixing, only the designation for the line from $|5907\rangle$ agrees with the present calculations. The corresponding calculated wavelengths are 5.8387 Å, 5.8315 Å, and 5.8297 Å. A second line measured from ASDEX Upgrade plasmas by Neu et al. [4] was determined to have a wavelength of 7.34(2) Å. This line is assigned to the $|0\rangle$–$|5424\rangle$ transition and its calculated value is 7.36 Å.

Kramida observed a transition at 6.0451(11) Å in spectra acquired at the Livermore SuperEBIT [23]. This line is here identified (differently from Kramida's analysis) as the $|0\rangle$–$|5727\rangle$ transition at 6.0381 Å. The $|5727\rangle$ level is only 34.5% pure.

Osborne et al. observed a large number of spectral lines from N-shell tungsten ions at the Livermore EBIT-I machine [17]. Of the non-identified lines, X2 and X3 followed the intensity trends of Ge-like tungsten, W^{42+}, based on detailed charge-balance modeling. The current calculations present two candidates for the X2 line at 6.000 Å (there is also a Ga-like tungsten, W^{43+}, candidate, see below): The ground-state transition from $|5761\rangle$ at 5.988 Å and the $|0\rangle$–$|5743\rangle$ and $|0\rangle$–$|5749\rangle$ and $|2\rangle$–$|6093\rangle$ transitions that produce an emissivity-weighted wavelength at 6.013 Å.

Other experimental efforts on the Ge-like tungsten ion, W XLIII, spectrum have focused on EUV measurements of transitions among the lowest N-shell levels. Asmussen et al. [57] and Pütterich et al. [11,12] have studied the tungsten emission from ASDEX Upgrade plasmas. Utter et al. [56], Pütterich et al. [11], and Ralchenko et al. [20] have studied EUV tungsten spectra at the Livermore EBIT-II, the Berlin EBIT, and the NIST EBIT, respectively. The most high-precision measurement of the $|0\rangle$–$|8\rangle$ transition is by Utter et al. with a wavelength of 47.191(7) Å. The calculated wavelength is 47.008 Å. The predicted wavelength for $|0\rangle$–$|6\rangle$ is 61.178 Å and the highest-precision measurement is again by

Utter et al. with 61.304(8) Å. They also observed two lines at 70.435(9) Å and 83.289(7) Å, which they assigned $|6\rangle$–$|26\rangle$ and $|2\rangle$–$|7\rangle$, respectively. The present calculations suggest assigning the first of these to $|2\rangle$–$|10\rangle$ instead and thus produce the wavelengths 70.502 Å and 83.418 Å. Kramida and Shirai find both of the line identifications in Ref. [56] questionable [22].

Transitions among the first four levels in Ge-like tungsten, W^{42+}, have been observed by Asmussen et al. [57] and Pütterich et al. [11,12] at ASDEX Upgrade, and by Ralchenko et al. [20] at the NIST EBIT. The $|0\rangle$–$|1\rangle$ M1 transition is calculated to be at 135.62 Å and observed in high resolution at 135.45(4) Å by Ralchenko et al. The neighboring E2 transition $|0\rangle$–$|2\rangle$ is calculated to be at 129.41 Å and measured at 129.45(5) Å by Pütterich et al. and at 129.41(4) Å by Ralchenko et al. Next to these two forbidden lines are two E1 transitions, $|1\rangle$–$|3\rangle$ and $|2\rangle$–$|3\rangle$, with calculated wavelengths of 129.19 Å and 135.38 Å, respectively, that have been measured at 129.12(5) Å and 134.75(5) Å by Pütterich et al. and at 128.95(4) Å and 134.95(6) Å by Ralchenko et al. All lines by Pütterich et al. are reported to have blends. This system of four close lines has been discussed by Ralchenko et al. and may be of interest for density diagnostics. According to the spectral model, the population of $|2\rangle$ is affected at tokamak plasma densities.

3.2. Ga-like tungsten, W^{43+}

Gallium-like tungsten, W^{43+}, has a $(4s^2 4p_{1/2})_{1/2}$ ground level. A total of 27631 energy levels are calculated of which 126 levels are connected by the 126 transitions more intense than 1% of the $3d_{3/2}$–$4f_{5/2}$ ($|0\rangle$–$|8291\rangle$) line. The energy levels are listed in Table 2, and the radiative transitions are listed in Table 12. Of the tabulated energy levels there are seventeen levels with $3l^{18}4l^3$, five levels with $3l^{18}4l^2 5l$, nine with $3l^{18}4l^2 6l$, eighty-four energy levels with $3l^{17}4l^4$, seven with $3l^{17}4l^3 5l$, and four with $3l^{17}4l^3 6l$ configurations. The spectrum is modeled at $T_{CRM} = 4500$ eV, where the $3d_{3/2}$–$4f_{5/2}$ resonance line at 2140.29 eV emits 3804 γ/ion/s. All the levels above the ionization energy that are listed in Table 12 are affected by autoionization.

The W XLIV spectrum has been observed in numerous plasma experiments: Klapisch et al. [53], Zigler et al. [54], and Tragin et al. [36] observed X-rays from W^{43+} from laser-produced plasmas; Radtke et al. [55], Utter et al. [56], Neill et al. [6], Pütterich et al. [11], Ralchenko et al. [20], Kramida [23], and Osborne et al. [17] studied the Ga-like spectrum in EBIT plasmas; and Neu et al. [4], Asmussen et al. [57], and Pütterich et al. [11,12] measured W^{43+} lines from tokamak plasmas.

Using laser-produced plasmas, Zigler et al. [54] and Tragin et al. [36] measured Ga-like tungsten, W^{43+}, transitions of the type $3d$–nf with $n = 5$ and 6. Such transitions proceed from two close-lying excited levels, $(3d_j nf_{j'})_{1/2,3/2}$, and, since these are not experimentally resolved, the calculated emissivity-weighted wavelengths will be used. $|0\rangle$–$|11806\rangle$, $|11808\rangle$ is calculated at 4.5620 Å and measured at 4.564(2) Å by Tragin et al. This line was also recently identified at 4.5608(6) Å by Kramida [23] in spectra obtained by Clementson et al. at the Livermore SuperEBIT. Tragin et al. measured the $|0\rangle$–$|12028\rangle$, $|12033\rangle$ line, calculated at 4.459 Å, at 4.457(14) Å (blended with a Cu-like tungsten, W^{45+}, line). The calculated wavelength for $|0\rangle$–$|18686\rangle$, $|18687\rangle$ is 4.0489 Å. Tragin et al. measured and Kramida determined this line at 4.047(2) Å and 4.0472(12) Å, respectively. $|0\rangle$–$|18884\rangle$, $|18894\rangle$ have a predicted line wavelength of 3.9661 Å and are observed at 3.964(2) Å and 3.9636(12) Å by Tragin et al. and Kramida, respectively.

Neu et al. [4] measured a line at 7.26(2) Å at the ASDEX Upgrade tokamak. This line, from the $|0\rangle$–$|7803\rangle$, $|7805\rangle$ transitions, is predicted at 7.28 Å. Neu et al. also measured a Ga-like (W^{43+}) E2 line, $|1\rangle$–$|7797\rangle$, at 8.23(2) Å. This line could be potentially blended with other Ga-like tungsten, W^{43+}, transitions. The calculated wavelength is 8.23 Å. Kramida and Shirai [22] have calculated the radiative lifetime of $|7797\rangle$ using the Cowan codes [22]. Their value of approximately 0.14 ns is slightly smaller than the value of 0.21 ns presented here.

Pütterich et al. measured the strong W XLIV line from the $3d_{3/2}$–$4f_{5/2}$ transitions at 5.79(1) Å at the ASDEX Upgrade tokamak [12]. The line components have been resolved by Neill/Kramida [6,23] and found at 5.7961(6) Å for $|8291\rangle$ and 5.7938(5) Å for $|8295\rangle$. The present calculated wavelengths are 5.7929 Å and 5.7924 Å, respectively.

In their analysis of moderate-resolution spectra acquired at the Livermore EBIT-I, Osborne et al. [17], did not identify three of the observed lines (the spectral features in the EBIT spectra can be expected to be similar to tokamak spectra since both originate from low-density sources). The present calculations suggest that two of these lines could be from Ga-like tungsten, W^{43+} (although Osborne et al. point out that the intensities better follow the trend of Ge-like tungsten, W^{42+}, lines). The observed line designated X2 at 6.000 Å in [17] matches a structure at 5.9972 Å in the calculated spectrum consisting of strong ground-level transitions proceeding from $|8111\rangle$, $|8113\rangle$, $|8116\rangle$, and $|8120\rangle$, which all have configurations of the type $3d^5_{5/2}4s_{1/2}4p_{1/2}4p_{3/2}4d_{5/2}$ (and thus transitions to the ground level involve 2-electron–1-photon decays). These levels are all strongly mixed. Pütterich et al. [12] report on a line at 5.98(1) Å observed at the ASDEX Upgrade tokamak, which they assigned to be a blend of $3d$–$4f$ transitions. This identification is also made by Kramida [23], who determined the line to be at 5.9996(11) Å. There are also features in the Ge-like tungsten, W XLIII, spectrum that are possible candidates (see above). Also, line X3, observed by Osborne et al. at 6.277 Å, may be explained by two unresolved Ga-like tungsten, W^{43+}, transitions proceeding from $|8486\rangle$ to $|5\rangle$ and $|6\rangle$ at 6.265 Å.

EUV spectroscopy of transitions among the lowest excited levels in Ga-like tungsten, W^{43+}, has been performed at the ASDEX Upgrade tokamak by Asmussen et al. [57] and Pütterich et al. [11, 12], at the Livermore EBIT-II by Utter et al. [56], the Berlin EBIT by Pütterich et al. [11], and the NIST EBIT by Ralchenko et al. [20]. The $|0\rangle$–$|1\rangle$ transition, measured at 128.24(5) Å by Pütterich et al. [11, 12], and 128.17(4) Å by Ralchenko et al. [20], is predicted from the calculations to be at 128.25 Å. The measurement of Ref. [12] suffered from a line blend. The neighboring M1 $|0\rangle$–$|2\rangle$ transition, calculated at 126.35 Å was measured at 126.39(5) Å by Pütterich et al. [11,12] at ASDEX Upgrade and at 126.29(3) Å by Ralchenko et al. [20]. Asmussen et al. and Pütterich et al. also measured three ground-level transitions from levels $|5\rangle$, $|6\rangle$, and $|7\rangle$. The lines measured by Pütterich et al. are reported to be blended. These have been measured in higher resolution by Utter et al., resulting in wavelengths of 61.334(6) Å, 60.616(7) Å, and 47.903(6) Å, respectively. The calculated wavelengths are 61.296 Å, 60.398 Å, and 47.784 Å.

3.3. Zn-like tungsten, W^{44+}

The ground configuration of forty-four times ionized, zinc-like tungsten, W^{44+}, has a closed $4s$ subshell and hence a $J = 0$ ground state. Out of 20 282 energy levels calculated, seventy-eight are connected by transitions stronger than 1% of the $3d_{3/2}$–$4f_{5/2}$ ($|0\rangle$–$|448\rangle$) line intensity. Of the levels, listed in Table 3, thirteen have a $3l^{18}4l^2$ superconfiguration, forty-eight a $3l^{17}4l^3$, three a $3l^{18}4l5l$, five a $3l^{18}4l6l$, six a $3l^{17}4l^2 5l$, and three a $3l^{17}4l^2 6l$ superconfiguration. All levels above the ionization energy that are listed in Table 3 are affected by autoionization. The spectrum is modeled at $T_{CRM} = 4770$ eV, where the $3d_{3/2}$–$4f_{5/2}$ transition at 2158.98 eV emits 5787 γ/ion/s. Seventy-four radiative transitions are included in Table 13.

The Zn-like tungsten, W XLV, spectrum has been observed in several experiments. Reader and Luther [58], Acquista and Reader [59], Mandelbaum et al. [32], Klapisch et al. [53], Zigler et al. [54], Tragin et al. [36], and Seely et al. [60] observed X-ray and EUV emissions from laser-produced plasmas; Radtke et al. [55], Utter et al. [56], Neill et al. [6], Pütterich et al. [11], Ralchenko et al. [20], Clementson et al. [14], and Osborne et al. [17] studied zinc-like tungsten using EBITs; and Neu et al. [4], Asmussen et al. [57], and Pütterich et al. [11,12] observed Zn-like tungsten, W^{44+}, emission from tokamak plasmas.

Neu et al. [4] first measured the $|0\rangle$–$|87\rangle$ transition at the ASDEX Upgrade tokamak. This line was later remeasured by Clementson et al. at the Livermore SuperEBIT at 7.3433(35) Å [14]. The calculated wavelength is 7.3447 Å. Pütterich et al. [12] measured $|0\rangle$–$|303\rangle$ from ASDEX Upgrade plasmas. This transition, calculated at 5.9534 Å, has also been remeasured at 5.9545(11) Å [14]. Pütterich et al. further measured a line at 5.75(1) Å. This line has been measured by Neill/Kramida [6,23] at 5.7471(4) Å at the Livermore EBIT-II. This is the strongest line in the synthetic spectrum, $3d_{3/2}$–$4f_{5/2}$ ($|0\rangle$–$|448\rangle$), calculated at 5.7427 Å, however Neill/Kramida assigns it to a different transition. The same is true for the line measured by Neill/Kramida at 5.7680(6) Å, which here is associated with the ground-state transition from $|414\rangle$ at 5.7651 Å. In this spectral region there are two additional lines reported; 5.7945(22) Å by Clementson et al. and 5.7538(4) Å by Neill/Kramida. Whereas the latter wavelength does not match any of the calculated transitions, the former agrees reasonably well with $|0\rangle$–$|394\rangle$ at 5.7901 Å. It should be noted that the levels responsible for the transitions in this region are strongly mixed.

High-n transitions in Zn-like tungsten, W XLV, have been measured by Zigler et al. [54] and Tragin et al. [36] in laser-produced plasmas and by Clementson et al. [14] and Osborne et al. [17] at the Livermore EBITs. $|0\rangle$–$|12154\rangle$ is calculated to have a wavelength of 4.5082 Å and measured at 4.507(5) Å by Tragin et al. and 4.5080(16) Å by Clementson et al. (the measurements were affected by a line blend from Ge-like tungsten, W^{42+}). Another blended line is from $|0\rangle$–$|12276\rangle$, calculated at 4.410 Å and measured at 4.411(5) by Tragin et al. The $|0\rangle$–$|15691\rangle$ transition is predicted to have a wavelength of 3.9894 Å and has been measured at 3.9895(6) Å by Clementson et al. The neighboring $|0\rangle$–$|15817\rangle$ has been measured at 3.9097(7) Å by Clementson et al. and is calculated at 3.9099 Å. The ground-state transition from $|13626\rangle$ is calculated to have a wavelength of 3.972 Å and measured by Tragin et al. at 3.973(2) Å.

Several EUV measurements of transitions among the lower $n = 4$ levels of W^{44+} have been performed. Reader and Luther [58] and Acquista and Reader [59] first measured the $|0\rangle$–$|5\rangle$ resonance line from a laser-produced plasma. This line has later been measured by Seely et al. [60], also from a laser-produced plasma, by Asmussen et al. [57] and Pütterichet al. [11,12] at the ASDEX Upgrade tokamak, by Pütterich et al. [11] at the Berlin EBIT, and by Utter et al. [56] at the EBIT-II. The calculated wavelength for this transition is 60.854 Å, which may be compared to the highest-precision measurement of Utter et al. at 60.931(6) Å. Utter et al. further measured two Zn-like tungsten, W XLV, lines at 66.930(7) Å from $|3\rangle$–$|11\rangle$ and 48.617(7) Å from $|2\rangle$–$|9\rangle$, which the calculations predict at 66.834 and 48.585 Å, respectively. Also an M1 line from $|2\rangle$–$|11\rangle$ was observed at 44.530(9) Å; however, based on term analysis, Ralchenko et al. [20] found it more likely that this transition should be at 44.724(4) Å. The calculated wavelength for this forbidden transition is 44.520 Å. The wavelength of the $4s_{1/2}$–$4p_{3/2}$ E1 transition ($|0\rangle$–$|2\rangle$) was first measured by Asmussen et al. at the ASDEX Upgrade tokamak and later, on the same machine, by Pütterich et al. [11,12] at 132.87(5). Pütterich et al. [11] also measured the line at the Berlin EBIT at 132.75(5) Å. Ralchenko et al. [20] arrived at a wavelength of 132.88(3) Å from a measurement at the NIST EBIT. They also measured the neighboring M1 line $|2\rangle$–$|3\rangle$ at 134.80(3) Å. The calculated wavelengths are 132.99 and 133.34 Å, respectively.

3.4. Cu-like tungsten, W^{45+}

Copper-like tungsten, W^{45+}, with a $(3d^{10}4s_{1/2})_{1/2}$ ground level, is the highest N-shell tungsten charge state. Of 3729 calculated energy levels, eighty-three are connected (Table 4) by the eighty-four transitions (Table 14) with intensities greater than 1% of the strongest line, $3d_{3/2}$–$4f_{5/2}$ ($|0\rangle$–$|222\rangle$) at 2169.76 eV with 5242 γ/ion/s at the temperature used in the model, $T_{CRM} = 5325$ eV. There are seven levels having a $3l^{18}4l$ superconfiguration, fifty-seven levels with a $3l^{17}4l^2$, four with a $3l^{18}5l$, four with a $3l^{18}6l$, seven with a $3l^{17}4l5l$, and four levels with a $3l^{17}4l6l$ superconfiguration. Most of the levels above the ionization limit that are listed in Table 14 are affected by autoionization.

X-ray and EUV spectra of Cu-like tungsten, W XLV, have been observed from numerous experiments: Reader and Luther [58, 61], Klapisch et al. [62,53], Mandelbaum et al. [32], Zigler et al. [54], Tragin et al. [36], and Seely et al. [60] measured spectral lines from laser-produced plasmas; Neu et al. [4], Asmussen et al. [57], and Pütterich et al. [11,12] from tokamak plasmas; and Radtke et al. [55], Utter et al. [56], Neill et al. [6], Pütterich et al. [11], Ralchenko et al. [8,20], Clementson et al. [14], Osborne et al. [17], and Kramida [23] from EBIT plasmas.

Mandelbaum et al. [32] measured several $n = 3$–4 transitions in a laser-produced plasma. Some of these transitions have recently also been measured in EBIT experiments at Livermore by Clementson et al. [14] and Osborne et al. [17]. Mandelbaum measured a line at 6.827(3) Å identified as $|0\rangle$–$|31\rangle$. This transition is calculated to have a wavelength of 6.823 Å. However, Clementson et al. interpreted a line measured at 6.8251(38) Å as being comprised of two transitions of different types, $|0\rangle$–$|31\rangle$ and $|2\rangle$–$|111\rangle$. The predicted line position is 6.8201 Å. Mandelbaum et al. further measured a line at 6.884(3) Å assigned to the $|0\rangle$–$|27\rangle$ transition, which the present calculations place at 6.883 Å. This line, found at 6.8892(31) Å in the EBIT measurement, was also interpreted by Clementson et al. to consist of several transitions: $|0\rangle$–$|26\rangle$ and $|0\rangle$–$|27\rangle$ and $|2\rangle$–$|97\rangle$, with a weighted wavelength of 6.8813 Å. The unresolved ground-level transitions from $|15\rangle$ and $|16\rangle$ are predicted to have a wavelength of 7.2603 Å. This line, also observed in low resolution at the ASDEX Upgrade tokamak by Neu et al. [4] and Pütterich et al. [12], was measured at 7.262(3) Å by Mandelbaum et al. and at 7.2616(26) Å by Clementson et al. The transitions to $|0\rangle$ proceeding from $|13\rangle$, $|19\rangle$, $|21\rangle$, $|26\rangle$ are predicted at 7.299 Å, 7.138 Å, 7.133 Å, and 6.897 Å, respectively. Mandelbaum et al. measured them at 7.295(3) Å, 7.137(3) Å, 7.131(3) Å, and 6.896(3) Å. A line at 7.075(3) Å was interpreted by Mandelbaum et al. as consisting of several transitions. In the low-density EBIT measurements, Clementson et al. associated a line at 7.0771(32) Å with the $|0\rangle$–$|24\rangle$ transition at 7.0744 Å.

The Livermore EBIT studies of Clementson et al. [14], Osborne et al. [17], and Neill/Kramida [6,23] also measured the transitions from $|158\rangle$ and $|163\rangle$ proceeding to the ground level, with an average line position the calculations place at 5.9151 Å. This line, also measured by Pütterich et al. [12] at the ASDEX Upgrade tokamak, has a measured wavelength of 5.9187(14) Å [14] and 5.9170(9) Å [6,23]. Neill/Kramida [6,23] resolved the transitions from $|218\rangle$ and $|222\rangle$ to the ground level at 5.7237(4) Å and 5.7188(4) Å, which are predicted at 5.7173 Å and 5.7142 Å by the present calculations. They also measured the $|0\rangle$–$|441\rangle$ transition at 5.2289(11) Å, which the calculations predict at 5.2230 Å and the $|0\rangle$–$|437\rangle$ transition at 5.2379(17) Å, calculated to be at 5.2313 Å.

The unidentified line X1 at 5.369 Å of Osborne et al. [17] at the EBIT-I device followed the intensity trend of Zn- or Cu-like W ions in their charge-balance modeling. A candidate transition for the X1 line from the present calculations is $|1\rangle$–$|454\rangle$ 5.352 Å.

Kramida [23] determined a number of long-wavelength Cu-like tungsten, W XLVI, lines in spectra obtained by Clementson et al. at the Livermore SuperEBIT. These $n = 4$–5, 6 transitions had previously been measured with slightly less precision by Seely et al. [60] from a laser-produced plasma source. The $|0\rangle$–$|1303\rangle$ transition, calculated at 11.656 Å was determined at 11.664(15) Å [60] and 11.675(6) Å [23]. The wavelength for $|1\rangle$–$|1304\rangle$ is calculated to be 11.947 Å and measured by Seely et al. at 11.965(15) Å and determined by Kramida to be at 11.938(6) Å. $|3\rangle$–$|1315\rangle$ and $|4\rangle$–$|1316\rangle$ were measured at 10.024(15) Å and 10.181(15) Å by Seely et al. and determined to be at 10.017(4) Å and 10.181(4) Å by Kramida. The calculated wavelengths are 10.017 Å and 10.178 Å. Kramida also determined the $|2\rangle$–$|7\rangle$ transition to be at 9.193(3) Å, which had been previously measured by Neu et al. at the ASDEX Upgrade tokamak [4] and by Ralchenko et al. at the NIST EBIT [8]. The calculated wavelength is 9.193 Å.

Short-wavelength lines from Cu-like tungsten, W^{45+}, have been studied in laser-produced plasmas by Zigler et al. [54] and Tragin et al. [36] and at the Livermore EBIT facility by Clementson et al. [14] and Osborne et al. [17]. These lines are blends of $3d$–nf transitions with $n = 5$ or 6. The line from $|1448\rangle$ and $|1451\rangle$ is predicted at 4.4562 Å and measured at 4.4551(13) Å [14] (with a possible Ga-like tungsten, W XLIV, blend). The line from $|1542\rangle$ and $|1543\rangle$ was measured at 4.3578(6) Å by Clementson et al.; it was calculated to be at 4.3591 Å. 3.9341 Å is the predicted wavelength of the ground-level transitions from $|2460\rangle$ and $|2461\rangle$. This feature has been measured at 3.9329(6) Å [14]. The $|0\rangle$–$|2582\rangle$, $|2583\rangle$ transitions have been measured at 3.8555(6) Å [14]. The average position of these transitions is calculated to be at 3.8566 Å.

N-shell $n = 4$–4 transitions have been studied in several laser-produced, tokamak, and EBIT plasma experiments. Reader and Luther [58,61] measured several lines between the lowest levels in Cu-like tungsten, W^{45+}, from a laser-produced plasma. The same lines have later been measured by Seely et al. [60], also from a laser-produced plasma source, and Utter et al. [56] at the Livermore EBIT-II. The $|0\rangle$–$|2\rangle$ transition has a calculated wavelength of 62.332 Å and a measured wavelength of 62.336(6) Å [56]. $|1\rangle$–$|3\rangle$ is predicted at 49.216 Å and measured at 49.208(9) Å [56]. Calculated at 72.025 Å, the $|2\rangle$–$|4\rangle$ transition is measured at 72.053(15) Å [61], 71.977(15) Å [60], and 71.94(5) Å [56]. The $|3\rangle$–$|5\rangle$ transition is predicted to be at 67.855 Å and measured at 68.157(7) Å [56]. The wavelength for $|4\rangle$–$|6\rangle$ is calculated to be 74.416 Å and measured at 74.515(15) Å [61] and 74.434(15) Å [60]. Seely et al. measured the $|0\rangle$–$|1\rangle$ transition, which later has been measured with higher precision at 127.12(3) Å by Ralchenko et al. at the NIST EBIT [20]. The calculated wavelength is 127.04 Å.

3.5. Ni-like tungsten, W^{46+}

Nickel-like tungsten, W^{46+}, has a closed M-shell ground configuration and a $(3s^2 3p^6 3d^{10})_0$ ground state. The X-ray spectrum from low-density plasma sources is, therefore, relatively simple. The atomic structure calculations produced 427 energy levels, of which twenty-one are listed in Table 5. Of these, there are fourteen levels with a $3l^{17}4l$ superconfiguration, four levels with a $3l^{17}5l$ superconfiguration, and two levels with a $3l^{17}6l$ superconfiguration. These levels are connected by the twenty transitions, listed in Table 15, that are stronger than 1% of the $3d_{3/2}$–$4f_{5/2}$ transition, $|0\rangle$–$|58\rangle$, at 2181.36 eV with 13257 γ/ion/s. The spectrum has been modeled for an electron temperature of $T_{CRM} = 6375$ eV. All calculated energy levels with a $3l^{17}4l$ superconfiguration are listed in Table B in the Calculations section, where they are compared to theoretical and experimental energy levels.

The W XLVII spectrum has been observed from exploded-wire plasmas by Burkhalter et al. [34]; in laser-produced plasma experiments by Zigler et al. [33,54], Klapisch et al. [62], Mandelbaum et al. [32], Wyart et al. [37], Tragin et al. [36], MacGowan et al. [63], and Butzbach et al. [35]; in tokamak plasmas by Neu et al. [4] and Pütterich et al. [12]; and in EBIT measurements by Beiersdorfer et al. and Elliott et al. [30,31], Neill et al. [6], Ralchenko et al. [8, 20], Clementson et al. [14,15], and Osborne et al. [17].

The observed $n = 3$–4 ground-state transitions are listed in Table B, where reported wavelengths have been converted to corresponding energy levels. High-n transitions have been measured from plasmas following laser irradiation by Zigler et al. [33,54] and Tragin et al. [36] and from EBIT plasmas by Ralchenko et al. [8], Clementson et al. [14], and Osborne et al. [17]. The $3d_{5/2}$–$5f_{7/2}$ transition ($|0\rangle$–$|152\rangle$) is calculated to have a wavelength of 4.4046 Å. The spectral line has been measured at 4.4027(5) Å [14]. The similar $3d_{3/2}$–$5f_{5/2}$ transition ($|0\rangle$–$|172\rangle$) has a wavelength predicted at 4.3091 Å and has been observed at 4.3077(4) Å [14]. The analogue transitions from $n = 6$, $|0\rangle$–$|286\rangle$ and $|0\rangle$–$|326\rangle$, have calculated wavelengths of 3.8800 Å and 3.8044 Å. The measured wavelengths for these transitions are 3.8784(4) Å and 3.8033(4) Å, respectively [14].

EUV transitions among $3l^{-1}4l$ excited levels have been studied at the Livermore Nova laser by MacGowan et al. [63] and at the NIST EBIT by Ralchenko et al. [20]. The $|8\rangle$–$|36\rangle$ transition is predicted at 42.12 Å and measured at 43.19(1) Å [63]. The other two Nova-measured transitions, $|11\rangle$–$|21\rangle$ and $|24\rangle$ were found to have wavelengths of 75.35(2) Å and 72.40(2) Å, respectively. The present calculations place these at 75.56 Å and 72.55 Å. The measurements of Ralchenko et al. found the transitions decaying to $|2\rangle$ from $|3\rangle$, $|5\rangle$, and $|6\rangle$ at 191.49(2) Å, 131.13(3) Å, and 129.58(4) Å. The corresponding calculated wavelengths are 191.71 Å, 131.17 Å, and 129.55 Å. Ralchenko et al. also measured the two transitions from $|7\rangle$ down to $|3\rangle$ and $|4\rangle$ at 128.60(3) Å and 130.19(6) Å, respectively. These are predicted at 128.54 Å and 130.21 Å.

3.6. Co-like tungsten, W^{47+}

Cobalt-like tungsten, W^{47+}, has a ground level where the twenty-seven electrons are one $3d_{5/2}$ spin–orbital short from being arranged in a filled M-shell structure, $(3s^2 3p^6 3d^4_{3/2} 3d^5_{5/2})_{5/2}$. The spectrum has been calculated for $T_{CRM} = 7770$ eV and includes ninety-eight strong transitions (based on the "stronger than 1% of the most intense line" criterion) that are listed in Table 16. The corresponding energy levels are found in Table 6, where ninety-five of the total 3245 calculated levels are tabulated. Of these, three have a $3l^{17}$ superconfiguration, seventy-eight a $3l^{16}4l$, ten a $3l^{16}5l$, and four a $3l^{16}6l$ superconfiguration. The strong $3d_{3/2}$–$4f_{5/2}$ line, $|0\rangle$–$|228\rangle$, falls at 2227.47 eV and has a line emissivity of 6121 γ/ion/s. Many lines are split into several fine-structure components due to the couplings of the M-shell electrons' angular momenta. This increases the difficulty of comparing the calculated transitions to measured line positions.

The Co-like tungsten, W XLVIII, spectrum has been investigated in several experiments: Klapisch et al. [62,53], Mandelbaum et al. [32], Tragin et al. [36], and Seely et al. [60] have observed X-ray and EUV line emission from laser-produced plasma sources; Pütterich et al. [12] have observed the spectrum at the ASDEX Upgrade tokamak; and Neill et al. [6], Ralchenko et al. and Reader et al. [20,21,64], Clementson et al. [14], Osborne et al. [17], and Lennartsson et al. [18] have measured Co-like tungsten, W XLVIII, at EBIT facilities.

The $|0\rangle$–$|36\rangle$, $|37\rangle$ ($3d_{5/2}$–$4p_{3/2}$) and $|0\rangle$–$|32\rangle$, $|33\rangle$ ($3d_{3/2}$–$4p_{1/2}$) transitions were first measured with unknown uncertainty by Klapisch et al. [62] on a laser-produced plasma source. Mandelbaum et al. [32] measured the transitions at the same wavelengths with 3 mÅ uncertainties, 6.844(3) Å and 6.949(3) Å, respectively. Clementson et al. later re-measured the lines at the Livermore SuperEBIT [14] and arrived at 6.8409(30) Å and 6.9506(31) Å. The present calculations place the emissivity-weighted average wavelengths at 6.8489 Å and 6.9536 Å. Mandelbaum et al.

and Clementson et al. also measured a line at 6.806(3) Å and 6.8101(30) Å, respectively. Differently from the Mandelbaum analysis, this line is here interpreted as a blend of $|0\rangle$–$|41\rangle$ and $|1\rangle$–$|55\rangle$ with a wavelength of 6.8111 Å.

The emission from the $3d_{3/2}$–$4f_{5/2}$ transitions has been observed at ASDEX Upgrade by Pütterich et al. [12] and at SuperEBIT by Clementson et al. [14]. The two strong components have been resolved in EBIT-II measurements by Neill/Kramida [6, 23] arriving at 5.5669(5) Å for $|0\rangle$–$|228\rangle$, which is calculated to be at 5.5662 Å, and at 5.5696(5) Å for $|0\rangle$–$|229\rangle$, which is calculated to be at 5.5637 Å. The upper levels for these, the strongest lines in the calculated spectrum, are strongly influenced by configuration interaction.

Additional lines measured at SuperEBIT [14] include the $|0\rangle$–$|128\rangle$ transition at 5.9812(29) Å, which is predicted at 5.9818 Å; the $|0\rangle$–$|124\rangle$, $|125\rangle$ transitions at 6.0116(29) Å, predicted at 6.0097 Å; and $|0\rangle$–$|14\rangle$, $|15\rangle$ at 7.3503(22) Å, which the calculations place at 7.3545 Å.

The work of Neill/Kramida [6,23] produced several high-precision wavelengths of W XLVIII. These include the ground-level transitions from $|170\rangle$ and $|172\rangle$ at 5.7534(4) Å and 5.7753(5) Å, which have the calculated wavelengths 5.7842 Å and 5.7798 Å; $|179\rangle$ at 5.7239(5) Å, with calculated wavelength of 5.7286 Å; and $|222\rangle$ and $|227\rangle$ at 5.5795(5) Å and 5.5624(5), which are calculated to be at 5.5830 Å and 5.5724 Å.

High-n spectral lines have been measured by Tragin et al. [36] and Clementson et al. [14]. These ground-level transitions all consist of two or more fine-structure components, and the weighted averaged wavelengths are therefore used. For $n = 5$, the line resulting from $|919\rangle$ and $|920\rangle$ is measured at 4.2897(7) Å [14]. The line is predicted at 4.2931 Å. The $n = 6$ analogue transitions from $|2095\rangle$ and $|2096\rangle$ produce a line at 3.691(2) Å [36], which the present calculations predict at 3.6961 Å.

Intrashell transitions have been studied in the EUV by Seely et al. on a laser-produced plasma [60], by Ralchenko et al. and Reader et al. at the NIST EBIT [20,21,64], and by Lennartsson et al. at the Livermore EBIT-I machine [18]. The line from the $|0\rangle$–$|1\rangle$ transition ($3d_{5/2} \rightarrow 3d_{3/2}$) is predicted at 185.69 Å and measured at 185.67(3) Å [21,64]. The line due to $|0\rangle$–$|2\rangle$ transition ($3d_{5/2} \rightarrow 3p_{3/2}$) was first measured by Seely et al. but has recently been re-measured with higher precision at 27.6821(7) Å [18]. The calculated wavelength is 27.5743 Å. For $|1\rangle$–$|2\rangle$, the calculations produce a wavelength of 32.383 Å and the measurement by Lennartsson et al. finds it at 32.532(3) Å [18].

3.7. Fe-like tungsten, W^{48+}

Forty-eight times ionized, iron-like tungsten, W^{48+}, has a $3d^4_{3/2}3d^4_{5/2}$ ground configuration with a $J = 4$ ground level. Of the 9265 levels calculated, 165 are connected by the transitions listed in Table 17. These energy levels are listed in Table 7. Ten of them have a $3l^{16}$ superconfiguration, 136 a $3l^{15}4l$ superconfiguration, fourteen a $3l^{15}5l$, and five a $3l^{15}6l$ superconfiguration. At an electron temperature $T_{CRM} = 8745$ eV, 178 transitions are predicted to have intensities greater than 1% of the strong $3d_{3/2}$–$4f_{5/2}$ line ($|0\rangle$–$|562\rangle$), which radiates 3503 γ/ion/s at 2274.11 eV.

Few measurements exist of the Fe-like tungsten, W XLIX, spectrum. The strong X-ray line from the $3d_{3/2}$–$4f_{5/2}$ emission was observed in low resolution by Pütterich et al. [12] at the ASDEX Upgrade tokamak. This line together with several other nearby transitions has been measured by Neill et al. at the Livermore EBIT-II [6]; however, due to the complex atomic structure several lines are not associated with specific transitions [23]. Seely et al. measured one intrashell EUV transition from a laser-produced plasma [60] and Ralchenko et al. [21] and Lennartsson et al. [18] have recently measured a few EUV lines at the NIST and Livermore EBIT facilities, respectively.

The work of Neill/Kramida [6,23] has produced several high-precision wavelengths in the 5–6 Å interval from W XLIX transitions. The $|0\rangle$–$|562\rangle$ transition, calculated at 5.4520 Å was measured at 5.4510(5) Å and the neighboring $|0\rangle$–$|553\rangle$ transition measured at 5.4554(7) Å. The latter transition has a calculated wavelength of 5.4597 Å but a different upper-level assignment than by Neill/Kramida. The upper levels for the strong transitions in this spectral region are all strongly mixed. Other $3d$–$4f$ transitions measured by Neill/Kramida are the ground-level transitions from $|552\rangle$, $|541\rangle$, and $|422\rangle$ with wavelengths of 5.4576(10) Å, 5.4696(9) Å, and 5.6371(6) Å, respectively. The calculated wavelengths for these transitions are 5.4641 Å, 5.4721 Å, and 5.6377 Å. Neill/Kramida also measured a $4d_{5/2} \rightarrow 3p_{3/2}$ line at 5.0948(15) Å from $|795\rangle$, which the calculations predict to be at 5.0842 Å.

The $|0\rangle$–$|11\rangle$ transition was first measured by Seely et al. [60] and later re-measured by Lennartsson et al. [18] at 27.5055(9) Å. The present calculations assign this transition a wavelength of 27.362 Å. Ralchenko et al. [21] measured four magnetic-dipole transitions at the NIST EBIT. The ground-level transitions from $|3\rangle$ and $|6\rangle$ are measured at 189.88(3) Å, calculated to be at 190.05 Å, and at 155.11(3) Å, calculated to be at 154.56 Å. Transitions proceeding to $|1\rangle$ from $|4\rangle$ and $|5\rangle$ are measured at 188.78(3) Å and 175.02(3) Å. These transitions are calculated to have wavelengths of 188.65 Å and 174.58 Å. The density sensitivity of these M1 lines have been discussed by Ralchenko et al. [21].

3.8. Mn-like tungsten, W^{49+}

Manganese-like tungsten, W^{49+}, has a half-filled $3d_{5/2}$ subshell in its ground configuration with a $J = 9/2$ ground level. The spectrum is calculated for $T_{CRM} = 9600$ eV. Including the $3d_{3/2}$–$4f_{5/2}$ ($|0\rangle$–$|958\rangle$) line at 2318.75 eV, with an emissivity of 2279 γ/ion/s, there are 256 transitions listed in Table 18 (based on the "stronger than 1% of the most intense line" criterion). The 229 levels, out of the 21 254 energy levels calculated, connected by these transitions are listed in Table 8. Of these, there are twenty-one with a $3l^{15}$ superconfiguration, 179 with a $3l^{14}4l$, twenty-two with a $3l^{14}5l$, and seven with a $3l^{14}6l$ superconfiguration.

The only X-ray observation reported of Mn-like tungsten, W L, is from the Livermore EBIT-II measurement of Neill et al. [6]. However, in the analysis of these data by Kramida and Shirai [22] and Kramida [23], no detailed line assignments are provided for the observed features. Still, from the measured Neill/Kramida wavelengths, one can associate the strongest line at 5.3444(6) Å to mainly be from the $|0\rangle$–$|958\rangle$ transition at 5.3470 Å and the second strongest X-ray line at 5.5098(6) Å to arise from the decay of $|728\rangle$ to the ground level at 5.5137 Å. Both of these upper levels are strongly affected by level mixing.

Ralchenko et al. [21] have measured several density-sensitive magnetic-dipole EUV lines at the NIST EBIT from transitions among low-lying energy levels. The ground-level transitions from $|3\rangle$, $|4\rangle$, $|8\rangle$, and $|9\rangle$ were found at 188.80(3) Å, 171.06(3) Å, 153.68(3) Å, and 141.66(3) Å, respectively. The corresponding calculated wavelengths are 188.99 Å, 170.79 Å, 152.97 Å, and 141.23 Å. However, the intermediate angular momenta of the $3d_{5/2}$ subshell are different for levels $|3\rangle$ and $|4\rangle$ than in [21]. In a recent measurement of $|0\rangle$–$|25\rangle$ by Lennartsson et al. at the Livermore EBIT-I [18] the line was observed at 27.5702(7) Å. The calculated wavelength is 27.4283 Å.

3.9. Cr-like tungsten, W^{50+}

The ground level of chromium-like tungsten, W^{50+}, is $(3d^4_{3/2}\,3d^2_{5/2})_4$. The atomic structure calculation yields 19 632 energy levels, of which 334 are connected by transitions stronger than 1% of the brightest line. These are listed in Table 9. The line emission has been modeled for a tokamak plasma with temperature T_{CRM} = 10500 eV and resulted in 387 transitions, presented in Table 19. Of the listed transitions, 264 proceed from $3l^{13}4l$ levels and thirty from levels with a $3l^{13}5l$ superconfiguration. The remaining forty levels have configurations where all electrons are arranged in the M shell. Similar to the other ions considered in this work, the strongest line in the modeled Cr-like tungsten, W LI, spectrum is due to a $3d_{3/2}$–$4f_{5/2}$ transition, $|0\rangle$–$|1488\rangle$. This line falls at 2369.43 eV and has an emissivity of 1093 γ/ion/s.

Neill et al. [6] measured three lines at the Livermore EBIT-II that they associated with W LI. No detailed identifications have been assigned to these lines [6,22,23], although based on the wavelengths listed in [23], one can compare them with the calculated spectrum. There are several energetically close-lying transitions and so any observed line will likely be made up of several components. As an example, the strongest line reported in Ref. [23] has a wavelength of 5.2393(11) Å. The $|0\rangle$–$|1488\rangle$ transition at 5.2327 Å comes close, but also taking into account the transitions at slightly lower energy an unresolved peak would get shifted toward longer wavelengths. For instance, the emissivity-weighted wavelength for the transitions between 5.2327 Å and 5.2508 Å is 5.2403 Å. The same is probably true also for the other two wavelengths listed in [23] (at 5.3796(10) Å and 5.3988(10) Å), however, the intensities assigned to these lines do not agree with the modeled spectrum.

Because the fine-structure levels of the $3d^4_{3/2}3d^2_{5/2}$ and $3d^3_{3/2}3d^3_{5/2}$ configurations have the same parity, W^{50+} ions excited to these levels may only decay by means of high-order multipole transitions. This results in the levels being very sensitive to the electron density, something that Ralchenko et al. [21] and Reader et al. [64] have studied by comparing line ratios for several transitions in the EUV wavelength range. Ralchenko et al. measured nine transitions between the two configurations at the NIST EBIT [21]. The ground-level transitions from $|3\rangle$, $|4\rangle$, $|6\rangle$, and $|9\rangle$ were measured at 196.84(3) Å, 192.39(3) Å, 171.33(3) Å, and 153.63(3) Å. The corresponding wavelengths from the calculated energy levels are 196.72 Å, 191.99 Å, 170.51 Å, and 153.28 Å. The ground-level transitions from $|11\rangle$ and $|14\rangle$ have wavelengths of 131.37(3) Å and 127.79(3) Å, respectively. These transitions are predicted to have wavelengths of 130.97 Å and 127.30 Å. Recently, the $|0\rangle$–$|42\rangle$ transition was measured by Lennartsson et al. at the Livermore EBIT-I [18]. The wavelength, which the calculations predict to be at 28.796 Å, was found at 28.894(2) Å.

3.10. V-like tungsten, W^{51+}

Fifty-one times ionized, vanadium-like, tungsten, W^{51+}, is the last ion with a $3d_{5/2}$ electron in the ground configuration. The spectrum has been calculated for T_{CRM} = 11040 eV. At this temperature there are 263 transitions that are stronger than 1% of the $3d_{3/2}$–$4f_{5/2}$ ($|0\rangle$–$|2075\rangle$) line intensity, which at 2414.74 eV emits 1363 γ/ion/s. These transitions, listed in Table 20, are connecting 220 of the total 22 881 energy levels calculated. The levels involved in the transitions are listed in Table 10. Of these, there are thirty-six levels with a $3l^{13}$ superconfiguration, 158 with a $3l^{12}4l$, and twenty-six with a $3l^{12}5l$ superconfiguration.

No X-ray transitions are reported from the V-like tungsten, W LII, spectrum. The recent measurements of Ralchenko et al. from the NIST EBIT facility [21] and Lennartsson et al. at the Livermore EBIT facility [18] have produced high-precision EUV wavelengths for transitions among the $3d^{13}$ levels. The ground-level transitions from $|1\rangle$ and $|2\rangle$, measured be Ralchenko et al. at 212.03(3) Å and 176.60(3) Å, are calculated at 211.75 Å and 175.91 Å, respectively. From levels $|4\rangle$ and $|8\rangle$, the ground level is reached by 172.15(3) Å and 145.31(3) Å, as determined by Ralchenko et al. These wavelengths are calculated at 171.88 Å and 144.49 Å. The ground-level transitions proceeding from levels $|40\rangle$, $|42\rangle$, and $|44\rangle$ have wavelengths at 31.997(1) Å, 30.285(2) Å, and 29.124(1) Å according to Lennartsson et al. These transitions are predicted to have wavelengths of 32.053 Å, 30.260 Å, and 29.018 Å, respectively. As discussed by Ralchenko et al., several of the $3d^3_{3/2}3d^2_{5/2}$ energy levels are density sensitive.

4. Summary

The atomic structure and X-ray spectra of the ten tungsten ions isoelectronic to germanium, W^{42+}, through vanadium, W^{51+}, have been calculated and modeled under tokamak plasma conditions, extending the database on highly charged tungsten ions relevant to moderate-temperature tokamak plasmas from the calculations by Fournier [13]. M-shell X-ray lines with $\Delta n = 1$, 2, and 3 are presented together with some weaker N-shell transitions in the 1–4 keV X-ray range. A total of 1473 energy levels (Tables 1–10) and 1609 radiative transitions (Tables 11–20) are presented. Data for each energy level include basis-function purity, electron configuration, total angular momentum, parity, energy, radiative lifetime, and level lifetime for the plasma conditions of the collisional–radiative model. The data for the each radiative transition include transition energy, wavelength, oscillator strength, radiative transition probability rate, and emissivity for the plasma conditions of the collisional–radiative model. Although not of spectroscopic accuracy, most of the calculated transitions compare well with measured line positions. Together with the modeled line intensities, the theoretical wavelengths should allow for identification of observed X-ray features from tungsten-seeded fusion plasmas.

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Explanation of Tables

Tables 1–10	**Energy levels**	
	Energy levels to which the transitions in Tables 11–20 connect.	
	Index	energy-level number
	Purity	level percentage (%) of basis function
	Configuration	electron configuration in *jj* coupling
	J^{π}	total angular momentum and parity
	E	level energy in electronvolt (eV)
	τ_{rad}	radiative lifetime in second (s)
	τ_{level}	level lifetime (where different from τ_{rad}) in second (s) (at $N_e = 1 \times 10^{14}$ cm^{-3}, T_{CRM} according to Table E)
Tables 11–20	**Radiative transitions**	
	Radiative transitions in the 1–4 keV X-ray interval with intensities greater than 1% of the strongest line in each charge state.	
	i, k	lower and upper energy-level index, respectively, as defined in Tables 1–10
	ΔE	transition energy in electronvolt (eV)
	λ	wavelength in ångström (Å)
	gf	weighted absorption oscillator strength; statistical weight $g = 2J + 1$
	A	radiative transition probability rate in per second (s^{-1})
	ϵ	line emissivity in photon per ion per second (γ/ion/s) (at $N_e = 1 \times 10^{14}$ cm^{-3}, T_{CRM} according to Table E)

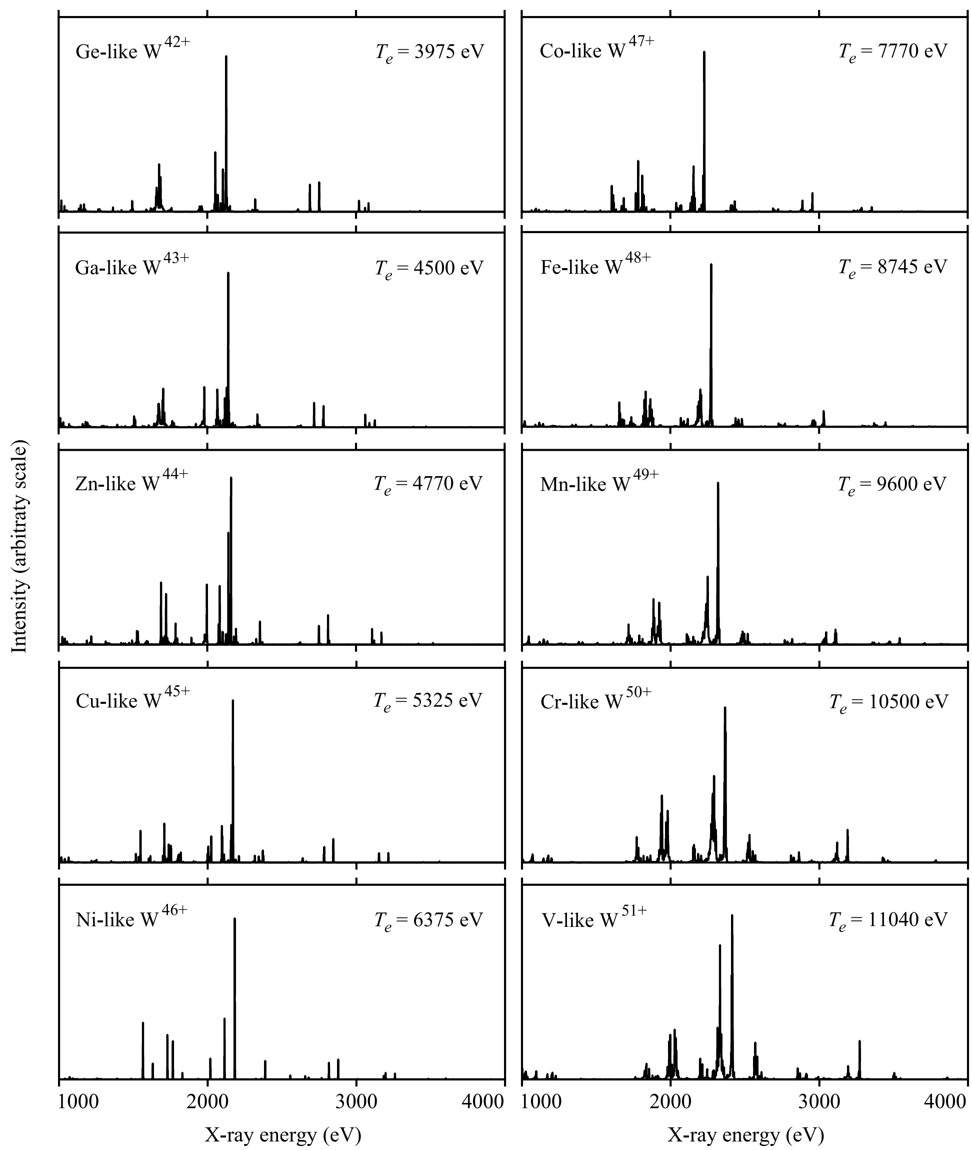

Fig. 1. Theoretical spectra of Ge-like tungsten, W^{42+} through V-like tungsten, W^{51+}. Each spectrum is calculated for the labeled electron temperature at $N_e = 1 \times 10^{14}$ cm^{-3} and modeled with a resolution of 2 eV.

Table 1
Energy levels in Ge-like tungsten, W^{42+}.

Index	Purity (%)	Configuration	J^{π}	E (eV)	τ_{rad} (s)	τ_{level} (s)
0	99.2	$3s^2 3p^6 3d^{10} 4s^2 4p^2_{1/2}$	0^+	0.00		
1	99.2	$3s^2 3p^6 3d^{10} 4s^2 4p_{1/2} 4p_{3/2}$	1^+	91.42	2.02×10^{-7}	1.90×10^{-7}
2	99.0	$3s^2 3p^6 3d^{10} 4s^2 4p_{1/2} 4p_{3/2}$	2^+	95.81	6.61×10^{-6}	2.07×10^{-6}
3	96.2	$3s^2 3p^6 3d^{10} 4s_{1/2} 4p^2_{1/2} 4p_{3/2}$	2^-	187.39	4.42×10^{-11}	
6	92.5	$3s^2 3p^6 3d^{10} 4s_{1/2} 4p^2_{1/2} 4p_{3/2}$	1^-	202.66	2.70×10^{-12}	
7	97.5	$3s^2 3p^6 3d^{10} 4s^2 4p_{1/2} 4d_{3/2}$	2^-	244.44	9.35×10^{-11}	
8	91.0	$3s^2 3p^6 3d^{10} 4s^2 4p_{1/2} 4d_{3/2}$	1^-	263.75	5.68×10^{-13}	
9	46.9	$3s^2 3p^6 3d^{10} 4s^2 4p_{1/2} 4d_{5/2}$	2^-	267.01	2.64×10^{-11}	
10	73.1	$3s^2 3p^6 3d^{10} 4s^2 4p_{1/2} 4d_{5/2}$	3^-	271.67	1.14×10^{-11}	
14	64.2	$3s^2 3p^6 3d^{10} (4s_{1/2} 4p_{1/2})_1 (4p^2_{3/2})_0$	1^-	298.25	2.23×10^{-12}	
16	64.4	$3s^2 3p^6 3d^{10} (4s_{1/2} 4p_{1/2})_1 (4p^2_{3/2})_2$	1^-	303.02	9.99×10^{-13}	
17	96.5	$3s^2 3p^6 3d^{10} 4s_{1/2} 4p^2_{1/2} 4d_{3/2}$	1^+	341.73	1.83×10^{-11}	
18	92.0	$3s^2 3p^6 3d^{10} 4s_{1/2} 4p^2_{1/2} 4d_{3/2}$	2^+	345.04	1.97×10^{-11}	
25	93.7	$3s^2 3p^6 3d^{10} 4s_{1/2} 4p^2_{1/2} 4d_{5/2}$	3^+	368.48	4.02×10^{-12}	
26	80.0	$3s^2 3p^6 3d^{10} 4s_{1/2} 4p^2_{1/2} 4d_{5/2}$	2^+	374.84	4.56×10^{-12}	
30	72.6	$3s^2 3p^6 3d^{10} 4p^2_{1/2} 4p^2_{3/2}$	2^+	399.25	1.50×10^{-12}	
38	56.6	$3s^2 3p^6 3d^{10} 4s^2 4p_{1/2} 4f_{5/2}$	3^+	435.83	5.60×10^{-11}	
39	36.7	$3s^2 3p^6 3d^{10} [(4s_{1/2} 4p_{1/2})_1 4p_{3/2}]_{1/2} 4d_{3/2}$	2^+	440.76	5.37×10^{-12}	
45	53.8	$3s^2 3p^6 3d^{10} 4s^2 4p_{1/2} 4f_{7/2}$	3^+	450.05	2.50×10^{-12}	
47	76.2	$3s^2 3p^6 3d^{10} 4s^2 4p_{1/2} 4f_{7/2}$	4^+	451.13	7.86×10^{-12}	
50	24.7	$3s^2 3p^6 3d^{10} [(4s_{1/2} 4p_{1/2})_1 4p_{3/2}]_{5/2} 4d_{5/2}$	1^+	458.45	1.43×10^{-12}	
98	35.9	$3s^2 3p^6 3d^{10} 4p^2_{1/2} 4p_{3/2} 4d_{3/2}$	3^-	556.93	1.83×10^{-12}	
4453	96.6	$3s^2 3p^6 3d^{10} 4s_{1/2} 4p^2_{1/2} 5p_{3/2}$	1^-	1018.01	1.95×10^{-13}	
4485	96.2	$3s^2 3p^6 3d^{10} 4s_{1/2} 4p^2_{1/2} 5d_{5/2}$	2^+	1100.64	1.83×10^{-13}	
4530	95.3	$3s^2 3p^6 3d^{10} 4s_{1/2} 4p^2_{1/2} 5f_{7/2}$	3^-	1178.79	1.10×10^{-13}	
4871	99.6	$3s^2 3p^6 3d^{10} 4s^2 4p_{1/2} 6s_{1/2}$	1^-	1274.02	1.48×10^{-13}	
4873	99.5	$3s^2 3p^6 3d^{10} 4s^2 4p_{1/2} 6p_{1/2}$	0^+	1302.44	2.58×10^{-13}	
4875	99.5	$3s^2 3p^6 3d^{10} 4s^2 4p_{1/2} 6p_{3/2}$	2^+	1325.14	3.59×10^{-13}	
4876	93.3	$3s^2 3p^6 3d^{10} 4s^2 4p_{1/2} 6d_{3/2}$	1^-	1365.13	1.77×10^{-13}	
4880	99.6	$3s^2 3p^6 3d^{10} 4s^2 4p_{1/2} 6d_{5/2}$	3^-	1371.07	1.85×10^{-13}	
4883	97.5	$3s^2 3p^6 3d^{10} 4s_{1/2} 4p^2_{1/2} 6s_{1/2}$	0^+	1372.86	1.62×10^{-13}	
4889	97.7	$3s^2 3p^6 3d^{10} 4s^2 4p_{1/2} 6f_{5/2}$	2^+	1411.95	1.29×10^{-13}	
4891	99.6	$3s^2 3p^6 3d^{10} 4s^2 4p_{1/2} 6f_{7/2}$	4^+	1413.66	1.25×10^{-13}	
4895	97.4	$3s^2 3p^6 3d^{10} 4s_{1/2} 4p^2_{1/2} 6p_{3/2}$	1^-	1422.35	2.19×10^{-13}	
4917	87.6	$3s^2 3p^6 3d^{10} 4s_{1/2} 4p^2_{1/2} 6d_{5/2}$	2^+	1468.05	1.79×10^{-13}	
4937	94.4	$3s^2 3p^6 3d^{10} 4s_{1/2} 4p^2_{1/2} 6f_{5/2}$	3^-	1508.40	1.26×10^{-13}	
4944	94.5	$3s^2 3p^6 3d^{10} 4s_{1/2} 4p^2_{1/2} 6f_{7/2}$	3^-	1510.43	1.27×10^{-13}	
5422	99.0	$3s^2 3p^6 3d^4_{3/2} 3d^5_{5/2} 4s^2 4p^2_{1/2} 4p_{3/2}$	4^-	1681.84	2.18×10^{-10}	
5423	98.9	$3s^2 3p^6 3d^4_{3/2} 3d^5_{5/2} 4s^2 4p^2_{1/2} 4p_{3/2}$	2^-	1683.53	7.44×10^{-11}	
5424	98.9	$3s^2 3p^6 3d^4_{3/2} 3d^5_{5/2} 4s^2 4p^2_{1/2} 4p_{3/2}$	1^-	1685.32	1.15×10^{-13}	
5425	98.8	$3s^2 3p^6 3d^4_{3/2} 3d^5_{5/2} 4s^2 4p^2_{1/2} 4p_{3/2}$	3^-	1686.37	1.45×10^{-10}	
5427	98.2	$3s^2 3p^6 3d^3_{3/2} 3d^6_{5/2} 4s^2 4p^2_{1/2} 4p_{3/2}$	1^-	1749.84	1.66×10^{-13}	
5428	98.2	$3s^2 3p^6 3d^3_{3/2} 3d^6_{5/2} 4s^2 4p^2_{1/2} 4p_{3/2}$	3^-	1749.99	2.42×10^{-13}	
5432	98.4	$3s^2 3p^6 3d^4_{3/2} (3d^5_{5/2} 4s^2 4p_{1/2})_3 (4p^2_{3/2})_2$	1^-	1776.50	2.82×10^{-13}	
5438	58.1	$3s^2 3p^6 3d^4_{3/2} (3d^5_{5/2} 4s^2 4p_{1/2})_3 (4p^2_{3/2})_2$	3^-	1782.94	1.22×10^{-13}	
5439	65.6	$3s^2 3p^6 3d^4_{3/2} (3d^5_{5/2} 4s^2 4p_{1/2})_2 (4p^2_{3/2})_2$	2^-	1783.41	1.41×10^{-13}	
5440	90.3	$3s^2 3p^6 3d^4_{3/2} (3d^5_{5/2} 4s^2 4p_{1/2})_2 (4p^2_{3/2})_0$	2^-	1789.71	1.70×10^{-12}	
5442	96.2	$3s^2 3p^6 3d^4_{3/2} 3d^5_{5/2} 4s^2 4p^2_{1/2} 4d_{3/2}$	1^+	1831.16	1.97×10^{-11}	
5444	96.7	$3s^2 3p^6 3d^4_{3/2} 3d^5_{5/2} 4s^2 4p^2_{1/2} 4d_{3/2}$	2^+	1836.15	1.08×10^{-11}	
5445	96.6	$3s^2 3p^6 3d^4_{3/2} 3d^5_{5/2} 4s^2 4p^2_{1/2} 4d_{3/2}$	3^+	1837.83	2.29×10^{-11}	
5456	82.6	$3s^2 3p^6 3d^4_{3/2} 3d^5_{5/2} 4s^2 4p^2_{1/2} 4d_{5/2}$	1^+	1858.05	1.53×10^{-12}	
5458	74.7	$3s^2 3p^6 3d^4_{3/2} 3d^5_{5/2} 4s^2 4p^2_{1/2} 4d_{5/2}$	3^+	1861.52	9.91×10^{-13}	
5460	74.9	$3s^2 3p^6 3d^4_{3/2} 3d^5_{5/2} 4s^2 4p^2_{1/2} 4d_{5/2}$	2^+	1862.97	7.09×10^{-13}	
5461	72.6	$3s^2 3p^6 3d^4_{3/2} (3d^5_{5/2} 4s_{1/2})_2 4p^2_{1/2} (4p^2_{3/2})_2$	0^+	1869.41	6.69×10^{-13}	
5466	51.7	$3s^2 3p^6 3d^4_{3/2} (3d^5_{5/2} 4s_{1/2})_2 4p^2_{1/2} (4p^2_{3/2})_2$	2^+	1879.54	1.76×10^{-13}	
5470	46.6	$3s^2 3p^6 3d^4_{3/2} 3d^5_{5/2} 4s^2 4p^2_{1/2} 4d_{5/2}$	0^+	1882.68	1.24×10^{-12}	
5478	96.0	$3s^2 3p^6 3d^3_{3/2} 3d^6_{5/2} 4s^2 4p^2_{1/2} 4d_{3/2}$	3^+	1900.70	2.66×10^{-13}	
5479	96.2	$3s^2 3p^6 3d^3_{3/2} 3d^6_{5/2} 4s^2 4p^2_{1/2} 4d_{3/2}$	1^+	1900.82	2.46×10^{-13}	
5480	95.6	$3s^2 3p^6 3d^3_{3/2} 3d^6_{5/2} 4s^2 4p^2_{1/2} 4d_{3/2}$	2^+	1906.11	2.41×10^{-13}	
5482	73.6	$3s^2 3p^6 3d^3_{3/2} 3d^6_{5/2} 4s^2 4p^2_{1/2} 4d_{5/2}$	1^+	1923.80	2.64×10^{-13}	
5486	73.5	$3s^2 3p^6 3d^3_{3/2} 3d^6_{5/2} 4s^2 4p^2_{1/2} 4d_{5/2}$	4^+	1926.40	2.56×10^{-13}	
5488	67.0	$3s^2 3p^6 3d^3_{3/2} 3d^6_{5/2} 4s^2 4p^2_{1/2} 4d_{5/2}$	2^+	1927.02	2.44×10^{-13}	
5503	40.9	$3s^2 3p^6 3d^3_{3/2} 3d^6_{5/2} 4s^2 4p^2_{1/2} 4d_{3/2}$	0^+	1939.21	1.03×10^{-13}	
5534	41.6	$3s^2 3p^6 3d^4_{3/2} [(3d^5_{5/2} 4s^2 4p_{1/2})_2 4p_{3/2}]_{5/2} 4d_{5/2}$	0^+	1953.73	3.92×10^{-13}	
5544	31.7	$3s^2 3p^6 3d^4_{3/2} [(3d^5_{5/2} 4s^2 4p_{1/2})_2 4p_{3/2}]_{5/2} 4d_{5/2}$	0^+	1957.08	2.44×10^{-13}	
5551	37.9	$3s^2 3p^6 (3d^3_{3/2} 3d^6_{5/2} 4s_{1/2})_2 4p^2_{1/2} (4p^2_{3/2})_2$	0^+	1961.36	2.64×10^{-13}	
5645	88.1	$3s^2 3p^6 3d^4_{3/2} [(3d^5_{5/2} 4s_{1/2})_2 4p^2_{1/2} 4p_{3/2}]_{1/2} 4d_{3/2}$	1^-	2028.74	1.11×10^{-13}	

(continued on next page)

Table 1 (*continued*)

Index	Purity (%)	Configuration	J^{π}	E (eV)	τ_{rad} (s)	τ_{level} (s)
5646	60.1	$3s^2 3p^6 3d^4_{3/2} 3d^5_{5/2} 4s^2 4p^2_{1/2} 4f_{5/2}$	3^-	2029.70	2.61×10^{-12}	
5668	72.9	$3s^2 3p^6 3d^4_{3/2} 3d^5_{5/2} 4s^2 4p^2_{1/2} 4f_{7/2}$	2^-	2039.36	9.52×10^{-13}	
5681	35.6	$3s^2 3p^6 3d^4_{3/2} 3d^5_{5/2} 4s^2 4p^2_{1/2} 4f_{7/2}$	3^-	2042.56	1.16×10^{-12}	
5687	40.3	$3s^2 3p^6 3d^4_{3/2} 3d^5_{5/2} 4s^2 4p^2_{1/2} 4f_{7/2}$	3^-	2043.90	3.74×10^{-13}	
5705	45.9	$3s^2 3p^6 3d^4_{3/2} [(3d^5_{5/2} 4s_{1/2})_3 4p^2_{1/2} 4p_{3/2}]_{3/2} 4d_{3/2}$	1^-	2047.37	7.37×10^{-14}	
5727	34.5	$3s^2 3p^6 3d^4_{3/2} [(3d^5_{5/2} 4s_{1/2})_2 4p^2_{1/2} 4p_{3/2}]_{3/2} 4d_{5/2}$	1^-	2053.38	1.77×10^{-14}	
5743	33.6	$3s^2 3p^6 3d^4_{3/2} [(3d^5_{5/2} 4s_{1/2})_3 4p^2_{1/2} 4p_{3/2}]_{7/2} 4d_{5/2}$	1^-	2060.76	1.22×10^{-13}	
5749	33.8	$3s^2 3p^6 3d^4_{3/2} [(3d^5_{5/2} 4s_{1/2})_2 4p^2_{1/2} 4p_{3/2}]_{3/2} 4d_{5/2}$	1^-	2062.08	6.41×10^{-14}	
5761	35.3	$3s^2 3p^6 3d^4_{3/2} [(3d^5_{5/2} 4s_{1/2})_3 4p^2_{1/2} 4p_{3/2}]_{3/2} 4d_{5/2}$	1^-	2070.64	4.16×10^{-14}	
5788	21.9	$3s^2 3p^6 [(3d^3_{3/2} 3d^6_{5/2} 4s_{1/2})_2 4p^2_{1/2} 4p_{3/2}]_{3/2} 4d_{3/2}$	1^-	2088.29	6.67×10^{-14}	
5807	63.6	$3s^2 3p^6 3d^3_{3/2} 3d^6_{5/2} 4s^2 4p^2_{1/2} 4f_{5/2}$	3^-	2098.07	2.47×10^{-13}	
5810	68.3	$3s^2 3p^6 3d^3_{3/2} 3d^6_{5/2} 4s^2 4p^2_{1/2} 4f_{7/2}$	2^-	2103.16	2.55×10^{-13}	
5813	50.2	$3s^2 3p^6 [(3d^3_{3/2} 3d^6_{5/2} 4s_{1/2})_2 4p^2_{1/2} 4p_{3/2}]_{1/2} 4d_{3/2}$	1^-	2104.37	1.81×10^{-14}	
5821	76.8	$3s^2 3p^6 3d^3_{3/2} 3d^6_{5/2} 4s^2 4p^2_{1/2} 4f_{7/2}$	5^-	2106.17	2.53×10^{-13}	
5828	72.6	$3s^2 3p^6 3d^3_{3/2} 3d^6_{5/2} 4s^2 4p^2_{1/2} 4f_{7/2}$	3^-	2108.13	2.60×10^{-13}	
5854	30.9	$3s^2 3p^6 [(3d^3_{3/2} 3d^6_{5/2} 4s_{1/2})_2 4p^2_{1/2} 4p_{3/2}]_{3/2} 4d_{3/2}$	1^-	2114.61	6.56×10^{-14}	
5884	23.7	$3s^2 3p^6 3d^4_{3/2} [(3d^5_{5/2} 4s^2 4p_{1/2})_3 4p_{3/2}]_{5/2} 4f_{5/2}$	1^-	2120.65	1.28×10^{-13}	
5891	22.7	$3s^2 3p^6 3d^4_{3/2} [(3d^5_{5/2} 4s^2 4p_{1/2})_2 4p_{3/2}]_{5/2} 4f_{5/2}$	1^-	2122.30	9.45×10^{-14}	
5897	25.7	$3s^2 3p^6 [(3d^3_{3/2} 3d^6_{5/2} 4s_{1/2})_2 4p^2_{1/2} 4p_{3/2}]_{7/2} 4d_{5/2}$	1^-	2123.47	1.93×10^{-14}	
5907	17.2	$3s^2 3p^6 3d^3_{3/2} 3d^6_{5/2} 4s^2 4p^2_{1/2} 4f_{5/2}$	1^-	2126.12	1.24×10^{-14}	
5911	29.4	$3s^2 3p^6 3d^3_{3/2} 3d^6_{5/2} 4s^2 4p^2_{1/2} 4f_{5/2}$	1^-	2126.75	8.39×10^{-15}	
6027	53.5	$3s^2 3p^6 [(3d^3_{3/2} 3d^6_{5/2} 4s_{1/2})_2 4p^2_{1/2} 4p_{3/2}]_{3/2} 4d_{5/2}$	1^-	2144.82	7.89×10^{-14}	
6032	24.6	$3s^2 3p^6 3d^4_{3/2} [(3d^5_{5/2} 4s^2 4p_{1/2})_2 4p_{3/2}]_{5/2} 4f_{7/2}$	1^-	2145.59	4.62×10^{-14}	
6043	95.1	$3s^2 3p^2_{1/2} 3p^3_{3/2} 3d^{10} 4s^2 4p^2_{1/2} 4p_{3/2}$	2^+	2147.15	5.93×10^{-14}	5.86×10^{-14}
6056	22.4	$3s^2 3p^6 3d^4_{3/2} [[(3d^5_{5/2} 4s_{1/2})_3 4p_{1/2}]_{5/2} (4p^2_{3/2})_2]_{1/2} 4d_{3/2}$	1^-	2149.58	7.85×10^{-14}	7.36×10^{-14}
6062	10.9	$3s^2 3p^6 3d^4_{3/2} [(3d^5_{5/2} 4s^2 4p_{1/2})_3 4p_{3/2}]_{5/2} 4f_{7/2}$	1^-	2150.65	3.10×10^{-14}	3.09×10^{-14}
6070	7.6	$3s^2 3p^6 3d^3_{3/2} 3d^6_{5/2} 4p^2_{1/2} 4p^3_{3/2}$	1^-	2152.07	3.47×10^{-14}	2.79×10^{-14}
6093	12.7	$3s^2 3p^6 3d^4_{3/2} [(3d^5_{5/2} 4s^2 4p_{1/2})_2 4p_{3/2}]_{3/2} 4f_{7/2}$	3^-	2158.32	1.39×10^{-14}	
6132	96.5	$3s^2 3p^2_{1/2} 3p^3_{3/2} 3d^{10} 4s^2 4p^2_{1/2} 4p_{3/2}$	0^+	2167.55	4.40×10^{-14}	1.04×10^{-15}
6307	13.6	$3s^2 3p^6 [(3d^3_{3/2} 3d^6_{5/2} 4s^2 4p_{1/2})_1 4p_{3/2}]_{3/2} 4f_{7/2}$	2^-	2214.19	2.64×10^{-14}	2.62×10^{-14}
6312	14.0	$3s^2 3p^6 [(3d^3_{3/2} 3d^6_{5/2} 4s^2 4p_{1/2})_1 4p_{3/2}]_{1/2} 4f_{5/2}$	3^-	2215.24	3.31×10^{-14}	3.30×10^{-14}
6313	16.6	$3s^2 3p^6 [(3d^3_{3/2} 3d^6_{5/2} 4s^2 4p_{1/2})_1 4p_{3/2}]_{5/2} 4f_{7/2}$	1^-	2215.29	1.30×10^{-14}	1.24×10^{-14}
6348	11.3	$3s^2 3p^6 [[(3d^3_{3/2} 3d^6_{5/2} 4s_{1/2})_2 4p_{1/2}]_{5/2} (4p^2_{3/2})_2]_{9/2} 4d_{5/2}$	2^-	2221.58	1.11×10^{-14}	
6354	15.4	$3s^2 3p^6 [[(3d^3_{3/2} 3d^6_{5/2} 4s_{1/2})_1 4p_{1/2}]_{3/2} (4p^2_{3/2})_0]_{3/2} 4d_{5/2}$	2^-	2222.94	1.23×10^{-14}	1.22×10^{-14}
6358	8.5	$3s^2 3p^6 [[(3d^3_{3/2} 3d^6_{5/2} 4s_{1/2})_2 4p_{1/2}]_{5/2} (4p^2_{3/2})_2]_{7/2} 4d_{5/2}$	2^-	2223.45	1.61×10^{-14}	
6362	13.7	$3s^2 3p^6 [[(3d^3_{3/2} 3d^6_{5/2} 4s_{1/2})_2 4p_{1/2}]_{5/2} (4p^2_{3/2})_2]_{9/2} 4d_{5/2}$	3^-	2224.08	3.05×10^{-14}	3.03×10^{-14}
6369	11.4	$3s^2 3p^6 3d^4_{3/2} [3d^5_{5/2} 4s^2 (4p^2_{3/2})_2]_{7/2} 4f_{5/2}$	3^-	2224.54	2.83×10^{-14}	2.82×10^{-14}
6372	8.9	$3s^2 3p^6 3d^4_{3/2} [3d^5_{5/2} 4s^2 (4p^2_{3/2})_2]_{7/2} 4f_{5/2}$	3^-	2225.19	2.30×10^{-14}	2.29×10^{-14}
6381	13.8	$3s^2 3p^6 [[(3d^3_{3/2} 3d^6_{5/2} 4s_{1/2})_1 4p_{1/2}]_{3/2} (4p^2_{3/2})_0]_{3/2} 4d_{5/2}$	3^-	2226.21	8.58×10^{-15}	8.54×10^{-15}
6386	22.3	$3s^2 3p^6 3d^4_{3/2} [3d^5_{5/2} 4s^2 (4p^2_{3/2})_2]_{5/2} 4f_{5/2}$	1^-	2227.17	1.01×10^{-14}	8.89×10^{-15}
6728	90.6	$3s^2 3p^2_{1/2} 3p^3_{3/2} 3d^{10} 4s^2 4p^2_{1/2} 4d_{3/2}$	3^-	2294.47	7.18×10^{-14}	6.69×10^{-14}
6880	73.2	$3s^2 3p^2_{1/2} 3p^3_{3/2} 3d^{10} 4s^2 4p^2_{1/2} 4d_{5/2}$	1^-	2321.87	1.19×10^{-14}	1.02×10^{-14}
7013	47.7	$3s^2 3p^2_{1/2} (3p^3_{3/2} 3d^{10} 4s_{1/2})_1 4p^2_{1/2} (4p^2_{3/2})_2$	1^-	2337.16	3.15×10^{-14}	2.34×10^{-14}
7775	45.9	$3s^2 3p^2_{1/2} 3p^3_{3/2} 3d^{10} 4s^2 4p^2_{1/2} 4f_{7/2}$	2^+	2505.09	3.49×10^{-14}	1.42×10^{-14}
10262	90.4	$3s^2 3p^6 3d^4_{3/2} 3d^5_{5/2} 4s^2 4p^2_{1/2} 5f_{7/2}$	1^-	2689.33	1.01×10^{-14}	7.66×10^{-15}
10381	95.8	$3s^2 3p^6 3d^3_{3/2} 3d^6_{5/2} 4s^2 4p^2_{1/2} 5f_{5/2}$	1^-	2751.73	8.16×10^{-15}	6.10×10^{-15}
10529	36.9	$3s^2 3p^6 3d^4_{3/2} [(3d^5_{5/2} 4s^2 4p_{1/2})_3 4p_{3/2}]_{7/2} 5f_{7/2}$	2^-	2787.63	1.07×10^{-14}	8.05×10^{-15}
10537	20.8	$3s^2 3p^6 3d^4_{3/2} [(3d^5_{5/2} 4s^2 4p_{1/2})_3 4p_{3/2}]_{7/2} 5f_{7/2}$	3^-	2788.83	1.01×10^{-14}	8.31×10^{-15}
10746	30.2	$3s^2 3p^6 [(3d^3_{3/2} 3d^6_{5/2} 4s^2 4p_{1/2})_1 4p_{3/2}]_{5/2} 5f_{5/2}$	2^-	2849.62	8.63×10^{-15}	6.58×10^{-15}
10750	34.7	$3s^2 3p^6 [(3d^3_{3/2} 3d^6_{5/2} 4s^2 4p_{1/2})_1 4p_{3/2}]_{3/2} 5f_{5/2}$	3^-	2851.00	8.72×10^{-15}	7.02×10^{-15}
11126	98.0	$3s^2 3p^2_{1/2} 3p^3_{3/2} 3d^{10} 4s^2 4p^2_{1/2} 5d_{5/2}$	1^-	3060.36	1.40×10^{-14}	1.32×10^{-14}
11178	80.2	$3s^2 3p^2_{1/2} 3p^3_{3/2} 3d^{10} 4s^2 4p^2_{1/2} 5f_{7/2}$	2^+	3140.63	4.05×10^{-14}	2.15×10^{-14}
12059	90.2	$3s^2 3p^6 3d^4_{3/2} 3d^5_{5/2} 4s^2 4p^2_{1/2} 6f_{7/2}$	1^-	3019.93	1.67×10^{-14}	1.36×10^{-14}
12237	96.1	$3s^2 3p^6 3d^3_{3/2} 3d^6_{5/2} 4s^2 4p^2_{1/2} 6f_{5/2}$	1^-	3083.87	1.66×10^{-14}	1.31×10^{-14}
13330	90.6	$3s^2 3p^2_{1/2} 3p^3_{3/2} 3d^{10} 4s^2 4p^2_{1/2} 6d_{5/2}$	1^-	3430.29	2.11×10^{-14}	2.02×10^{-14}

Table 2
Energy levels in Ga-like tungsten, W^{43+}.

Index	Purity (%)	Configuration	J^{π}	E (eV)	τ_{rad} (s)	τ_{level} (s)
0	99.5	$3s^23p^63d^{10}4s^24p_{1/2}$	$1/2^-$	0.00		
1	97.6	$3s^23p^63d^{10}4s_{1/2}4p^2_{1/2}$	$1/2^+$	96.68	3.29×10^{-11}	
2	99.0	$3s^23p^63d^{10}4s^24p_{3/2}$	$3/2^-$	98.13	2.19×10^{-7}	2.06×10^{-7}
3	73.1	$3s^23p^63d^{10}(4s_{1/2}4p_{1/2})_04p_{3/2}$	$3/2^+$	181.22	1.94×10^{-10}	
4	97.6	$3s^23p^63d^{10}(4s_{1/2}4p_{1/2})_14p_{3/2}$	$5/2^+$	189.88	7.17×10^{-11}	
5	69.7	$3s^23p^63d^{10}(4s_{1/2}4p_{1/2})_14p_{3/2}$	$3/2^+$	202.27	2.59×10^{-12}	
6	96.5	$3s^23p^63d^{10}(4s_{1/2}4p_{1/2})_14p_{3/2}$	$1/2^+$	205.28	1.30×10^{-12}	
7	92.8	$3s^23p^63d^{10}4s^24d_{3/2}$	$3/2^+$	259.47	7.71×10^{-13}	
8	62.6	$3s^23p^63d^{10}4s^24d_{5/2}$	$5/2^+$	273.35	1.20×10^{-11}	
11	98.3	$3s^23p^63d^{10}4s_{1/2}(4p^2_{3/2})_0$	$1/2^+$	303.03	1.90×10^{-12}	
12	96.1	$3s^23p^63d^{10}4s_{1/2}(4p^2_{3/2})_2$	$3/2^+$	307.24	8.92×10^{-13}	
14	93.9	$3s^23p^63d^{10}(4s_{1/2}4p_{1/2})_14d_{3/2}$	$5/2^-$	341.63	2.90×10^{-11}	
19	80.5	$3s^23p^63d^{10}(4s_{1/2}4p_{1/2})_14d_{5/2}$	$5/2^-$	374.00	3.51×10^{-12}	
20	68.8	$3s^23p^63d^{10}(4s_{1/2}4p_{1/2})_14d_{5/2}$	$3/2^-$	374.03	2.36×10^{-12}	
24	43.6	$3s^23p^63d^{10}(4s_{1/2}4p_{3/2})_24d_{3/2}$	$5/2^-$	439.93	1.56×10^{-12}	
34	90.9	$3s^23p^63d^{10}(4s_{1/2}4p_{3/2})_14d_{3/2}$	$1/2^-$	465.50	5.55×10^{-13}	
35	50.7	$3s^23p^63d^{10}(4s_{1/2}4p_{3/2})_24d_{5/2}$	$3/2^-$	466.75	1.63×10^{-12}	
687	95.5	$3s^23p^63d^{10}4s^25d_{3/2}$	$3/2^+$	1010.14	2.05×10^{-13}	
689	97.8	$3s^23p^63d^{10}(4s_{1/2}4p_{1/2})_05p_{3/2}$	$3/2^+$	1023.44	2.67×10^{-13}	
690	76.1	$3s^23p^63d^{10}(4s_{1/2}4p_{1/2})_15p_{3/2}$	$1/2^+$	1026.57	1.67×10^{-13}	
692	96.6	$3s^23p^63d^{10}(4s_{1/2}4p_{1/2})_15p_{3/2}$	$3/2^+$	1031.59	2.18×10^{-13}	
706	94.8	$3s^23p^63d^{10}(4s_{1/2}4p_{1/2})_15d_{3/2}$	$3/2^-$	1103.98	1.78×10^{-13}	
3751	99.0	$3s^23p^63d^{10}4s^26p_{1/2}$	$1/2^-$	1329.14	2.42×10^{-13}	
3754	98.2	$3s^23p^63d^{10}4s^26d_{3/2}$	$3/2^+$	1394.20	1.86×10^{-13}	
3756	96.4	$3s^23p^63d^{10}(4s_{1/2}4p_{1/2})_16s_{1/2}$	$1/2^-$	1397.00	1.54×10^{-13}	
3761	98.9	$3s^23p^63d^{10}4s^26f_{5/2}$	$5/2^-$	1440.23	1.18×10^{-13}	
3767	99.2	$3s^23p^63d^{10}4s^26g_{7/2}$	$7/2^+$	1465.70	8.36×10^{-14}	
3778	93.4	$3s^23p^63d^{10}(4s_{1/2}4p_{1/2})_16d_{5/2}$	$3/2^-$	1493.11	1.72×10^{-13}	
3791	97.3	$3s^23p^63d^{10}(4s_{1/2}4p_{1/2})_16f_{5/2}$	$7/2^+$	1533.37	1.15×10^{-13}	
3794	92.2	$3s^23p^63d^{10}(4s_{1/2}4p_{1/2})_16f_{7/2}$	$5/2^+$	1535.15	1.18×10^{-13}	
3796	89.9	$3s^23p^63d^{10}(4s_{1/2}4p_{1/2})_16f_{7/2}$	$7/2^+$	1535.49	1.23×10^{-13}	
7797	99.1	$3s^23p^63d^4_{3/2}3d^5_{5/2}4s^24p^2_{1/2}$	$5/2^+$	1603.64	2.05×10^{-10}	
7798	98.2	$3s^23p^63d^3_{3/2}3d^6_{5/2}4s^24p^2_{1/2}$	$3/2^+$	1670.59	2.39×10^{-13}	
7799	84.5	$3s^23p^63d^4_{3/2}(3d^5_{5/2}4s^24p_{1/2})_24p_{3/2}$	$7/2^+$	1695.61	2.11×10^{-10}	
7800	63.3	$3s^23p^63d^4_{3/2}(3d^5_{5/2}4s^24p_{1/2})_34p_{3/2}$	$3/2^+$	1698.55	3.02×10^{-13}	
7802	99.1	$3s^23p^63d^4_{3/2}(3d^5_{5/2}4s^24p_{1/2})_34p_{3/2}$	$9/2^+$	1700.59	2.10×10^{-10}	
7803	64.0	$3s^23p^63d^4_{3/2}(3d^5_{5/2}4s^24p_{1/2})_24p_{3/2}$	$3/2^+$	1702.61	1.48×10^{-13}	
7804	88.2	$3s^23p^63d^4_{3/2}(3d^5_{5/2}4s^24p_{1/2})_24p_{3/2}$	$5/2^+$	1702.99	9.70×10^{-11}	
7805	98.8	$3s^23p^63d^4_{3/2}(3d^5_{5/2}4s^24p_{1/2})_24p_{3/2}$	$1/2^+$	1703.16	1.14×10^{-13}	
7806	84.4	$3s^23p^63d^4_{3/2}(3d^5_{5/2}4s^24p_{1/2})_34p_{3/2}$	$7/2^+$	1704.55	2.05×10^{-10}	
7807	98.0	$3s^23p^6(3d^3_{3/2}3d^6_{5/2}4s^24p_{1/2})_24p_{3/2}$	$1/2^+$	1759.64	2.26×10^{-12}	
7808	97.4	$3s^23p^6(3d^3_{3/2}3d^6_{5/2}4s^24p_{1/2})_24p_{3/2}$	$3/2^+$	1763.70	1.11×10^{-12}	
7809	57.2	$3s^23p^6(3d^3_{3/2}3d^6_{5/2}4s^24p_{1/2})_24p_{3/2}$	$5/2^+$	1764.34	4.15×10^{-13}	
7810	98.9	$3s^23p^6(3d^3_{3/2}3d^6_{5/2}4s^24p_{1/2})_24p_{3/2}$	$7/2^+$	1766.75	1.32×10^{-10}	
7811	98.0	$3s^23p^6(3d^3_{3/2}3d^6_{5/2}4s^24p_{1/2})_14p_{3/2}$	$1/2^+$	1768.41	1.35×10^{-13}	
7812	56.8	$3s^23p^6(3d^3_{3/2}3d^6_{5/2}4s^24p_{1/2})_14p_{3/2}$	$5/2^+$	1770.32	2.88×10^{-13}	
7813	97.2	$3s^23p^6(3d^3_{3/2}3d^6_{5/2}4s^24p_{1/2})_14p_{3/2}$	$3/2^+$	1771.02	1.55×10^{-13}	
7816	85.9	$3s^23p^63d^4_{3/2}(3d^5_{5/2}4s_{1/2})_24p^2_{1/2}4p_{3/2}$	$3/2^-$	1794.54	2.95×10^{-13}	
7818	96.5	$3s^23p^63d^4_{3/2}(3d^5_{5/2}4s_{1/2})_24p^2_{1/2}4p_{3/2}$	$1/2^-$	1795.98	1.15×10^{-13}	
7825	81.8	$3s^23p^63d^4_{3/2}(3d^5_{5/2}4s_{1/2})_34p^2_{1/2}4p_{3/2}$	$3/2^-$	1807.86	1.66×10^{-13}	
7846	54.3	$3s^23p^63d^4_{3/2}(3d^5_{5/2}4s^24p_{1/2})_34d_{5/2}$	$3/2^-$	1874.21	9.37×10^{-13}	
7854	39.0	$3s^23p^63d^4_{3/2}(3d^5_{5/2}4s^24p_{1/2})_24d_{5/2}$	$3/2^-$	1878.53	2.79×10^{-13}	
7855	45.8	$3s^23p^63d^4_{3/2}(3d^5_{5/2}4s^24p_{1/2})_34d_{5/2}$	$7/2^-$	1878.71	1.16×10^{-12}	
7857	43.6	$3s^23p^63d^4_{3/2}(3d^5_{5/2}4s^24p_{1/2})_24d_{5/2}$	$5/2^-$	1879.73	7.25×10^{-13}	
7858	57.8	$3s^23p^63d^4_{3/2}[(3d^5_{5/2}4s_{1/2})_24p_{1/2}]_{5/2}(4p^2_{3/2})_2$	$1/2^-$	1884.51	3.56×10^{-13}	
7861	46.6	$3s^23p^63d^4_{3/2}[(3d^5_{5/2}4s_{1/2})_24p_{1/2}]_{5/2}(4p^2_{3/2})_2$	$3/2^-$	1892.73	1.98×10^{-13}	
7863	50.8	$3s^23p^63d^4_{3/2}[(3d^5_{5/2}4s_{1/2})_24p_{1/2}]_{3/2}(4p^2_{3/2})_2$	$1/2^-$	1893.33	3.77×10^{-13}	
7869	24.0	$3s^23p^63d^4_{3/2}(3d^5_{5/2}4s^24p_{1/2})_34d_{5/2}$	$1/2^-$	1900.57	8.17×10^{-13}	
7883	58.4	$3s^23p^6(3d^3_{3/2}3d^6_{5/2}4s^24p_{1/2})_14d_{3/2}$	$3/2^-$	1915.57	2.84×10^{-13}	
7884	53.5	$3s^23p^6(3d^3_{3/2}3d^6_{5/2}4s^24p_{1/2})_24d_{3/2}$	$5/2^-$	1918.59	3.65×10^{-13}	
7885	58.8	$3s^23p^6(3d^3_{3/2}3d^6_{5/2}4s^24p_{1/2})_14d_{3/2}$	$1/2^-$	1925.91	1.91×10^{-13}	
7888	34.4	$3s^23p^6(3d^3_{3/2}3d^6_{5/2}4s^24p_{1/2})_24d_{3/2}$	$3/2^-$	1937.59	3.50×10^{-13}	
7894	73.4	$3s^23p^6(3d^3_{3/2}3d^6_{5/2}4s^24p_{1/2})_14d_{5/2}$	$3/2^-$	1943.48	1.94×10^{-13}	
7898	64.2	$3s^23p^6(3d^3_{3/2}3d^6_{5/2}4s^24p_{1/2})_14d_{5/2}$	$5/2^-$	1946.03	1.89×10^{-13}	
7907	42.6	$3s^23p^63d^4_{3/2}(3d^5_{5/2}4s^24p_{3/2})_14d_{3/2}$	$1/2^-$	1957.08	1.62×10^{-13}	
7911	55.5	$3s^23p^63d^4_{3/2}(3d^5_{5/2}4s^24p_{3/2})_24d_{3/2}$	$1/2^-$	1959.69	2.34×10^{-13}	
7930	31.7	$3s^23p^63d^4_{3/2}(3d^5_{5/2}4s^24p_{3/2})_14d_{3/2}$	$1/2^-$	1969.42	3.02×10^{-13}	
7951	35.8	$3s^23p^6[(3d^3_{3/2}3d^6_{5/2}4s_{1/2})_14p_{1/2}]_{1/2}(4p^2_{3/2})_0$	$1/2^-$	1977.88	2.50×10^{-13}	

(*continued on next page*)

Table 2 (*continued*)

Index	Purity (%)	Configuration	J^{π}	E (eV)	τ_{rad} (s)	τ_{level} (s)
7956	27.1	$3s^2 3p^6[(3d^3_{3/2}3d^6_{5/2}4s_{1/2})_2 4p_{1/2}]_{3/2}(4p^2_{3/2})_2$	$1/2^-$	1980.77	1.76×10^{-13}	
8039	38.1	$3s^2 3p^6 3d^4_{3/2}[[(3d^5_{5/2}4s_{1/2})_2 4p_{1/2}]_{3/2}4p_{3/2}]_0 4d_{3/2}$	$3/2^+$	2042.37	1.02×10^{-13}	
8090	21.0	$3s^2 3p^6 3d^4_{3/2}[[(3d^5_{5/2}4s_{1/2})_2 4p_{1/2}]_{5/2}4p_{3/2}]_1 4d_{3/2}$	$1/2^+$	2059.10	4.14×10^{-14}	
8092	24.3	$3s^2 3p^6 3d^4_{3/2}[[(3d^5_{5/2}4s_{1/2})_3 4p_{1/2}]_{5/2}4p_{3/2}]_1 4d_{3/2}$	$3/2^+$	2059.47	1.37×10^{-13}	
8095	32.3	$3s^2 3p^6 3d^4_{3/2}[[(3d^5_{5/2}4s_{1/2})_2 4p_{1/2}]_{5/2}4p_{3/2}]_2 4d_{3/2}$	$1/2^+$	2060.44	1.16×10^{-13}	
8105	20.9	$3s^2 3p^6 3d^4_{3/2}[[(3d^5_{5/2}4s_{1/2})_2 4p_{1/2}]_{5/2}4p_{3/2}]_3 4d_{5/2}$	$1/2^+$	2062.82	5.68×10^{-14}	
8106	96.7	$3s^2 3p^2_{1/2}3p^3_{3/2}3d^{10}4s^2 4p^2_{1/2}$	$3/2^-$	2062.83	5.77×10^{-14}	
8111	21.1	$3s^2 3p^6 3d^4_{3/2}[[(3d^5_{5/2}4s_{1/2})_2 4p_{1/2}]_{5/2}4p_{3/2}]_2 4d_{5/2}$	$3/2^+$	2066.27	2.94×10^{-14}	
8113	37.3	$3s^2 3p^6 3d^4_{3/2}[[(3d^5_{5/2}4s_{1/2})_2 4p_{1/2}]_{5/2}4p_{3/2}]_2 4d_{5/2}$	$1/2^+$	2066.84	3.85×10^{-14}	
8116	16.0	$3s^2 3p^6 3d^4_{3/2}[[(3d^5_{5/2}4s_{1/2})_3 4p_{1/2}]_{7/2}4p_{3/2}]_4 4d_{5/2}$	$3/2^+$	2067.95	5.40×10^{-14}	
8120	17.0	$3s^2 3p^6 3d^4_{3/2}[[(3d^5_{5/2}4s_{1/2})_2 4p_{1/2}]_{5/2}4p_{3/2}]_3 4d_{5/2}$	$3/2^+$	2068.74	3.55×10^{-14}	
8124	29.7	$3s^2 3p^6 3d^4_{3/2}[[(3d^5_{5/2}4s_{1/2})_2 4p_{1/2}]_{3/2}4p_{3/2}]_2 4d_{5/2}$	$1/2^+$	2071.75	4.85×10^{-14}	
8147	20.5	$3s^2 3p^6 3d^4_{3/2}[[(3d^5_{5/2}4s_{1/2})_2 4p_{1/2}]_{3/2}4p_{3/2}]_2 4d_{5/2}$	$1/2^+$	2078.76	7.57×10^{-14}	
8161	27.8	$3s^2 3p^6 3d^4_{3/2}[[(3d^5_{5/2}4s_{1/2})_3 4p_{1/2}]_{5/2}4p_{3/2}]_4 4d_{5/2}$	$3/2^+$	2084.33	1.93×10^{-13}	
8168	21.7	$3s^2 3p^6 3d^4_{3/2}[[(3d^5_{5/2}4s_{1/2})_3 4p_{1/2}]_{5/2}4p_{3/2}]_1 4d_{5/2}$	$3/2^+$	2085.70	1.49×10^{-13}	
8169	29.7	$3s^2 3p^6 3d^4_{3/2}[[(3d^5_{5/2}4s_{1/2})_3 4p_{1/2}]_{5/2}4p_{3/2}]_2 4d_{5/2}$	$1/2^+$	2085.92	5.20×10^{-14}	
8171	22.8	$3s^2 3p^6 3d^4_{3/2}[[(3d^5_{5/2}4s_{1/2})_3 4p_{1/2}]_{7/2}4p_{3/2}]_2 4d_{5/2}$	$3/2^+$	2087.65	8.90×10^{-14}	
8209	18.2	$3s^2 3p^6 3d^4_{3/2}[[(3d^5_{5/2}4s_{1/2})_3 4p_{1/2}]_{7/2}4p_{3/2}]_3 4d_{5/2}$	$3/2^+$	2105.63	7.00×10^{-14}	
8211	19.9	$3s^2 3p^6 3d^4_{3/2}[[(3d^5_{5/2}4s_{1/2})_3 4p_{1/2}]_{7/2}4p_{3/2}]_3 4d_{5/2}$	$1/2^+$	2106.85	9.16×10^{-14}	
8232	20.8	$3s^2 3p^6[[(3d^3_{3/2}3d^6_{5/2}4s_{1/2})_2 4p_{1/2}]_{5/2}4p_{3/2}]_1 4d_{3/2}$	$3/2^+$	2117.53	2.07×10^{-14}	
8241	34.1	$3s^2 3p^6[[(3d^3_{3/2}3d^6_{5/2}4s_{1/2})_1 4p_{1/2}]_{1/2}4p_{3/2}]_1 4d_{3/2}$	$3/2^+$	2120.51	8.61×10^{-14}	
8243	26.1	$3s^2 3p^6[[(3d^3_{3/2}3d^6_{5/2}4s_{1/2})_2 4p_{1/2}]_{5/2}4p_{3/2}]_2 4d_{3/2}$	$1/2^+$	2121.07	9.49×10^{-14}	
8255	41.6	$3s^2 3p^6[[(3d^3_{3/2}3d^6_{5/2}4s_{1/2})_1 4p_{1/2}]_{3/2}4p_{3/2}]_2 4d_{3/2}$	$1/2^+$	2125.40	4.37×10^{-14}	
8257	28.6	$3s^2 3p^6[[(3d^3_{3/2}3d^6_{5/2}4s_{1/2})_1 4p_{1/2}]_{3/2}4p_{3/2}]_2 4d_{5/2}$	$1/2^+$	2126.58	4.97×10^{-14}	
8258	22.4	$3s^2 3p^6[[(3d^3_{3/2}3d^6_{5/2}4s_{1/2})_2 4p_{1/2}]_{3/2}4p_{3/2}]_3 4d_{5/2}$	$3/2^+$	2127.28	9.00×10^{-14}	
8265	17.6	$3s^2 3p^6[[(3d^3_{3/2}3d^6_{5/2}4s_{1/2})_1 4p_{1/2}]_{1/2}4p_{3/2}]_2 4d_{3/2}$	$1/2^+$	2130.50	1.22×10^{-14}	
8266	21.4	$3s^2 3p^6[[(3d^3_{3/2}3d^6_{5/2}4s_{1/2})_2 4p_{1/2}]_{3/2}4p_{3/2}]_1 4d_{3/2}$	$3/2^+$	2130.97	3.45×10^{-14}	
8275	16.0	$3s^2 3p^6[[(3d^3_{3/2}3d^6_{5/2}4s_{1/2})_2 4p_{1/2}]_{5/2}4p_{3/2}]_4 4d_{5/2}$	$3/2^+$	2134.97	2.26×10^{-14}	
8291	25.9	$3s^2 3p^6(3d^3_{3/2}3d^6_{5/2}4s^2 4p_{1/2})_1 4f_{5/2}$	$3/2^+$	2140.29	5.39×10^{-15}	
8295	23.8	$3s^2 3p^6(3d^3_{3/2}3d^6_{5/2}4s^2 4p_{1/2})_2 4f_{5/2}$	$1/2^+$	2140.48	9.97×10^{-15}	
8307	13.9	$3s^2 3p^6[[(3d^3_{3/2}3d^6_{5/2}4s_{1/2})_2 4p_{1/2}]_{3/2}4p_{3/2}]_2 4d_{5/2}$	$1/2^+$	2142.83	1.72×10^{-14}	
8308	25.6	$3s^2 3p^6 3d^4_{3/2}(3d^5_{5/2}4s^2 4p_{3/2})_1 4f_{5/2}$	$3/2^+$	2142.93	7.04×10^{-14}	
8311	17.1	$3s^2 3p^6 3d^4_{3/2}[(3d^5_{5/2}4s_{1/2})_2(4p^2_{3/2})_2]_0 4d_{3/2}$	$3/2^+$	2143.32	4.08×10^{-14}	
8324	16.9	$3s^2 3p^6[[(3d^3_{3/2}3d^6_{5/2}4s_{1/2})_2 4p_{1/2}]_{3/2}4p_{3/2}]_2 4d_{5/2}$	$1/2^+$	2145.98	1.71×10^{-14}	
8377	8.9	$3s^2 3p^6[[(3d^3_{3/2}3d^6_{5/2}4s_{1/2})_1 4p_{1/2}]_{3/2}4p_{3/2}]_1 4d_{3/2}$	$3/2^+$	2154.78	7.86×10^{-14}	
8407	27.6	$3s^2 3p^6[[(3d^3_{3/2}3d^6_{5/2}4s_{1/2})_2 4p_{1/2}]_{3/2}4p_{3/2}]_2 4d_{5/2}$	$3/2^+$	2160.43	9.68×10^{-14}	
8415	18.2	$3s^2 3p^6[[(3d^3_{3/2}3d^6_{5/2}4s_{1/2})_2 4p_{1/2}]_{5/2}4p_{3/2}]_2 4d_{5/2}$	$3/2^+$	2161.27	1.06×10^{-13}	
8446	16.6	$3s^2 3p^6 3d^4_{3/2}[(3d^5_{5/2}4s_{1/2})_2(4p^2_{3/2})_0]_2 4d_{3/2}$	$3/2^+$	2170.28	5.08×10^{-14}	
8447	26.3	$3s^2 3p^6 3d^4_{3/2}(3d^5_{5/2}4s^2 4p_{3/2})_4 4f_{7/2}$	$1/2^+$	2170.66	1.67×10^{-14}	
8486	53.1	$3s^2 3p^2_{1/2}(3p^3_{3/2}3d^{10}4s^2 4p_{1/2})_2 4p_{3/2}$	$1/2^-$	2182.04	4.28×10^{-14}	
8502	14.8	$3s^2 3p^6 3d^4_{3/2}[(3d^5_{5/2}4s_{1/2})_3(4p^2_{3/2})_2]_1 4d_{3/2}$	$3/2^+$	2185.86	1.23×10^{-13}	
8504	19.9	$3s^2 3p^6(3d^3_{3/2}3d^6_{5/2}4p_{1/2})_1 4p^3_{3/2}$	$1/2^+$	2186.58	7.58×10^{-14}	
9009	97.1	$3s^2 3p^2_{1/2}(3p^3_{3/2}3d^{10}4s^2 4p_{1/2})_2 4d_{3/2}$	$7/2^+$	2306.89	6.75×10^{-14}	6.39×10^{-14}
9132	47.4	$3s^2 3p^2_{1/2}(3p^3_{3/2}3d^{10}4s^2 4p_{1/2})_2 4d_{5/2}$	$1/2^+$	2334.88	1.52×10^{-14}	1.21×10^{-14}
9147	43.0	$3s^2 3p^2_{1/2}(3p^3_{3/2}3d^{10}4s^2 4p_{1/2})_1 4d_{5/2}$	$3/2^+$	2336.94	1.14×10^{-14}	9.92×10^{-15}
9224	42.2	$3s^2 3p^2_{1/2}(3p^3_{3/2}3d^{10}4s^2 4p_{1/2})_2 4d_{5/2}$	$1/2^+$	2349.15	1.87×10^{-14}	1.37×10^{-14}
9253	29.0	$3s^2 3p^2_{1/2}[(3p^3_{3/2}3d^{10}4s_{1/2})_1 4p_{1/2}]_{3/2}(4p^2_{3/2})_2$	$3/2^+$	2354.36	3.13×10^{-14}	2.32×10^{-14}
11806	77.4	$3s^2 3p^6 3d^4_{3/2}(3d^5_{5/2}4s^2 4p_{1/2})_3 5f_{7/2}$	$1/2^+$	2716.89	1.18×10^{-14}	7.81×10^{-15}
11808	57.5	$3s^2 3p^6 3d^4_{3/2}(3d^5_{5/2}4s^2 4p_{1/2})_2 5f_{7/2}$	$3/2^+$	2718.08	1.05×10^{-14}	8.37×10^{-15}
12028	74.6	$3s^2 3p^6(3d^3_{3/2}3d^6_{5/2}4s^2 4p_{1/2})_2 5f_{5/2}$	$1/2^+$	2777.86	1.03×10^{-14}	6.35×10^{-15}
12033	75.7	$3s^2 3p^6(3d^3_{3/2}3d^6_{5/2}4s^2 4p_{1/2})_1 5f_{5/2}$	$3/2^+$	2781.22	8.58×10^{-15}	6.82×10^{-15}
12038	39.8	$3s^2 3p^6(3d^3_{3/2}3d^6_{5/2}4s_{1/2})_1 4p^2_{1/2}5d_{3/2}$	$1/2^+$	2786.03	3.82×10^{-14}	2.27×10^{-14}
14464	85.4	$3s^2 3p^2_{1/2}(3p^3_{3/2}3d^{10}4s^2 4p_{1/2})_2 5d_{5/2}$	$1/2^+$	3088.74	1.46×10^{-14}	1.29×10^{-14}
14473	58.9	$3s^2 3p^2_{1/2}(3p^3_{3/2}3d^{10}4s^2 4p_{1/2})_1 5d_{5/2}$	$3/2^+$	3089.75	1.38×10^{-14}	1.29×10^{-14}
18686	52.4	$3s^2 3p^6 3d^4_{3/2}(3d^5_{5/2}4s^2 4p_{1/2})_2 6f_{7/2}$	$3/2^+$	3062.11	1.59×10^{-14}	1.37×10^{-14}
18687	91.3	$3s^2 3p^6 3d^4_{3/2}(3d^5_{5/2}4s^2 4p_{1/2})_3 6f_{7/2}$	$1/2^+$	3062.22	1.62×10^{-14}	1.27×10^{-14}
18884	93.4	$3s^2 3p^6(3d^3_{3/2}3d^6_{5/2}4s^2 4p_{1/2})_2 6f_{5/2}$	$1/2^+$	3124.81	1.75×10^{-14}	1.30×10^{-14}
18894	84.1	$3s^2 3p^6(3d^3_{3/2}3d^6_{5/2}4s^2 4p_{1/2})_1 6f_{5/2}$	$3/2^+$	3126.72	1.70×10^{-14}	1.46×10^{-14}

Table 3
Energy levels in Zn-like tungsten, W^{44+}.

Index	Purity (%)	Configuration	J^{π}	E (eV)	τ_{rad} (s)	τ_{level} (s)
0	99.3	$3s^2 3p^6 3d^{10} 4s^2$	0^+	0.00		
1	99.9	$3s^2 3p^6 3d^{10} 4s_{1/2} 4p_{1/2}$	0^-	86.16		
2	98.6	$3s^2 3p^6 3d^{10} 4s_{1/2} 4p_{1/2}$	1^-	93.23	5.82×10^{-11}	
3	99.8	$3s^2 3p^6 3d^{10} 4s_{1/2} 4p_{3/2}$	2^-	186.21	2.24×10^{-7}	2.14×10^{-7}
5	98.3	$3s^2 3p^6 3d^{10} 4s_{1/2} 4p_{3/2}$	1^-	203.74	1.53×10^{-12}	
7	95.6	$3s^2 3p^6 3d^{10} 4p_{1/2} 4p_{3/2}$	2^+	292.44	3.39×10^{-12}	
9	91.6	$3s^2 3p^6 3d^{10} 4s_{1/2} 4d_{3/2}$	2^+	348.42	1.01×10^{-12}	
11	78.6	$3s^2 3p^6 3d^{10} 4s_{1/2} 4d_{5/2}$	2^+	371.72	2.94×10^{-12}	
13	99.0	$3s^2 3p^6 3d^{10} 4p^2_{3/2}$	0^+	403.20	1.16×10^{-12}	
16	96.3	$3s^2 3p^6 3d^{10} 4p_{1/2} 4d_{5/2}$	3^-	466.21	3.88×10^{-12}	
21	85.3	$3s^2 3p^6 3d^{10} 4s_{1/2} 4f_{7/2}$	3^-	539.37	2.59×10^{-12}	
22	89.3	$3s^2 3p^6 3d^{10} 4p_{3/2} 4d_{3/2}$	2^-	543.74	7.59×10^{-13}	
25	54.5	$3s^2 3p^6 3d^{10} 4p_{3/2} 4d_{3/2}$	3^-	553.54	8.17×10^{-13}	
84	99.2	$3s^2 3p^6 3d^4_{3/2} 3d^5_{5/2} 4s^2 4p_{1/2}$	2^-	1618.73	1.79×10^{-10}	
85	99.3	$3s^2 3p^6 3d^4_{3/2} 3d^5_{5/2} 4s^2 4p_{1/2}$	3^-	1619.72	1.88×10^{-10}	
86	99.1	$3s^2 3p^6 3d^3_{3/2} 3d^6_{5/2} 4s^2 4p_{1/2}$	2^-	1684.66	1.45×10^{-10}	
87	98.8	$3s^2 3p^6 3d^3_{3/2} 3d^6_{5/2} 4s^2 4p_{1/2}$	1^-	1688.07	1.78×10^{-13}	
90	98.9	$3s^2 3p^6 3d^4_{3/2} 3d^5_{5/2} 4s^2 4p_{3/2}$	4^-	1718.43	1.89×10^{-10}	
91	98.5	$3s^2 3p^6 3d^4_{3/2} 3d^5_{5/2} 4s^2 4p_{3/2}$	2^-	1720.43	1.75×10^{-10}	
92	98.1	$3s^2 3p^6 3d^4_{3/2} 3d^5_{5/2} 4s^2 4p_{3/2}$	1^-	1722.01	1.01×10^{-13}	
93	98.9	$3s^2 3p^6 3d^4_{3/2} 3d^5_{5/2} 4s^2 4p_{3/2}$	3^-	1723.27	1.78×10^{-10}	
97	98.6	$3s^2 3p^6 3d^3_{3/2} 3d^6_{5/2} 4s^2 4p_{3/2}$	1^-	1785.84	7.99×10^{-13}	
98	98.9	$3s^2 3p^6 3d^3_{3/2} 3d^6_{5/2} 4s^2 4p_{3/2}$	3^-	1785.92	7.45×10^{-11}	
105	44.1	$3s^2 3p^6 3d^4_{3/2} [(3d^5_{5/2} 4s_{1/2})_2 4p_{1/2}]_{3/2} 4p_{3/2}$	2^+	1811.99	4.21×10^{-13}	
118	63.3	$3s^2 3p^6 [(3d^3_{3/2} 3d^6_{5/2} 4s_{1/2})_2 4p_{1/2}]_{3/2} 4p_{3/2}$	3^+	1869.65	3.81×10^{-13}	
124	64.8	$3s^2 3p^6 3d^4_{3/2} 3d^5_{5/2} 4s^2 4d_{3/2}$	2^+	1878.84	4.34×10^{-13}	
125	44.0	$3s^2 3p^6 [(3d^3_{3/2} 3d^6_{5/2} 4s_{1/2})_1 4p_{1/2}]_{3/2} 4p_{3/2}$	3^+	1878.95	3.05×10^{-13}	
126	30.3	$3s^2 3p^6 [(3d^3_{3/2} 3d^6_{5/2} 4s_{1/2})_1 4p_{1/2}]_{1/2} 4p_{3/2}$	2^+	1879.69	1.92×10^{-13}	
133	75.8	$3s^2 3p^6 3d^4_{3/2} 3d^5_{5/2} 4s^2 4d_{5/2}$	1^+	1892.72	1.03×10^{-12}	
136	74.4	$3s^2 3p^6 3d^4_{3/2} 3d^5_{5/2} 4s^2 4d_{5/2}$	3^+	1896.25	7.42×10^{-13}	
138	73.3	$3s^2 3p^6 3d^4_{3/2} 3d^5_{5/2} 4s^2 4d_{5/2}$	2^+	1897.81	4.96×10^{-13}	
139	75.2	$3s^2 3p^6 3d^4_{3/2} (3d^5_{5/2} 4s_{1/2})_2 (4p^2_{3/2})_2$	0^+	1905.81	2.90×10^{-13}	
144	53.9	$3s^2 3p^6 3d^4_{3/2} (3d^5_{5/2} 4s_{1/2})_2 (4p^2_{3/2})_2$	2^+	1917.24	1.47×10^{-13}	
191	48.4	$3s^2 3p^6 3d^3_{3/2} 3d^6_{5/2} 4s^2 4d_{3/2}$	0^+	1985.96	5.32×10^{-13}	
214	72.3	$3s^2 3p^6 (3d^3_{3/2} 3d^6_{5/2} 4s_{1/2})_2 (4p^2_{3/2})_2$	0^+	2001.16	4.75×10^{-13}	
292	21.7	$3s^2 3p^6 [(3d^3_{3/2} 3d^6_{5/2} 4s_{1/2})_2 4p_{1/2}]_{5/2} 4d_{3/2}$	1^-	2075.14	4.43×10^{-14}	
298	98.4	$3s^2 3p^2_{1/2} 3p^3_{3/2} 3d^{10} 4s^2 4p_{1/2}$	2^+	2076.74	5.79×10^{-14}	
303	34.1	$3s^2 3p^6 3d^4_{3/2} 3d^5_{5/2} 4s^2 4f_{7/2}$	1^-	2082.57	2.00×10^{-14}	
308	21.1	$3s^2 3p^6 3d^4_{3/2} [(3d^5_{5/2} 4s_{1/2})_2 4p_{3/2}]_{5/2} 4d_{5/2}$	1^-	2085.35	7.35×10^{-14}	
327	20.4	$3s^2 3p^6 3d^4_{3/2} [(3d^5_{5/2} 4s_{1/2})_3 4p_{3/2}]_{3/2} 4d_{3/2}$	1^-	2090.99	1.37×10^{-13}	
344	30.8	$3s^2 3p^6 3d^4_{3/2} [(3d^5_{5/2} 4s_{1/2})_3 4p_{3/2}]_{3/2} 4d_{5/2}$	1^-	2103.23	5.89×10^{-14}	
365	25.2	$3s^2 3p^6 3d^4_{3/2} [(3d^5_{5/2} 4s_{1/2})_3 4p_{3/2}]_{5/2} 4d_{5/2}$	1^-	2124.57	7.57×10^{-14}	
392	79.2	$3s^2 3p^6 3d^4_{3/2} 3d^5_{5/2} 4p^3_{3/2}$	1^-	2139.87	6.65×10^{-14}	
394	36.9	$3s^2 3p^6 [(3d^3_{3/2} 3d^6_{5/2} 4s_{1/2})_2 4p_{3/2}]_{1/2} 4d_{3/2}$	1^-	2141.32	9.42×10^{-15}	
414	28.6	$3s^2 3p^6 [(3d^3_{3/2} 3d^6_{5/2} 4s_{1/2})_2 4p_{3/2}]_{5/2} 4d_{5/2}$	1^-	2150.58	2.31×10^{-14}	
418	60.7	$3s^2 3p^6 [(3d^3_{3/2} 3d^6_{5/2} 4s_{1/2})_1 4p_{3/2}]_{3/2} 4d_{5/2}$	1^-	2151.04	9.50×10^{-14}	
448	42.9	$3s^2 3p^6 3d^3_{3/2} 3d^6_{5/2} 4s^2 4f_{5/2}$	1^-	2158.98	5.46×10^{-15}	
484	47.9	$3s^2 3p^6 [(3d^3_{3/2} 3d^6_{5/2} 4s_{1/2})_2 4p_{3/2}]_{7/2} 4d_{5/2}$	1^-	2171.12	2.23×10^{-13}	
489	44.9	$3s^2 3p^6 [(3d^3_{3/2} 3d^6_{5/2} 4s_{1/2})_1 4p_{3/2}]_{5/2} 4d_{5/2}$	1^-	2172.86	2.27×10^{-13}	
508	64.5	$3s^2 3p^6 [(3d^3_{3/2} 3d^6_{5/2} 4s_{1/2})_2 4p_{3/2}]_{3/2} 4d_{5/2}$	1^-	2178.77	7.82×10^{-14}	
535	28.6	$3s^2 3p^6 3d^3_{3/2} 3d^6_{5/2} 4p^3_{3/2}$	1^-	2192.47	4.22×10^{-14}	
544	93.0	$3s^2 3p^2_{1/2} 3p^3_{3/2} 3d^{10} 4s^2 4p_{3/2}$	0^+	2200.14	4.03×10^{-14}	
555	53.4	$3s^2 3p^6 3d^3_{3/2} 3d^6_{5/2} 4p^3_{3/2}$	1^-	2204.63	1.31×10^{-13}	
630	13.8	$3s^2 3p^6 [(3d^3_{3/2} 3d^6_{5/2} 4s_{1/2})_2 4p_{1/2}]_{3/2} 4f_{5/2}$	1^+	2240.09	9.03×10^{-15}	
1021	91.7	$3s^2 3p^2_{1/2} 3p^3_{3/2} 3d^{10} 4s^2 4d_{3/2}$	3^-	2335.63	5.46×10^{-14}	
1098	68.1	$3s^2 3p^2_{1/2} 3p^3_{3/2} 3d^{10} 4s^2 4d_{5/2}$	1^-	2353.46	1.20×10^{-14}	
1189	37.4	$3s^2 3p^2_{1/2} (3p^3_{3/2} 3d^{10} 4s_{1/2})_1 (4p^2_{3/2})_2$	1^-	2370.77	2.90×10^{-14}	2.19×10^{-14}
2159	36.7	$3s^2 3p^2_{1/2} [(3p^3_{3/2} 3d^{10} 4s_{1/2})_1 4p_{3/2}]_{1/2} 4d_{3/2}$	2^+	2525.51	4.84×10^{-14}	2.66×10^{-14}
2224	34.1	$3s^2 3p^2_{1/2} 3p^3_{3/2} 3d^{10} 4s^2 4f_{7/2}$	2^+	2532.34	3.90×10^{-14}	3.61×10^{-14}
2945	63.3	$3s_{1/2} 3p^6 3d^{10} 4s^2 4p_{1/2}$	1^-	2624.83	1.95×10^{-14}	6.54×10^{-15}
4806	30.7	$3s^2 3p_{1/2} 3p^4_{3/2} 3d^{10} 4s^2 4f_{5/2}$	2^+	2821.61	2.62×10^{-14}	1.85×10^{-14}
11470	61.2	$3s^2 3p^6 3d^{10} 4s_{1/2} 5p_{3/2}$	1^-	1041.05	1.44×10^{-13}	
11476	98.4	$3s^2 3p^6 3d^{10} 4s_{1/2} 5d_{3/2}$	2^+	1117.70	1.68×10^{-13}	
11488	88.0	$3s^2 3p^6 3d^{10} 4s_{1/2} 5f_{7/2}$	3^-	1203.07	9.69×10^{-14}	
11699	99.7	$3s^2 3p^6 3d^{10} 4s_{1/2} 6s_{1/2}$	0^+	1422.90	1.36×10^{-13}	
11703	99.0	$3s^2 3p^6 3d^{10} 4s_{1/2} 6p_{3/2}$	1^-	1473.71	1.91×10^{-13}	
11708	99.1	$3s^2 3p^6 3d^{10} 4s_{1/2} 6d_{5/2}$	2^+	1519.52	1.68×10^{-13}	

(*continued on next page*)

Table 3 (*continued*)

Index	Purity (%)	Configuration	J^{π}	E (eV)	τ_{rad} (s)	τ_{level} (s)
11713	97.8	$3s^2 3p^6 3d^{10} 4s_{1/2} 6f_{5/2}$	3^-	1559.18	1.10×10^{-13}	
11715	97.5	$3s^2 3p^6 3d^{10} 4s_{1/2} 6f_{7/2}$	3^-	1561.07	1.10×10^{-13}	
12148	38.9	$3s^2 3p^6 3d^4_{3/2} [(3d^5_{5/2} 4s_{1/2})_2 4p_{1/2}]_{5/2} 5d_{3/2}$	1^-	2748.78	4.39×10^{-14}	3.50×10^{-14}
12154	50.8	$3s^2 3p^6 3d^4_{3/2} 3d^5_{5/2} 4s^2 5f_{7/2}$	1^-	2750.19	1.53×10^{-14}	1.13×10^{-14}
12276	71.3	$3s^2 3p^6 3d^3_{3/2} 3d^6_{5/2} 4s^2 5f_{5/2}$	1^-	2811.57	1.00×10^{-14}	7.65×10^{-15}
12289	45.2	$3s^2 3p^6 [(3d^3_{3/2} 3d^6_{5/2} 4s_{1/2})_1 4p_{1/2}]_{1/2} 5d_{3/2}$	1^-	2819.19	3.19×10^{-14}	2.06×10^{-14}
13626	80.4	$3s^2 3p^2_{1/2} 3p^3_{3/2} 3d^{10} 4s^2 5d_{5/2}$	1^-	3121.26	1.45×10^{-14}	1.35×10^{-14}
13911	75.2	$3s^2 3p^2_{1/2} 3p^3_{3/2} 3d^{10} 4s^2 5f_{7/2}$	2^+	3199.94	3.13×10^{-14}	3.07×10^{-14}
15691	92.3	$3s^2 3p^6 3d^4_{3/2} 3d^5_{5/2} 4s^2 6f_{7/2}$	1^-	3107.86	1.50×10^{-14}	1.29×10^{-14}
15817	97.2	$3s^2 3p^6 3d^3_{3/2} 3d^6_{5/2} 4s^2 6f_{5/2}$	1^-	3171.04	1.59×10^{-14}	1.36×10^{-14}
17820	96.4	$3s^2 3p^2_{1/2} 3p^3_{3/2} 3d^{10} 4s^2 6d_{5/2}$	1^-	3517.26	1.86×10^{-14}	1.84×10^{-14}

Table 4
Energy levels in Cu-like tungsten, W^{45+}.

Index	Purity (%)	Configuration	J^π	E (eV)	τ_{rad} (s)	τ_{level} (s)
0	99.9	$3s^2 3p^6 3d^{10} 4s_{1/2}$	$1/2^+$	0.00		
1	99.9	$3s^2 3p^6 3d^{10} 4p_{1/2}$	$1/2^-$	97.59	2.09×10^{-11}	
2	99.9	$3s^2 3p^6 3d^{10} 4p_{3/2}$	$3/2^-$	198.91	2.36×10^{-12}	
3	99.9	$3s^2 3p^6 3d^{10} 4d_{3/2}$	$3/2^+$	349.51	1.18×10^{-12}	
4	99.9	$3s^2 3p^6 3d^{10} 4d_{5/2}$	$5/2^+$	371.05	3.04×10^{-12}	
5	99.9	$3s^2 3p^6 3d^{10} 4f_{5/2}$	$5/2^-$	532.23	3.23×10^{-12}	
6	99.9	$3s^2 3p^6 3d^{10} 4f_{7/2}$	$7/2^-$	537.66	4.13×10^{-12}	
7	99.2	$3s^2 3p^6 3d^4_{3/2} 3d^5_{5/2} 4s^2$	$5/2^+$	1547.66	1.84×10^{-10}	
8	99.3	$3s^2 3p^6 3d^3_{3/2} 3d^6_{5/2} 4s^2$	$3/2^+$	1613.95	8.09×10^{-11}	
9	76.7	$3s^2 3p^6 3d^4_{3/2} (3d^5_{5/2} 4s_{1/2})_3 4p_{1/2}$	$5/2^-$	1632.13	5.72×10^{-10}	
11	75.9	$3s^2 3p^6 3d^4_{3/2} (3d^5_{5/2} 4s_{1/2})_2 4p_{1/2}$	$5/2^-$	1639.57	5.19×10^{-11}	
13	64.8	$3s^2 3p^6 (3d^3_{3/2} 3d^6_{5/2} 4s_{1/2})_1 4p_{1/2}$	$3/2^-$	1698.73	1.24×10^{-12}	
14	98.4	$3s^2 3p^6 (3d^3_{3/2} 3d^6_{5/2} 4s_{1/2})_2 4p_{1/2}$	$5/2^-$	1705.86	4.49×10^{-11}	
15	63.9	$3s^2 3p^6 (3d^3_{3/2} 3d^6_{5/2} 4s_{1/2})_2 4p_{1/2}$	$3/2^-$	1707.30	1.94×10^{-13}	
16	98.4	$3s^2 3p^6 (3d^3_{3/2} 3d^6_{5/2} 4s_{1/2})_1 4p_{1/2}$	$1/2^-$	1708.40	1.83×10^{-13}	
18	56.2	$3s^2 3p^6 3d^4_{3/2} (3d^5_{5/2} 4s_{1/2})_2 4p_{3/2}$	$5/2^-$	1736.77	8.85×10^{-11}	
19	88.7	$3s^2 3p^6 3d^4_{3/2} (3d^5_{5/2} 4s_{1/2})_2 4p_{3/2}$	$3/2^-$	1736.99	2.45×10^{-13}	
20	57.6	$3s^2 3p^6 3d^4_{3/2} (3d^5_{5/2} 4s_{1/2})_3 4p_{3/2}$	$7/2^-$	1737.54	2.37×10^{-10}	
21	99.0	$3s^2 3p^6 3d^4_{3/2} (3d^5_{5/2} 4s_{1/2})_2 4p_{3/2}$	$1/2^-$	1738.13	9.89×10^{-14}	
24	87.6	$3s^2 3p^6 3d^4_{3/2} (3d^5_{5/2} 4s_{1/2})_3 4p_{3/2}$	$3/2^-$	1752.57	1.32×10^{-13}	
26	88.8	$3s^2 3p^6 (3d^3_{3/2} 3d^6_{5/2} 4s_{1/2})_1 4p_{3/2}$	$1/2^-$	1797.62	2.74×10^{-12}	
27	72.5	$3s^2 3p^6 (3d^3_{3/2} 3d^6_{5/2} 4s_{1/2})_1 4p_{3/2}$	$3/2^-$	1801.43	9.83×10^{-13}	
28	99.8	$3s^2 3p^6 (3d^3_{3/2} 3d^6_{5/2} 4s_{1/2})_2 4p_{3/2}$	$7/2^-$	1801.68	2.00×10^{-10}	
31	87.8	$3s^2 3p^6 (3d^3_{3/2} 3d^6_{5/2} 4s_{1/2})_2 4p_{3/2}$	$1/2^-$	1817.19	4.35×10^{-13}	
56	66.9	$3s^2 3p^6 (3d^3_{3/2} 3d^6_{5/2} 4p_{1/2})_1 4p_{3/2}$	$5/2^+$	1909.76	2.28×10^{-13}	
57	68.9	$3s^2 3p^6 (3d^3_{3/2} 3d^6_{5/2} 4p_{1/2})_1 4p_{3/2}$	$3/2^+$	1910.67	2.49×10^{-13}	
58	47.2	$3s^2 3p^6 3d^4_{3/2} (3d^5_{5/2} 4s_{1/2})_2 4d_{5/2}$	$3/2^+$	1911.39	3.43×10^{-13}	
64	60.2	$3s^2 3p^6 3d^4_{3/2} (3d^5_{5/2} 4s_{1/2})_3 4d_{5/2}$	$5/2^+$	1920.84	7.17×10^{-13}	
65	50.9	$3s^2 3p^6 3d^4_{3/2} (3d^5_{5/2} 4s_{1/2})_3 4d_{5/2}$	$3/2^+$	1920.85	8.42×10^{-13}	
67	36.4	$3s^2 3p^6 3d^4_{3/2} (3d^5_{5/2} 4s_{1/2})_3 4d_{5/2}$	$1/2^+$	1932.63	5.62×10^{-13}	
96	98.4	$3s^2 3p^2_{1/2} 3p^3_{3/2} 3d^{10} 4s^2$	$3/2^-$	2002.58	5.64×10^{-14}	
97	31.1	$3s^2 3p^6 (3d^3_{3/2} 3d^6_{5/2} 4s_{1/2})_2 4d_{3/2}$	$1/2^+$	2002.73	5.90×10^{-13}	
111	64.8	$3s^2 3p^6 3d^3_{3/2} 3d^6_{5/2} (4p^2_{3/2})_2$	$1/2^+$	2017.33	3.60×10^{-13}	
145	46.8	$3s^2 3p^6 3d^4_{3/2} (3d^5_{5/2} 4s_{1/2})_3 4f_{7/2}$	$7/2^-$	2083.44	1.69×10^{-12}	
151	84.3	$3s^2 3p^6 3d^4_{3/2} (3d^5_{5/2} 4p_{3/2})_2 4d_{3/2}$	$1/2^-$	2089.44	1.55×10^{-13}	
152	43.3	$3s^2 3p^6 3d^4_{3/2} (3d^5_{5/2} 4p_{3/2})_3 4d_{3/2}$	$3/2^-$	2090.51	1.34×10^{-13}	
158	34.0	$3s^2 3p^6 3d^4_{3/2} (3d^5_{5/2} 4s_{1/2})_2 4f_{7/2}$	$3/2^-$	2094.94	1.26×10^{-14}	
159	83.1	$3s^2 3p^2_{1/2} (3p^3_{3/2} 3d^{10} 4s_{1/2})_1 4p_{1/2}$	$3/2^+$	2095.09	5.21×10^{-14}	
163	58.5	$3s^2 3p^6 3d^4_{3/2} (3d^5_{5/2} 4s_{1/2})_3 4f_{7/2}$	$1/2^-$	2097.71	9.96×10^{-15}	
168	44.2	$3s^2 3p^6 3d^4_{3/2} (3d^5_{5/2} 4p_{3/2})_1 4d_{3/2}$	$3/2^-$	2102.68	4.02×10^{-14}	
174	37.3	$3s^2 3p^6 3d^4_{3/2} (3d^5_{5/2} 4p_{3/2})_1 4d_{5/2}$	$3/2^-$	2109.31	4.08×10^{-14}	
190	24.1	$3s^2 3p^6 3d^4_{3/2} (3d^5_{5/2} 4p_{3/2})_3 4d_{5/2}$	$3/2^-$	2137.04	1.21×10^{-13}	
205	69.0	$3s^2 3p^6 (3d^3_{3/2} 3d^6_{5/2} 4p_{3/2})_0 4d_{3/2}$	$3/2^-$	2155.20	2.49×10^{-14}	
206	55.5	$3s^2 3p^6 (3d^3_{3/2} 3d^6_{5/2} 4p_{3/2})_1 4d_{3/2}$	$1/2^-$	2155.72	4.95×10^{-14}	
209	56.2	$3s^2 3p^6 (3d^3_{3/2} 3d^6_{5/2} 4p_{3/2})_1 4d_{3/2}$	$3/2^-$	2158.35	1.24×10^{-14}	
218	80.6	$3s^2 3p^6 (3d^3_{3/2} 3d^6_{5/2} 4s_{1/2})_2 4f_{5/2}$	$1/2^-$	2168.60	2.59×10^{-15}	
222	34.4	$3s^2 3p^6 (3d^3_{3/2} 3d^6_{5/2} 4s_{1/2})_1 4f_{5/2}$	$3/2^-$	2169.76	4.19×10^{-15}	
238	48.8	$3s^2 3p^6 (3d^3_{3/2} 3d^6_{5/2} 4p_{3/2})_3 4d_{5/2}$	$3/2^-$	2178.58	1.21×10^{-13}	
248	61.3	$3s^2 3p^6 (3d^3_{3/2} 3d^6_{5/2} 4p_{3/2})_1 4d_{5/2}$	$3/2^-$	2188.43	9.09×10^{-14}	
251	56.6	$3s^2 3p^2_{1/2} (3p^3_{3/2} 3d^{10} 4s_{1/2})_2 4p_{3/2}$	$5/2^+$	2192.18	9.22×10^{-14}	
256	86.8	$3s^2 3p^2_{1/2} (3p^3_{3/2} 3d^{10} 4s_{1/2})_1 4p_{3/2}$	$1/2^+$	2196.98	4.60×10^{-14}	
262	24.0	$3s^2 3p^6 (3d^3_{3/2} 3d^6_{5/2} 4p_{3/2})_3 4d_{3/2}$	$3/2^-$	2209.85	4.35×10^{-14}	
264	85.2	$3s^2 3p^2_{1/2} (3p^3_{3/2} 3d^{10} 4s_{1/2})_2 4p_{3/2}$	$1/2^+$	2222.40	1.28×10^{-13}	
417	87.1	$3s^2 3p^2_{1/2} (3p^3_{3/2} 3d^{10} 4s_{1/2})_1 4d_{3/2}$	$1/2^-$	2351.40	2.41×10^{-14}	
437	86.5	$3s^2 3p^2_{1/2} (3p^3_{3/2} 3d^{10} 4s_{1/2})_1 4d_{5/2}$	$3/2^-$	2370.04	9.79×10^{-15}	
441	80.4	$3s^2 3p^2_{1/2} (3p^3_{3/2} 3d^{10} 4s_{1/2})_2 4d_{5/2}$	$1/2^-$	2373.80	1.46×10^{-14}	
442	73.6	$3s^2 3p^2_{1/2} (3p^3_{3/2} 3d^{10} 4s_{1/2})_2 4d_{5/2}$	$3/2^-$	2375.32	5.26×10^{-14}	
454	63.2	$3s^2 (3p_{1/2} 3p^4_{3/2} 3d^{10} 4s_{1/2})_1 4p_{1/2}$	$1/2^+$	2414.31	9.85×10^{-14}	
662	71.5	$3s^2 3p^2_{1/2} (3p^3_{3/2} 3d^{10} 4s_{1/2})_1 4f_{7/2}$	$5/2^+$	2541.30	3.83×10^{-14}	3.58×10^{-14}
663	40.7	$3s^2 3p^2_{1/2} (3p^3_{3/2} 3d^{10} 4s_{1/2})_2 4f_{7/2}$	$3/2^+$	2541.47	1.37×10^{-13}	1.36×10^{-13}
773	70.7	$(3s_{1/2} 3p^6 3d^{10} 4s_{1/2})_1 4p_{1/2}$	$3/2^-$	2638.29	2.13×10^{-14}	2.07×10^{-14}
781	42.8	$3s^2 (3p_{1/2} 3p^4_{3/2} 3d^{10} 4s_{1/2})_1 4d_{3/2}$	$3/2^-$	2662.95	4.25×10^{-14}	4.05×10^{-14}
907	72.3	$3s^2 (3p_{1/2} 3p^4_{3/2} 3d^{10} 4s_{1/2})_0 4f_{5/2}$	$5/2^+$	2833.17	5.10×10^{-14}	
909	56.2	$3s^2 (3p_{1/2} 3p^4_{3/2} 3d^{10} 4s_{1/2})_1 4f_{5/2}$	$5/2^+$	2835.39	3.51×10^{-14}	3.48×10^{-14}
1302	100.0	$3s^2 3p^6 3d^{10} 5p_{1/2}$	$1/2^-$	1016.17	1.19×10^{-13}	
1303	100.0	$3s^2 3p^6 3d^{10} 5p_{3/2}$	$3/2^-$	1063.73	1.87×10^{-13}	
1304	100.0	$3s^2 3p^6 3d^{10} 5d_{3/2}$	$3/2^+$	1135.41	1.70×10^{-13}	

(continued on next page)

Table 4 (*continued*)

Index	Purity (%)	Configuration	J^{π}	E (eV)	τ_{rad} (s)	τ_{level} (s)
1307	100.0	$3s^2 3p^6 3d^{10} 5f_{7/2}$	$7/2^-$	1220.34	8.84×10^{-14}	
1310	100.0	$3s^2 3p^6 3d^{10} 6s_{1/2}$	$1/2^+$	1449.68	1.24×10^{-13}	
1314	100.0	$3s^2 3p^6 3d^{10} 6d_{5/2}$	$5/2^+$	1548.45	1.55×10^{-13}	
1315	100.0	$3s^2 3p^6 3d^{10} 6f_{5/2}$	$5/2^-$	1587.27	1.03×10^{-13}	
1316	100.0	$3s^2 3p^6 3d^{10} 6f_{7/2}$	$7/2^-$	1589.23	1.02×10^{-13}	
1448	81.1	$3s^2 3p^6 3d^4_{3/2} (3d^5_{5/2} 4s_{1/2})_3 5f_{7/2}$	$1/2^-$	2780.50	1.04×10^{-14}	8.86×10^{-15}
1451	65.6	$3s^2 3p^6 3d^4_{3/2} (3d^5_{5/2} 4s_{1/2})_2 5f_{7/2}$	$3/2^-$	2783.11	9.59×10^{-15}	8.38×10^{-15}
1542	82.3	$3s^2 3p^6 (3d^3_{3/2} 3d^6_{5/2} 4s_{1/2})_2 5f_{5/2}$	$1/2^-$	2843.41	8.40×10^{-15}	7.72×10^{-15}
1543	59.4	$3s^2 3p^6 (3d^3_{3/2} 3d^6_{5/2} 4s_{1/2})_1 5f_{5/2}$	$3/2^-$	2844.69	7.64×10^{-15}	6.49×10^{-15}
1912	84.6	$3s^2 3p^2_{1/2} (3p^3_{3/2} 3d^{10} 4s_{1/2})_2 5d_{5/2}$	$1/2^-$	3150.21	1.65×10^{-14}	1.58×10^{-14}
1917	94.0	$3s^2 3p^2_{1/2} (3p^3_{3/2} 3d^{10} 4s_{1/2})_1 5d_{5/2}$	$3/2^-$	3154.74	1.45×10^{-14}	1.41×10^{-14}
1954	76.4	$3s^2 3p^2_{1/2} (3p^3_{3/2} 3d^{10} 4s_{1/2})_1 5f_{7/2}$	$5/2^+$	3231.20	3.27×10^{-14}	
2460	93.0	$3s^2 3p^6 3d^4_{3/2} (3d^5_{5/2} 4s_{1/2})_3 6f_{7/2}$	$1/2^-$	3150.67	1.47×10^{-14}	1.39×10^{-14}
2461	69.8	$3s^2 3p^6 3d^4_{3/2} (3d^5_{5/2} 4s_{1/2})_2 6f_{7/2}$	$3/2^-$	3151.94	1.47×10^{-14}	1.35×10^{-14}
2582	54.7	$3s^2 3p^6 (3d^3_{3/2} 3d^6_{5/2} 4s_{1/2})_2 6f_{5/2}$	$3/2^-$	3214.74	1.55×10^{-14}	1.38×10^{-14}
2583	98.6	$3s^2 3p^6 (3d^3_{3/2} 3d^6_{5/2} 4s_{1/2})_2 6f_{5/2}$	$1/2^-$	3215.02	1.51×10^{-14}	1.48×10^{-14}

Table 5
Energy levels in Ni-like tungsten, W^{46+}.

Index	Purity (%)	Configuration	J^π	E (eV)	τ_{rad} (s)	τ_{level} (s)
0	99.9	$3s^2 3p^6 3d^{10}$	0^+	0.00		
1	99.9	$3s^2 3p^6 3d_{3/2}^4 3d_{5/2}^5 4s_{1/2}$	3^+	1562.15	1.09×10^{-4}	8.23×10^{-6}
2	99.9	$3s^2 3p^6 3d_{3/2}^4 3d_{5/2}^5 4s_{1/2}$	2^+	1564.07	1.71×10^{-10}	
4	99.9	$3s^2 3p^6 3d_{3/2}^3 3d_{5/2}^6 4s_{1/2}$	2^+	1629.99	2.24×10^{-10}	
8	99.4	$3s^2 3p^6 3d_{3/2}^3 3d_{5/2}^6 4p_{1/2}$	1^-	1728.69	1.61×10^{-13}	
11	98.9	$3s^2 3p^6 3d_{3/2}^4 3d_{5/2}^5 4p_{3/2}$	1^-	1764.83	8.31×10^{-14}	
14	99.4	$3s^2 3p^6 3d_{3/2}^3 3d_{5/2}^6 4p_{3/2}$	1^-	1829.45	5.79×10^{-13}	
35	99.6	$3s^2 3p_{1/2}^2 3p_{3/2}^3 3d^{10} 4s_{1/2}$	1^-	2017.39	4.31×10^{-14}	
50	78.6	$3s^2 3p^6 3d_{3/2}^4 3d_{5/2}^5 4f_{7/2}$	1^-	2112.57	7.82×10^{-15}	
58	86.7	$3s^2 3p^6 3d_{3/2}^3 3d_{5/2}^6 4f_{5/2}$	1^-	2181.36	2.46×10^{-15}	
71	97.6	$3s^2 3p_{1/2}^2 3p_{3/2}^3 3d^{10} 4d_{5/2}$	1^-	2386.03	1.03×10^{-14}	
84	79.2	$3s^2 3p_{1/2}^2 3p_{3/2}^3 3d^{10} 4f_{7/2}$	2^+	2554.73	3.73×10^{-13}	
87	79.3	$3s_{1/2} 3p^6 3d^{10} 4p_{1/2}$	1^-	2655.04	2.04×10^{-14}	
90	79.5	$3s^2 3p_{1/2} 3p_{3/2}^4 3d^{10} 4d_{3/2}$	1^-	2678.60	4.11×10^{-14}	
94	99.7	$3s_{1/2} 3p^6 3d^{10} 4p_{3/2}$	1^-	2765.65	5.07×10^{-14}	
141	95.6	$3s^2 3p^6 3d_{3/2}^3 3d_{5/2}^6 5d_{3/2}$	0^+	2800.06	1.47×10^{-13}	
152	90.9	$3s^2 3p^6 3d_{3/2}^4 3d_{5/2}^5 5f_{7/2}$	1^-	2814.90	8.75×10^{-15}	
172	97.5	$3s^2 3p^6 3d_{3/2}^3 3d_{5/2}^6 5f_{5/2}$	1^-	2877.30	6.92×10^{-15}	
195	98.1	$3s^2 3p_{1/2}^2 3p_{3/2}^3 3d^{10} 5d_{5/2}$	1^-	3183.88	1.42×10^{-14}	
286	93.4	$3s^2 3p^6 3d_{3/2}^4 3d_{5/2}^5 6f_{7/2}$	1^-	3195.47	1.41×10^{-14}	
326	99.3	$3s^2 3p^6 3d_{3/2}^3 3d_{5/2}^6 6f_{5/2}$	1^-	3258.94	1.45×10^{-14}	

Table 6
Energy levels in Co-like tungsten, W^{47+}.

Index	Purity (%)	Configuration	J^π	E (eV)	τ_{rad} (s)	τ_{level} (s)
0	100.0	$3s^2 3p^6 3d_{3/2}^4 3d_{5/2}^5$	$5/2^+$	0.00		
1	100.0	$3s^2 3p^6 3d_{3/2}^3 3d_{5/2}^6$	$3/2^+$	66.77	4.00×10^{-7}	3.93×10^{-7}
2	100.0	$3s^2 3p_{1/2}^2 3p_{3/2}^3 3d^{10}$	$3/2^-$	449.64	5.27×10^{-13}	
5	98.9	$3s^2 3p^6 3d_{3/2}^4 (3d_{5/2}^4)_4 4s_{1/2}$	$9/2^+$	1604.91	1.28×10^{-9}	
6	99.1	$3s^2 3p^6 3d_{3/2}^4 (3d_{5/2}^4)_4 4s_{1/2}$	$7/2^+$	1608.03	8.55×10^{-11}	
7	99.7	$3s^2 3p^6 3d_{3/2}^4 (3d_{5/2}^4)_2 4s_{1/2}$	$5/2^+$	1614.52	2.61×10^{-10}	
8	99.4	$3s^2 3p^6 3d_{3/2}^4 (3d_{5/2}^4)_2 4s_{1/2}$	$3/2^+$	1615.99	9.99×10^{-11}	
9	98.3	$3s^2 3p^6 3d_{3/2}^4 (3d_{5/2}^4)_0 4s_{1/2}$	$1/2^+$	1634.29	1.21×10^{-10}	
10	99.6	$3s^2 3p^6 (3d_{3/2}^3 3d_{5/2}^5)_3 4s_{1/2}$	$7/2^+$	1670.95	2.15×10^{-10}	
11	97.6	$3s^2 3p^6 (3d_{3/2}^3 3d_{5/2}^5)_3 4s_{1/2}$	$5/2^+$	1671.69	1.66×10^{-10}	
12	97.2	$3s^2 3p^6 (3d_{3/2}^3 3d_{5/2}^5)_2 4s_{1/2}$	$5/2^+$	1680.32	1.76×10^{-10}	
14	90.3	$3s^2 3p^6 (3d_{3/2}^3 3d_{5/2}^5)_1 4s_{1/2}$	$3/2^+$	1685.47	1.43×10^{-10}	
15	98.9	$3s^2 3p^6 (3d_{3/2}^3 3d_{5/2}^5)_4 4s_{1/2}$	$9/2^+$	1685.90	1.79×10^{-10}	
16	99.0	$3s^2 3p^6 (3d_{3/2}^3 3d_{5/2}^5)_4 4s_{1/2}$	$7/2^+$	1686.51	1.34×10^{-10}	
18	98.8	$3s^2 3p^6 3d_{3/2}^4 (3d_{5/2}^4)_4 4p_{1/2}$	$7/2^-$	1700.37	1.51×10^{-11}	
25	98.9	$3s^2 3p^6 (3d_{3/2}^3 3d_{5/2}^5)_3 4p_{1/2}$	$7/2^-$	1766.52	1.57×10^{-12}	
26	94.7	$3s^2 3p^6 (3d_{3/2}^3 3d_{5/2}^5)_3 4p_{1/2}$	$5/2^-$	1767.01	3.53×10^{-13}	
28	90.5	$3s^2 3p^6 (3d_{3/2}^3 3d_{5/2}^5)_2 4p_{1/2}$	$3/2^-$	1775.37	8.04×10^{-13}	
29	94.2	$3s^2 3p^6 (3d_{3/2}^3 3d_{5/2}^5)_2 4p_{1/2}$	$5/2^-$	1776.99	2.55×10^{-13}	
32	97.7	$3s^2 3p^6 (3d_{3/2}^3 3d_{5/2}^5)_4 4p_{1/2}$	$7/2^-$	1783.01	1.44×10^{-13}	
33	90.9	$3s^2 3p^6 (3d_{3/2}^3 3d_{5/2}^5)_1 4p_{1/2}$	$3/2^-$	1783.09	1.73×10^{-13}	
36	84.4	$3s^2 3p^6 3d_{3/2}^4 (3d_{5/2}^4)_4 4p_{3/2}$	$7/2^-$	1810.14	1.53×10^{-13}	
37	93.9	$3s^2 3p^6 3d_{3/2}^4 (3d_{5/2}^4)_4 4p_{3/2}$	$5/2^-$	1810.53	1.25×10^{-13}	
38	94.5	$3s^2 3p^6 3d_{3/2}^4 (3d_{5/2}^4)_2 4p_{3/2}$	$5/2^-$	1816.45	1.23×10^{-13}	
39	85.9	$3s^2 3p^6 3d_{3/2}^4 (3d_{5/2}^4)_2 4p_{3/2}$	$7/2^-$	1818.92	1.43×10^{-12}	
41	95.6	$3s^2 3p^6 3d_{3/2}^4 (3d_{5/2}^4)_2 4p_{3/2}$	$3/2^-$	1820.29	9.39×10^{-14}	
42	94.7	$3s^2 3p^6 3d_{3/2}^4 (3d_{5/2}^4)_0 4p_{3/2}$	$3/2^-$	1837.84	5.03×10^{-13}	
47	89.3	$3s^2 3p^6 (3d_{3/2}^3 3d_{5/2}^5)_3 4p_{3/2}$	$5/2^-$	1873.15	6.88×10^{-13}	
48	97.0	$3s^2 3p^6 (3d_{3/2}^3 3d_{5/2}^5)_3 4p_{3/2}$	$7/2^-$	1874.33	9.44×10^{-13}	
49	96.8	$3s^2 3p^6 (3d_{3/2}^3 3d_{5/2}^5)_3 4p_{3/2}$	$3/2^-$	1875.05	1.26×10^{-13}	
50	82.5	$3s^2 3p^6 (3d_{3/2}^3 3d_{5/2}^5)_2 4p_{3/2}$	$5/2^-$	1881.28	5.05×10^{-13}	
52	86.3	$3s^2 3p^6 (3d_{3/2}^3 3d_{5/2}^5)_2 4p_{3/2}$	$3/2^-$	1884.26	1.27×10^{-13}	
55	95.0	$3s^2 3p^6 (3d_{3/2}^3 3d_{5/2}^5)_4 4p_{3/2}$	$5/2^-$	1887.20	9.22×10^{-14}	
58	92.5	$3s^2 3p^6 (3d_{3/2}^3 3d_{5/2}^5)_4 4p_{3/2}$	$7/2^-$	1890.35	9.46×10^{-13}	
102	99.5	$3s^2 3p_{1/2}^2 (3p_{3/2}^3 3d_{3/2}^4 3d_{5/2}^5)_4 4s_{1/2}$	$7/2^-$	2038.31	5.07×10^{-14}	
109	98.5	$3s^2 3p_{1/2}^2 (3p_{3/2}^3 3d_{3/2}^4 3d_{5/2}^5)_2 4s_{1/2}$	$5/2^-$	2045.37	1.22×10^{-13}	
110	98.1	$3s^2 3p_{1/2}^2 (3p_{3/2}^3 3d_{3/2}^4 3d_{5/2}^5)_2 4s_{1/2}$	$3/2^-$	2046.82	1.02×10^{-13}	
124	95.4	$3s^2 3p_{1/2}^2 (3p_{3/2}^3 3d_{3/2}^4 3d_{5/2}^5)_3 4s_{1/2}$	$7/2^-$	2060.79	1.47×10^{-13}	
125	95.5	$3s^2 3p_{1/2}^2 (3p_{3/2}^3 3d_{3/2}^4 3d_{5/2}^5)_3 4s_{1/2}$	$5/2^-$	2064.34	5.55×10^{-14}	
126	31.5	$3s^2 3p^6 (3d_{3/2}^3 3d_{5/2}^5)_4 4d_{3/2}$	$5/2^+$	2067.83	7.01×10^{-13}	
128	97.6	$3s^2 3p_{1/2}^2 (3p_{3/2}^3 3d_{3/2}^4 3d_{5/2}^5)_1 4s_{1/2}$	$3/2^-$	2072.70	5.99×10^{-14}	
155	74.4	$3s^2 3p^6 3d_{3/2}^4 (3d_{5/2}^4)_2 4f_{5/2}$	$5/2^-$	2131.08	4.07×10^{-13}	
160	63.2	$3s^2 3p^6 3d_{3/2}^4 (3d_{5/2}^4)_2 4f_{5/2}$	$7/2^-$	2133.61	6.90×10^{-13}	
161	77.7	$3s^2 3p^6 3d_{3/2}^4 (3d_{5/2}^4)_2 4f_{5/2}$	$3/2^-$	2135.59	1.68×10^{-13}	
164	43.8	$3s^2 3p^6 3d_{3/2}^4 (3d_{5/2}^4)_4 4f_{7/2}$	$7/2^-$	2137.72	7.19×10^{-13}	
170	62.1	$3s^2 3p^6 3d_{3/2}^4 (3d_{5/2}^4)_2 4f_{7/2}$	$5/2^-$	2143.49	2.12×10^{-13}	
172	63.2	$3s^2 3p^6 3d_{3/2}^4 (3d_{5/2}^4)_4 4f_{7/2}$	$3/2^-$	2145.12	1.31×10^{-14}	
174	40.7	$3s^2 3p^6 3d_{3/2}^4 (3d_{5/2}^4)_4 4f_{7/2}$	$5/2^-$	2153.51	1.15×10^{-14}	
175	61.2	$3s^2 3p^6 3d_{3/2}^4 (3d_{5/2}^4)_2 4f_{7/2}$	$7/2^-$	2155.44	9.17×10^{-15}	
178	72.3	$3s^2 3p^6 3d_{3/2}^4 (3d_{5/2}^4)_0 4f_{5/2}$	$5/2^-$	2158.00	3.22×10^{-14}	
179	92.5	$3s^2 3p^6 3d_{3/2}^4 (3d_{5/2}^4)_0 4f_{7/2}$	$7/2^-$	2164.29	5.13×10^{-14}	
186	53.5	$3s^2 3p^6 (3d_{3/2}^3 3d_{5/2}^5)_3 4f_{5/2}$	$5/2^-$	2192.77	1.37×10^{-13}	
187	60.7	$3s^2 3p^6 (3d_{3/2}^3 3d_{5/2}^5)_3 4f_{5/2}$	$7/2^-$	2194.77	1.70×10^{-13}	
200	39.1	$3s^2 3p^6 (3d_{3/2}^3 3d_{5/2}^5)_2 4f_{7/2}$	$7/2^-$	2205.23	6.89×10^{-13}	
205	41.7	$3s^2 3p^6 (3d_{3/2}^3 3d_{5/2}^5)_4 4f_{5/2}$	$7/2^-$	2208.72	1.64×10^{-13}	
206	44.9	$3s^2 3p^6 (3d_{3/2}^3 3d_{5/2}^5)_1 4f_{5/2}$	$5/2^-$	2209.11	1.98×10^{-13}	
207	44.5	$3s^2 3p^6 (3d_{3/2}^3 3d_{5/2}^5)_1 4f_{5/2}$	$7/2^-$	2209.11	1.25×10^{-13}	
222	52.5	$3s^2 3p^6 (3d_{3/2}^3 3d_{5/2}^5)_4 4f_{5/2}$	$3/2^-$	2220.76	3.53×10^{-15}	
227	25.3	$3s^2 3p^6 (3d_{3/2}^3 3d_{5/2}^5)_1 4f_{7/2}$	$5/2^-$	2224.96	5.14×10^{-15}	
228	26.7	$3s^2 3p^6 (3d_{3/2}^3 3d_{5/2}^5)_1 4f_{5/2}$	$7/2^-$	2227.47	2.36×10^{-15}	
229	45.6	$3s^2 3p^6 (3d_{3/2}^3 3d_{5/2}^5)_4 4f_{5/2}$	$5/2^-$	2228.45	3.20×10^{-15}	
230	38.0	$3s^2 3p^6 (3d_{3/2}^3 3d_{5/2}^5)_4 4f_{7/2}$	$3/2^-$	2230.53	5.10×10^{-15}	
234	64.2	$3s^2 3p_{1/2}^2 (3p_{3/2}^3 3d_{3/2}^4 3d_{5/2}^5)_4 4p_{3/2}$	$5/2^+$	2241.54	1.58×10^{-13}	
239	55.2	$3s^2 3p_{1/2}^2 (3p_{3/2}^3 3d_{3/2}^4 3d_{5/2}^5)_2 4p_{3/2}$	$5/2^+$	2252.58	1.09×10^{-13}	
284	62.3	$3s^2 3p_{1/2}^2 (3p_{3/2}^3 3d_{3/2}^4 3d_{5/2}^5)_4 4d_{5/2}$	$5/2^-$	2404.66	3.20×10^{-14}	
286	60.1	$3s^2 3p_{1/2}^2 (3p_{3/2}^3 3d_{3/2}^4 3d_{5/2}^5)_4 4d_{5/2}$	$3/2^-$	2406.69	1.74×10^{-14}	

(continued on next page)

Table 6 (*continued*)

Index	Purity (%)	Configuration	J^π	E (eV)	τ_{rad} (s)	τ_{level} (s)
287	60.9	$3s^2 3p_{1/2}^2(3p_{3/2}^3 3d_{3/2}^4 3d_{5/2}^5)_3 4d_{3/2}$	$5/2^-$	2407.23	4.64×10^{-14}	
291	96.8	$3s^2 3p_{1/2}^2(3p_{3/2}^3 3d_{3/2}^4 3d_{5/2}^5)_4 4d_{5/2}$	$7/2^-$	2408.58	6.41×10^{-14}	
295	97.3	$3s^2 3p_{1/2}^2(3p_{3/2}^3 3d_{3/2}^4 3d_{5/2}^5)_2 4d_{5/2}$	$7/2^-$	2415.31	2.81×10^{-14}	
302	42.2	$3s^2 3p_{1/2}^2(3p_{3/2}^3 3d_{3/2}^4 3d_{5/2}^5)_2 4d_{5/2}$	$3/2^-$	2422.26	2.41×10^{-14}	
306	87.7	$3s^2 3p_{1/2}^2(3p_{3/2}^3 3d_{3/2}^4 3d_{5/2}^5)_3 4d_{5/2}$	$5/2^-$	2432.48	1.82×10^{-14}	
307	86.6	$3s^2 3p_{1/2}^2(3p_{3/2}^3 3d_{3/2}^4 3d_{5/2}^5)_3 4d_{5/2}$	$7/2^-$	2433.22	2.16×10^{-14}	
309	89.3	$3s^2 3p_{1/2}^2(3p_{3/2}^3 3d_{3/2}^4 3d_{5/2}^5)_1 4d_{5/2}$	$7/2^-$	2442.98	9.05×10^{-14}	
387	55.0	$3s^2 3p_{1/2}^2(3p_{3/2}^3 3d_{3/2}^4 3d_{5/2}^5)_3 4f_{5/2}$	$1/2^+$	2583.29	4.03×10^{-14}	
388	37.5	$3s^2 3p_{1/2}^2(3p_{3/2}^3 3d_{3/2}^4 3d_{5/2}^5)_3 4f_{5/2}$	$5/2^+$	2584.57	4.95×10^{-14}	
389	26.3	$3s^2 3p_{1/2}^2(3p_{3/2}^3 3d_{3/2}^4 3d_{5/2}^5)_3 4f_{5/2}$	$3/2^+$	2585.50	3.54×10^{-14}	
400	50.2	$3s^2 3p_{1/2}^2(3p_{3/2}^3 3d_{3/2}^4 3d_{5/2}^5)_3 4f_{7/2}$	$5/2^+$	2599.37	7.92×10^{-14}	
406	67.0	$(3s_{1/2} 3p^6 3d_{3/2}^4 3d_{5/2}^5)_3 4s_{1/2}$	$5/2^+$	2604.76	8.45×10^{-14}	
452	87.4	$(3s_{1/2} 3p^6 3d_{3/2}^4 3d_{5/2}^5)_3 4p_{1/2}$	$7/2^-$	2690.03	2.18×10^{-14}	
457	77.9	$(3s_{1/2} 3p^6 3d_{3/2}^4 3d_{5/2}^5)_2 4p_{1/2}$	$3/2^-$	2699.76	1.91×10^{-14}	
467	74.7	$3s^2(3p_{1/2} 3p_{3/2}^4 3d_{3/2}^4 3d_{5/2}^5)_3 4d_{3/2}$	$5/2^-$	2724.75	2.98×10^{-14}	
854	72.8	$3s^2 3p^6 3d_{3/2}^4(3d_{5/2}^4)_2 5d_{5/2}$	$5/2^+$	2817.05	1.21×10^{-13}	
902	54.5	$3s^2 3p^6(3d_{3/2}^3 3d_{5/2}^5)_4 5d_{3/2}$	$5/2^+$	2878.64	1.37×10^{-13}	
905	60.8	$3s^2 3p^6 3d_{3/2}^4(3d_{5/2}^4)_2 5f_{5/2}$	$3/2^-$	2880.94	2.34×10^{-14}	
907	49.2	$3s^2 3p^6 3d_{3/2}^4(3d_{5/2}^4)_4 5f_{7/2}$	$5/2^-$	2881.09	3.09×10^{-14}	
919	68.0	$3s^2 3p^6 3d_{3/2}^4(3d_{5/2}^4)_2 5f_{7/2}$	$5/2^-$	2886.98	1.36×10^{-14}	
920	82.2	$3s^2 3p^6 3d_{3/2}^4(3d_{5/2}^4)_2 5f_{7/2}$	$7/2^-$	2888.54	1.13×10^{-14}	
980	59.6	$3s^2 3p^6(3d_{3/2}^3 3d_{5/2}^5)_2 5f_{5/2}$	$7/2^-$	2947.75	2.93×10^{-14}	
994	74.7	$3s^2 3p^6(3d_{3/2}^3 3d_{5/2}^5)_4 5f_{5/2}$	$3/2^-$	2954.00	8.59×10^{-15}	
998	37.3	$3s^2 3p^6(3d_{3/2}^3 3d_{5/2}^5)_1 5f_{5/2}$	$7/2^-$	2955.28	1.02×10^{-14}	
1000	50.2	$3s^2 3p^6(3d_{3/2}^3 3d_{5/2}^5)_4 5f_{5/2}$	$5/2^-$	2955.51	1.02×10^{-14}	
1956	92.5	$3s^2 3p^6 3d_{3/2}^4(3d_{5/2}^4)_2 6f_{7/2}$	$7/2^-$	3286.18	1.94×10^{-14}	
2093	80.7	$3s^2 3p^6(3d_{3/2}^3 3d_{5/2}^5)_4 6f_{5/2}$	$3/2^-$	3353.76	1.74×10^{-14}	
2095	49.1	$3s^2 3p^6(3d_{3/2}^3 3d_{5/2}^5)_4 6f_{5/2}$	$7/2^-$	3354.44	2.40×10^{-14}	
2096	57.4	$3s^2 3p^6(3d_{3/2}^3 3d_{5/2}^5)_4 6f_{5/2}$	$5/2^-$	3354.47	2.38×10^{-14}	

Table 7
Energy levels in Fe-like tungsten, W^{48+}.

Index	Purity (%)	Configuration	J^{π}	E (eV)	τ_{rad} (s)	τ_{level} (s)
0	99.1	$3s^2 3p^6 3d^4_{3/2} 3d^4_{5/2}$	4^+	0.00		
1	99.7	$3s^2 3p^6 3d^4_{3/2} 3d^4_{5/2}$	2^+	8.95	1.72×10	1.92×10^{-5}
2	98.6	$3s^2 3p^6 3d^4_{3/2} 3d^4_{5/2}$	0^+	28.37	7.91×10^{-2}	1.92×10^{-5}
3	100.0	$3s^2 3p^6 3d^3_{3/2} 3d^5_{5/2}$	3^+	65.24	2.88×10^{-7}	2.84×10^{-7}
4	99.2	$3s^2 3p^6 3d^3_{3/2} 3d^5_{5/2}$	2^+	74.67	5.06×10^{-7}	4.94×10^{-7}
5	100.0	$3s^2 3p^6 3d^3_{3/2} 3d^5_{5/2}$	1^+	79.97	4.19×10^{-7}	4.10×10^{-7}
6	99.1	$3s^2 3p^6 3d^3_{3/2} 3d^5_{5/2}$	4^+	80.22	9.74×10^{-7}	9.28×10^{-7}
9	100.0	$3s^2 3p^2_{1/2} 3p^3_{3/2} 3d^4_{3/2} 3d^5_{5/2}$	4^-	426.88	1.65×10^{-12}	
10	98.9	$3s^2 3p^2_{1/2} 3p^3_{3/2} 3d^4_{3/2} 3d^5_{5/2}$	2^-	436.97	8.04×10^{-13}	
11	96.2	$3s^2 3p^2_{1/2} 3p^3_{3/2} 3d^4_{3/2} 3d^5_{5/2}$	3^-	453.12	4.12×10^{-13}	
35	98.4	$3s^2 3p^6 3d^4_{3/2} (3d^3_{5/2})_{9/2} 4s_{1/2}$	5^+	1656.20	3.26×10^{-10}	
36	98.9	$3s^2 3p^6 3d^4_{3/2} (3d^3_{5/2})_{9/2} 4s_{1/2}$	4^+	1659.87	5.80×10^{-11}	
37	98.8	$3s^2 3p^6 3d^4_{3/2} (3d^3_{5/2})_{3/2} 4s_{1/2}$	2^+	1670.36	1.24×10^{-10}	
38	98.8	$3s^2 3p^6 3d^4_{3/2} (3d^3_{5/2})_{3/2} 4s_{1/2}$	1^+	1671.76	7.46×10^{-11}	
39	96.5	$3s^2 3p^6 3d^4_{3/2} (3d^3_{5/2})_{5/2} 4s_{1/2}$	3^+	1677.40	1.46×10^{-10}	
40	96.7	$3s^2 3p^6 3d^4_{3/2} (3d^3_{5/2})_{5/2} 4s_{1/2}$	2^+	1679.58	6.52×10^{-11}	
41	78.3	$3s^2 3p^6 [3d^3_{3/2} (3d^4_{5/2})_4]_{7/2} 4s_{1/2}$	4^+	1722.08	1.94×10^{-10}	
43	97.0	$3s^2 3p^6 [3d^3_{3/2} (3d^4_{5/2})_4]_{9/2} 4s_{1/2}$	5^+	1729.06	1.65×10^{-10}	
49	99.9	$3s^2 3p^6 [3d^3_{3/2} (3d^4_{5/2})_4]_{11/2} 4s_{1/2}$	6^+	1737.36	1.43×10^{-10}	
52	99.0	$3s^2 3p^6 [3d^3_{3/2} (3d^4_{5/2})_4]_{11/2} 4s_{1/2}$	5^+	1739.27	7.11×10^{-11}	
57	98.4	$3s^2 3p^6 3d^4_{3/2} (3d^3_{5/2})_{9/2} 4p_{1/2}$	4^-	1750.51	1.46×10^{-11}	
58	98.6	$3s^2 3p^6 3d^4_{3/2} (3d^3_{5/2})_{9/2} 4p_{1/2}$	5^-	1752.32	2.03×10^{-11}	
63	96.4	$3s^2 3p^6 3d^4_{3/2} (3d^3_{5/2})_{5/2} 4p_{1/2}$	2^-	1771.24	8.46×10^{-12}	
64	96.4	$3s^2 3p^6 3d^4_{3/2} (3d^3_{5/2})_{5/2} 4p_{1/2}$	3^-	1772.30	1.39×10^{-11}	
75	78.9	$3s^2 3p^6 [3d^3_{3/2} (3d^4_{5/2})_4]_{7/2} 4p_{1/2}$	3^-	1816.64	4.88×10^{-13}	
76	71.4	$3s^2 3p^6 [3d^3_{3/2} (3d^4_{5/2})_4]_{7/2} 4p_{1/2}$	4^-	1817.39	1.30×10^{-12}	
77	95.0	$3s^2 3p^6 [3d^3_{3/2} (3d^4_{5/2})_4]_{9/2} 4p_{1/2}$	5^-	1824.03	1.91×10^{-12}	
78	91.2	$3s^2 3p^6 [3d^3_{3/2} (3d^4_{5/2})_4]_{9/2} 4p_{1/2}$	4^-	1824.72	1.88×10^{-13}	
79	66.4	$3s^2 3p^6 [3d^3_{3/2} (3d^4_{5/2})_2]_{3/2} 4p_{1/2}$	2^-	1827.13	1.35×10^{-12}	
81	77.1	$3s^2 3p^6 [3d^3_{3/2} (3d^4_{5/2})_4]_{5/2} 4p_{1/2}$	2^-	1827.66	1.56×10^{-12}	
83	92.6	$3s^2 3p^6 [3d^3_{3/2} (3d^4_{5/2})_4]_{5/2} 4p_{1/2}$	3^-	1831.66	1.85×10^{-13}	
86	83.4	$3s^2 3p^6 [3d^3_{3/2} (3d^4_{5/2})_2]_{1/2} 4p_{1/2}$	1^-	1832.78	1.70×10^{-13}	
87	96.5	$3s^2 3p^6 [3d^3_{3/2} (3d^4_{5/2})_4]_{11/2} 4p_{1/2}$	5^-	1833.51	1.27×10^{-13}	
89	74.2	$3s^2 3p^6 [3d^3_{3/2} (3d^4_{5/2})_2]_{7/2} 4p_{1/2}$	4^-	1839.18	8.66×10^{-13}	
90	69.3	$3s^2 3p^6 [3d^3_{3/2} (3d^4_{5/2})_2]_{7/2} 4p_{1/2}$	3^-	1840.06	2.57×10^{-13}	
91	82.1	$3s^2 3p^6 [3d^3_{3/2} (3d^4_{5/2})_2]_{5/2} 4p_{1/2}$	3^-	1844.55	2.55×10^{-13}	
92	94.5	$3s^2 3p^6 [3d^3_{3/2} (3d^4_{5/2})_2]_{5/2} 4p_{1/2}$	2^-	1845.43	1.68×10^{-13}	
94	97.6	$3s^2 3p^6 3d^4_{3/2} (3d^3_{5/2})_{9/2} 4p_{3/2}$	5^-	1860.87	3.37×10^{-13}	
95	81.8	$3s^2 3p^6 [3d^3_{3/2} (3d^4_{5/2})_0]_{3/2} 4p_{1/2}$	2^-	1862.02	1.51×10^{-12}	
96	92.3	$3s^2 3p^6 3d^4_{3/2} (3d^3_{5/2})_{9/2} 4p_{3/2}$	3^-	1864.68	1.26×10^{-13}	
97	83.5	$3s^2 3p^6 [3d^3_{3/2} (3d^4_{5/2})_0]_{3/2} 4p_{1/2}$	1^-	1865.09	1.39×10^{-13}	
98	96.4	$3s^2 3p^6 3d^4_{3/2} (3d^3_{5/2})_{9/2} 4p_{3/2}$	4^-	1865.13	8.32×10^{-14}	
101	92.1	$3s^2 3p^6 3d^4_{3/2} (3d^3_{5/2})_{3/2} 4p_{3/2}$	2^-	1874.81	1.67×10^{-13}	
102	87.2	$3s^2 3p^6 3d^4_{3/2} (3d^3_{5/2})_{3/2} 4p_{3/2}$	3^-	1874.92	1.17×10^{-13}	
104	91.4	$3s^2 3p^6 3d^4_{3/2} (3d^3_{5/2})_{3/2} 4p_{3/2}$	1^-	1878.65	6.53×10^{-14}	
105	95.2	$3s^2 3p^6 3d^4_{3/2} (3d^3_{5/2})_{5/2} 4p_{3/2}$	4^-	1881.85	7.94×10^{-13}	
106	90.0	$3s^2 3p^6 3d^4_{3/2} (3d^3_{5/2})_{5/2} 4p_{3/2}$	2^-	1882.70	4.08×10^{-13}	
107	89.1	$3s^2 3p^6 3d^4_{3/2} (3d^3_{5/2})_{5/2} 4p_{3/2}$	3^-	1884.37	2.12×10^{-13}	
108	89.7	$3s^2 3p^6 3d^4_{3/2} (3d^3_{5/2})_{5/2} 4p_{3/2}$	1^-	1887.81	1.05×10^{-13}	
123	71.8	$3s^2 3p^6 [3d^3_{3/2} (3d^4_{5/2})_4]_{7/2} 4p_{3/2}$	3^-	1929.39	1.06×10^{-13}	
126	75.1	$3s^2 3p^6 [3d^3_{3/2} (3d^4_{5/2})_4]_{9/2} 4p_{3/2}$	4^-	1933.91	1.72×10^{-13}	
127	94.6	$3s^2 3p^6 [3d^3_{3/2} (3d^4_{5/2})_4]_{9/2} 4p_{3/2}$	5^-	1934.49	6.73×10^{-13}	
131	77.5	$3s^2 3p^6 [3d^3_{3/2} (3d^4_{5/2})_4]_{5/2} 4p_{3/2}$	4^-	1938.04	8.24×10^{-13}	
136	73.2	$3s^2 3p^6 [3d^3_{3/2} (3d^4_{5/2})_4]_{5/2} 4p_{3/2}$	3^-	1942.00	2.83×10^{-13}	
137	84.9	$3s^2 3p^6 [3d^3_{3/2} (3d^4_{5/2})_4]_{11/2} 4p_{3/2}$	4^-	1942.87	9.81×10^{-14}	
140	73.2	$3s^2 3p^6 [3d^3_{3/2} (3d^4_{5/2})_4]_{11/2} 4p_{3/2}$	5^-	1943.75	1.63×10^{-13}	
144	64.8	$3s^2 3p^6 [3d^3_{3/2} (3d^4_{5/2})_2]_{7/2} 4p_{3/2}$	4^-	1949.58	1.46×10^{-13}	
146	59.3	$3s^2 3p^6 [3d^3_{3/2} (3d^4_{5/2})_2]_{7/2} 4p_{3/2}$	5^-	1950.70	9.40×10^{-13}	
212	96.8	$3s^2 3p^2_{1/2} [3p^3_{3/2} 3d^4_{3/2} (3d^4_{5/2})_4]_{11/2} 4s_{1/2}$	5^-	2069.92	5.27×10^{-14}	
222	72.1	$3s^2 3p^2_{1/2} [3p^3_{3/2} 3d^4_{3/2} (3d^4_{5/2})_2]_{5/2} 4s_{1/2}$	3^-	2078.56	1.64×10^{-13}	
224	71.7	$3s^2 3p^2_{1/2} [3p^3_{3/2} 3d^4_{3/2} (3d^4_{5/2})_2]_{7/2} 4s_{1/2}$	4^-	2078.75	3.64×10^{-13}	
229	69.9	$3s^2 3p^2_{1/2} [3p^3_{3/2} 3d^4_{3/2} (3d^4_{5/2})_2]_{5/2} 4s_{1/2}$	2^-	2080.76	8.68×10^{-14}	
234	68.5	$3s^2 3p^2_{1/2} [3p^3_{3/2} 3d^4_{3/2} (3d^4_{5/2})_2]_{7/2} 4s_{1/2}$	3^-	2082.66	5.82×10^{-14}	
237	98.0	$3s^2 3p^2_{1/2} [3p^3_{3/2} 3d^4_{3/2} (3d^4_{5/2})_4]_{9/2} 4s_{1/2}$	5^-	2086.11	1.51×10^{-13}	
242	98.1	$3s^2 3p^2_{1/2} [3p^3_{3/2} 3d^4_{3/2} (3d^4_{5/2})_4]_{9/2} 4s_{1/2}$	4^-	2090.13	6.83×10^{-14}	
279	66.9	$3s^2 3p^2_{1/2} [3p^3_{3/2} 3d^4_{3/2} (3d^4_{5/2})_4]_{7/2} 4s_{1/2}$	4^-	2112.04	9.89×10^{-14}	

(*continued on next page*)

Table 7 (*continued*)

Index	Purity (%)	Configuration	J^π	E (eV)	τ_{rad} (s)	τ_{level} (s)
285	28.2	$3s^23p^6[3d_{3/2}^3(3d_{5/2}^4)_4]_{11/2}4d_{3/2}$	4^+	2114.91	6.42×10^{-13}	
287	38.6	$3s^23p_{1/2}^2[3p_{3/2}^33d_{3/2}^4(3d_{5/2}^4)_4]_{7/2}4s_{1/2}$	3^-	2115.61	1.09×10^{-13}	
288	42.5	$3s^23p_{1/2}^2[3p_{3/2}^33d_{3/2}^4(3d_{5/2}^4)_4]_{5/2}4s_{1/2}$	3^-	2116.21	5.14×10^{-14}	
299	23.1	$3s^23p^6[3d_{3/2}^3(3d_{5/2}^4)_2]_{7/2}4d_{3/2}$	2^+	2124.67	7.07×10^{-13}	
387	66.3	$3s^23p^63d_{3/2}^4(3d_{5/2}^3)_{3/2}4f_{5/2}$	4^-	2181.32	3.28×10^{-13}	
390	54.2	$3s^23p^63d_{3/2}^4(3d_{5/2}^3)_{9/2}4f_{7/2}$	2^-	2182.17	1.12×10^{-13}	
394	48.1	$3s^23p^63d_{3/2}^4(3d_{5/2}^3)_{9/2}4f_{7/2}$	3^-	2183.92	4.20×10^{-14}	
396	50.3	$3s^23p^63d_{3/2}^4(3d_{5/2}^3)_{3/2}4f_{5/2}$	3^-	2184.07	5.96×10^{-14}	
398	50.9	$3s^23p^63d_{3/2}^4(3d_{5/2}^3)_{9/2}4f_{7/2}$	5^-	2185.24	1.36×10^{-13}	
400	48.2	$3s^23p^63d_{3/2}^4(3d_{5/2}^3)_{3/2}4f_{7/2}$	4^-	2190.65	9.59×10^{-14}	
403	66.5	$3s^23p^63d_{3/2}^4(3d_{5/2}^3)_{5/2}4f_{5/2}$	3^-	2191.80	1.13×10^{-13}	
405	45.1	$3s^23p^63d_{3/2}^4(3d_{5/2}^3)_{9/2}4f_{7/2}$	4^-	2192.19	3.60×10^{-14}	
413	86.9	$3s^23p^63d_{3/2}^4(3d_{5/2}^3)_{5/2}4f_{5/2}$	5^-	2193.84	4.06×10^{-13}	
415	73.9	$3s^23p^63d_{3/2}^4(3d_{5/2}^3)_{9/2}4f_{7/2}$	1^-	2195.05	1.61×10^{-14}	
420	52.6	$3s^23p^63d_{3/2}^4(3d_{5/2}^3)_{5/2}4f_{5/2}$	4^-	2197.58	3.09×10^{-14}	
422	59.1	$3s^23p^63d_{3/2}^4(3d_{5/2}^3)_{3/2}4f_{7/2}$	5^-	2199.19	1.86×10^{-14}	
424	54.2	$3s^23p^63d_{3/2}^4(3d_{5/2}^3)_{3/2}4f_{7/2}$	2^-	2199.38	3.82×10^{-14}	
425	85.1	$3s^23p^63d_{3/2}^4(3d_{5/2}^3)_{5/2}4f_{7/2}$	4^-	2201.09	3.23×10^{-14}	
426	80.3	$3s^23p^63d_{3/2}^4(3d_{5/2}^3)_{5/2}4f_{7/2}$	2^-	2203.66	2.25×10^{-14}	
427	55.4	$3s^23p^63d_{3/2}^4(3d_{5/2}^3)_{5/2}4f_{7/2}$	3^-	2204.20	1.33×10^{-13}	
431	81.7	$3s^23p^63d_{3/2}^4(3d_{5/2}^3)_{5/2}4f_{7/2}$	5^-	2206.09	1.55×10^{-14}	
437	34.0	$3s^23p^63d_{3/2}^4(3d_{5/2}^3)_{3/2}4f_{7/2}$	3^-	2210.09	8.76×10^{-15}	
442	79.5	$3s^23p^63d_{3/2}^4(3d_{5/2}^3)_{5/2}4f_{7/2}$	1^-	2219.69	8.54×10^{-15}	
456	47.3	$3s^23p^6[3d_{3/2}^3(3d_{5/2}^4)_4]_{7/2}4f_{5/2}$	5^-	2239.15	1.41×10^{-13}	
478	34.5	$3s^23p^6[3d_{3/2}^3(3d_{5/2}^4)_4]_{11/2}4f_{5/2}$	4^-	2245.96	3.19×10^{-13}	
483	38.2	$3s^23p^6[3d_{3/2}^3(3d_{5/2}^4)_4]_{9/2}4f_{5/2}$	5^-	2247.49	1.24×10^{-13}	
489	35.9	$3s^23p^6[3d_{3/2}^3(3d_{5/2}^4)_4]_{11/2}4f_{5/2}$	5^-	2249.44	3.16×10^{-13}	
534	26.5	$3s^23p^6[3d_{3/2}^3(3d_{5/2}^4)_4]_{9/2}4f_{7/2}$	3^-	2262.72	1.50×10^{-14}	
541	23.1	$3s^23p^6[3d_{3/2}^3(3d_{5/2}^4)_2]_{5/2}4f_{5/2}$	3^-	2265.74	1.09×10^{-14}	
544	16.0	$3s^23p^6[3d_{3/2}^3(3d_{5/2}^4)_2]_{1/2}4f_{7/2}$	4^-	2266.78	2.31×10^{-14}	
547	33.2	$3s^23p^6[3d_{3/2}^3(3d_{5/2}^4)_2]_{7/2}4f_{7/2}$	4^-	2268.23	1.29×10^{-14}	
548	43.7	$3s^23p^6[3d_{3/2}^3(3d_{5/2}^4)_2]_{5/2}4f_{5/2}$	5^-	2268.33	3.11×10^{-14}	
552	46.4	$3s^23p^6[3d_{3/2}^3(3d_{5/2}^4)_4]_{11/2}4f_{5/2}$	3^-	2269.06	4.45×10^{-15}	
553	21.4	$3s^23p^6[3d_{3/2}^3(3d_{5/2}^4)_2]_{5/2}4f_{7/2}$	4^-	2270.91	4.37×10^{-15}	
562	29.2	$3s^23p^6[3d_{3/2}^3(3d_{5/2}^4)_4]_{5/2}4f_{5/2}$	5^-	2274.11	2.48×10^{-15}	
563	38.3	$3s^23p^6[3d_{3/2}^3(3d_{5/2}^4)_2]_{5/2}4f_{7/2}$	4^-	2274.41	6.58×10^{-15}	
567	27.2	$3s^23p^6[3d_{3/2}^3(3d_{5/2}^4)_2]_{7/2}4f_{7/2}$	2^-	2275.99	7.43×10^{-15}	
573	60.3	$3s^23p^6[3d_{3/2}^3(3d_{5/2}^4)_2]_{7/2}4f_{5/2}$	1^-	2279.27	3.96×10^{-15}	
574	28.6	$3s^23p^6[3d_{3/2}^3(3d_{5/2}^4)_2]_{5/2}4f_{5/2}$	2^-	2280.15	4.56×10^{-15}	
576	32.6	$3s^23p^6[3d_{3/2}^3(3d_{5/2}^4)_2]_{5/2}4f_{7/2}$	3^-	2281.06	4.74×10^{-15}	
579	29.8	$3s^23p^6[3d_{3/2}^3(3d_{5/2}^4)_2]_{5/2}4f_{5/2}$	3^-	2282.38	3.57×10^{-15}	
580	49.4	$3s^23p^6[3d_{3/2}^3(3d_{5/2}^4)_2]_{5/2}4f_{7/2}$	2^-	2282.72	9.42×10^{-15}	
582	31.9	$3s^23p^6[3d_{3/2}^3(3d_{5/2}^4)_2]_{5/2}4f_{7/2}$	1^-	2283.73	5.68×10^{-15}	
584	47.9	$3s^23p_{1/2}^2[3p_{3/2}^33d_{3/2}^4(3d_{5/2}^4)_2]_{5/2}4p_{3/2}$	4^+	2285.11	1.15×10^{-13}	
590	63.1	$3s^23p_{1/2}^2[3p_{3/2}^33d_{3/2}^4(3d_{5/2}^4)_2]_{7/2}4p_{3/2}$	4^+	2287.65	1.85×10^{-13}	
597	66.8	$3s^23p^6[3d_{3/2}^3(3d_{5/2}^4)_0]_{3/2}4f_{5/2}$	3^-	2291.75	1.65×10^{-14}	
602	24.6	$3s^23p_{1/2}^2[3p_{3/2}^33d_{3/2}^4(3d_{5/2}^4)_2]_{7/2}4p_{3/2}$	2^+	2294.51	8.74×10^{-14}	
605	69.3	$3s^23p_{1/2}^2[3p_{3/2}^33d_{3/2}^4(3d_{5/2}^4)_4]_{9/2}4p_{3/2}$	4^+	2301.79	1.32×10^{-13}	
606	81.2	$3s^23p^6[3d_{3/2}^3(3d_{5/2}^4)_0]_{3/2}4f_{5/2}$	1^-	2302.92	3.03×10^{-15}	
650	33.3	$3s^23p_{1/2}^2[3p_{3/2}^33d_{3/2}^4(3d_{5/2}^4)_4]_{7/2}4p_{3/2}$	4^+	2325.92	3.93×10^{-13}	
792	87.0	$3s^23p_{1/2}^2[3p_{3/2}^33d_{3/2}^4(3d_{5/2}^4)_4]_{11/2}4d_{5/2}$	5^-	2436.44	6.59×10^{-14}	
795	83.2	$3s^23p_{1/2}^2[3p_{3/2}^33d_{3/2}^4(3d_{5/2}^4)_4]_{11/2}4d_{5/2}$	3^-	2438.61	1.49×10^{-14}	
798	62.8	$3s^23p_{1/2}^2[3p_{3/2}^33d_{3/2}^4(3d_{5/2}^4)_4]_{11/2}4d_{5/2}$	4^-	2441.03	4.05×10^{-14}	
807	48.7	$3s^23p_{1/2}^2[3p_{3/2}^33d_{3/2}^4(3d_{5/2}^4)_2]_{5/2}4d_{5/2}$	5^-	2445.13	9.20×10^{-14}	
809	34.9	$3s^23p_{1/2}^2[3p_{3/2}^33d_{3/2}^4(3d_{5/2}^4)_2]_{5/2}4d_{5/2}$	3^-	2446.48	2.86×10^{-14}	
820	29.8	$3s^23p_{1/2}^2[3p_{3/2}^33d_{3/2}^4(3d_{5/2}^4)_2]_{7/2}4d_{5/2}$	4^-	2452.78	3.15×10^{-14}	
822	40.3	$3s^23p_{1/2}^2[3p_{3/2}^33d_{3/2}^4(3d_{5/2}^4)_2]_{7/2}4d_{5/2}$	2^-	2455.15	3.77×10^{-14}	
828	52.5	$3s^23p_{1/2}^2[3p_{3/2}^33d_{3/2}^4(3d_{5/2}^4)_4]_{7/2}4d_{3/2}$	4^-	2457.15	3.70×10^{-14}	
830	52.6	$3s^23p_{1/2}^2[3p_{3/2}^33d_{3/2}^4(3d_{5/2}^4)_4]_{9/2}4d_{5/2}$	5^-	2457.83	3.54×10^{-14}	
831	40.6	$3s^23p_{1/2}^2[3p_{3/2}^33d_{3/2}^4(3d_{5/2}^4)_4]_{9/2}4d_{5/2}$	5^-	2458.97	7.26×10^{-14}	
833	49.3	$3s^23p_{1/2}^2[3p_{3/2}^33d_{3/2}^4(3d_{5/2}^4)_4]_{9/2}4d_{5/2}$	3^-	2460.06	5.70×10^{-14}	
837	26.6	$3s^23p_{1/2}^2[3p_{3/2}^33d_{3/2}^4(3d_{5/2}^4)_2]_{1/2}4d_{5/2}$	2^-	2462.56	2.81×10^{-14}	
843	35.0	$3s^23p_{1/2}^2[3p_{3/2}^33d_{3/2}^4(3d_{5/2}^4)_4]_{5/2}4d_{3/2}$	3^-	2465.70	3.42×10^{-14}	
849	82.3	$3s^23p_{1/2}^2[3p_{3/2}^33d_{3/2}^4(3d_{5/2}^4)_2]_{1/2}4d_{5/2}$	3^-	2469.10	3.68×10^{-14}	
861	57.0	$3s^23p_{1/2}^2[3p_{3/2}^33d_{3/2}^4(3d_{5/2}^4)_4]_{7/2}4d_{5/2}$	5^-	2480.62	2.39×10^{-14}	
865	52.5	$3s^23p_{1/2}^2[3p_{3/2}^33d_{3/2}^4(3d_{5/2}^4)_4]_{7/2}4d_{5/2}$	4^-	2481.66	4.63×10^{-14}	

(*continued on next page*)

Table 7 (*continued*)

Index	Purity (%)	Configuration	J^{π}	E (eV)	τ_{rad} (s)	τ_{level} (s)
869	54.8	$3s^2 3p_{1/2}^2[3p_{3/2}^3 3d_{3/2}^4(3d_{5/2}^4)_4]_{5/2}4d_{5/2}$	5^-	2483.95	1.30×10^{-13}	
871	48.0	$3s^2 3p_{1/2}^2[3p_{3/2}^3 3d_{3/2}^4(3d_{5/2}^4)_2]_{3/2}4d_{5/2}$	3^-	2485.41	2.84×10^{-14}	
1109	28.4	$3s^2 3p_{1/2}^2[3p_{3/2}^3 3d_{3/2}^4(3d_{5/2}^4)_2]_{7/2}4f_{7/2}$	3^+	2606.72	1.92×10^{-14}	
1115	29.0	$3s^2 3p_{1/2}^2[3p_{3/2}^3 3d_{3/2}^4(3d_{5/2}^4)_4]_{9/2}4f_{7/2}$	5^+	2607.65	5.97×10^{-14}	
1129	25.3	$3s^2 3p_{1/2}^2[3p_{3/2}^3 3d_{3/2}^4(3d_{5/2}^4)_4]_{9/2}4f_{7/2}$	4^+	2611.17	3.66×10^{-14}	
1133	35.8	$3s^2 3p_{1/2}^2[3p_{3/2}^3 3d_{3/2}^4(3d_{5/2}^4)_2]_{7/2}4f_{7/2}$	2^+	2613.39	2.50×10^{-14}	
1135	25.1	$3s^2 3p_{1/2}^2[3p_{3/2}^3 3d_{3/2}^4(3d_{5/2}^4)_2]_{1/2}4f_{5/2}$	3^+	2613.58	5.02×10^{-14}	
1201	17.8	$3s^2 3p_{1/2}^2[3p_{3/2}^3 3d_{3/2}^4(3d_{5/2}^4)_4]_{7/2}4f_{7/2}$	4^+	2644.37	4.66×10^{-14}	
1427	90.6	$[3s_{1/2}3p^6 3d_{3/2}^4(3d_{5/2}^4)_4]_{9/2}4p_{1/2}$	5^-	2727.19	2.35×10^{-14}	
1445	79.5	$[3s_{1/2}3p^6 3d_{3/2}^4(3d_{5/2}^4)_4]_{7/2}4p_{1/2}$	3^-	2742.89	2.01×10^{-14}	
1447	84.4	$[3s_{1/2}3p^6 3d_{3/2}^4(3d_{5/2}^4)_4]_{7/2}4p_{1/2}$	4^-	2745.40	3.40×10^{-14}	
1469	89.9	$3s^2[3p_{1/2}3p_{3/2}^4 3d_{3/2}^4(3d_{5/2}^4)_4]_{7/2}4d_{3/2}$	5^-	2758.97	4.56×10^{-14}	
1494	64.1	$3s^2[3p_{1/2}3p_{3/2}^4 3d_{3/2}^4(3d_{5/2}^4)_4]_{9/2}4d_{3/2}$	4^-	2770.21	3.21×10^{-14}	
1495	90.8	$3s^2[3p_{1/2}3p_{3/2}^4 3d_{3/2}^4(3d_{5/2}^4)_4]_{9/2}4d_{3/2}$	5^-	2770.66	3.88×10^{-14}	
2389	81.6	$3s^2 3p^6 3d_{3/2}^4(3d_{5/2}^3)_{9/2}5f_{7/2}$	5^-	2954.75	2.53×10^{-14}	
2391	76.9	$3s^2 3p^6 3d_{3/2}^4(3d_{5/2}^3)_{9/2}5f_{7/2}$	4^-	2955.73	1.98×10^{-14}	
2423	78.7	$3s^2 3p^6 3d_{3/2}^4(3d_{5/2}^3)_{3/2}5f_{7/2}$	5^-	2964.98	2.28×10^{-14}	
2444	92.4	$3s^2 3p^6 3d_{3/2}^4(3d_{5/2}^3)_{5/2}5f_{7/2}$	5^-	2973.77	1.77×10^{-14}	
2447	77.2	$3s^2 3p^6 3d_{3/2}^4(3d_{5/2}^3)_{5/2}5f_{7/2}$	3^-	2974.71	1.40×10^{-14}	
2456	89.9	$3s^2 3p^6 3d_{3/2}^4(3d_{5/2}^3)_{5/2}5f_{7/2}$	1^-	2979.97	1.08×10^{-14}	
2592	42.9	$3s^2 3p^6[3d_{3/2}^3(3d_{5/2}^4)_4]_{5/2}5f_{7/2}$	4^-	3029.75	2.06×10^{-14}	
2596	41.4	$3s^2 3p^6[3d_{3/2}^3(3d_{5/2}^4)_4]_{11/2}5f_{5/2}$	5^-	3030.65	1.15×10^{-14}	
2597	33.6	$3s^2 3p^6[3d_{3/2}^3(3d_{5/2}^4)_4]_{11/2}5f_{5/2}$	4^-	3030.77	1.66×10^{-14}	
2606	72.7	$3s^2 3p^6[3d_{3/2}^3(3d_{5/2}^4)_4]_{11/2}5f_{5/2}$	3^-	3031.91	9.12×10^{-15}	
2611	34.4	$3s^2 3p^6[3d_{3/2}^3(3d_{5/2}^4)_2]_{7/2}5f_{5/2}$	4^-	3033.67	1.67×10^{-14}	
2633	69.9	$3s^2 3p^6[3d_{3/2}^3(3d_{5/2}^4)_2]_{5/2}5f_{5/2}$	3^-	3042.95	1.20×10^{-14}	
2634	80.2	$3s^2 3p^6[3d_{3/2}^3(3d_{5/2}^4)_2]_{5/2}5f_{5/2}$	2^-	3043.21	1.07×10^{-14}	
2696	87.0	$3s^2 3p^6[3d_{3/2}^3(3d_{5/2}^4)_0]_{3/2}5f_{5/2}$	1^-	3063.60	8.18×10^{-15}	
5368	90.1	$3s^2 3p^6 3d_{3/2}^4(3d_{5/2}^3)_{9/2}6f_{7/2}$	5^-	3369.86	2.88×10^{-14}	
5369	96.0	$3s^2 3p^6 3d_{3/2}^4(3d_{5/2}^3)_{9/2}6f_{7/2}$	4^-	3370.34	2.33×10^{-14}	
5426	94.9	$3s^2 3p^6 3d_{3/2}^4(3d_{5/2}^3)_{5/2}6f_{7/2}$	5^-	3389.24	2.85×10^{-14}	
5654	67.9	$3s^2 3p^6[3d_{3/2}^3(3d_{5/2}^4)_4]_{11/2}6f_{5/2}$	5^-	3446.43	2.76×10^{-14}	
5659	89.9	$3s^2 3p^6[3d_{3/2}^3(3d_{5/2}^4)_4]_{11/2}6f_{5/2}$	3^-	3447.21	1.69×10^{-14}	

Table 8
Energy levels in Mn-like tungsten, W^{49+}.

Index	Purity (%)	Configuration	J^π	E (eV)	τ_{rad} (s)	τ_{level} (s)
0	98.7	$3s^2 3p^6 3d_{3/2}^4 3d_{5/2}^3$	$9/2^+$	0.00		
1	98.9	$3s^2 3p^6 3d_{3/2}^4 3d_{5/2}^3$	$3/2^+$	12.54		
2	96.9	$3s^2 3p^6 3d_{3/2}^4 3d_{5/2}^3$	$5/2^+$	19.53	3.43×10^{-2}	1.88×10^{-5}
3	77.9	$3s^2 3p^6 3d_{3/2}^3 (3d_{5/2}^4)_4$	$7/2^+$	65.60	2.58×10^{-7}	2.55×10^{-7}
4	98.3	$3s^2 3p^6 3d_{3/2}^3 (3d_{5/2}^4)_4$	$9/2^+$	72.60	4.40×10^{-7}	4.30×10^{-7}
5	85.1	$3s^2 3p^6 3d_{3/2}^3 (3d_{5/2}^4)_2$	$3/2^+$	75.49	2.97×10^{-7}	2.92×10^{-7}
6	95.6	$3s^2 3p^6 3d_{3/2}^3 (3d_{5/2}^4)_4$	$5/2^+$	77.78	5.14×10^{-7}	5.00×10^{-7}
7	99.8	$3s^2 3p^6 3d_{3/2}^3 (3d_{5/2}^4)_2$	$1/2^+$	78.99	3.84×10^{-7}	3.76×10^{-7}
8	100.0	$3s^2 3p^6 3d_{3/2}^3 (3d_{5/2}^4)_4$	$11/2^+$	81.05	5.17×10^{-6}	4.06×10^{-6}
9	77.9	$3s^2 3p^6 3d_{3/2}^3 (3d_{5/2}^4)_2$	$7/2^+$	87.79	2.07×10^{-6}	1.86×10^{-6}
10	95.2	$3s^2 3p^6 3d_{3/2}^3 (3d_{5/2}^4)_2$	$5/2^+$	92.56	9.90×10^{-7}	9.40×10^{-7}
19	97.4	$3s^2 3p_{1/2}^2 3p_{3/2}^3 3d_{3/2}^4 (3d_{5/2}^4)_4$	$11/2^-$	406.18	7.82×10^{-12}	
20	71.0	$3s^2 3p_{1/2}^2 3p_{3/2}^3 3d_{3/2}^4 (3d_{5/2}^4)_2$	$5/2^-$	418.37	2.20×10^{-12}	
21	70.0	$3s^2 3p_{1/2}^2 3p_{3/2}^3 3d_{3/2}^4 (3d_{5/2}^4)_2$	$7/2^-$	419.37	3.84×10^{-12}	
22	98.8	$3s^2 3p_{1/2}^2 3p_{3/2}^3 3d_{3/2}^4 (3d_{5/2}^4)_4$	$9/2^-$	426.78	8.21×10^{-13}	
23	97.2	$3s^2 3p_{1/2}^2 3p_{3/2}^3 3d_{3/2}^4 (3d_{5/2}^4)_2$	$1/2^-$	438.37	6.84×10^{-13}	
25	65.9	$3s^2 3p_{1/2}^2 3p_{3/2}^3 3d_{3/2}^4 (3d_{5/2}^4)_4$	$7/2^-$	452.03	3.98×10^{-13}	
26	68.5	$3s^2 3p_{1/2}^2 3p_{3/2}^3 3d_{3/2}^4 (3d_{5/2}^4)_4$	$5/2^-$	454.39	7.19×10^{-13}	
27	53.0	$3s^2 3p_{1/2}^2 3p_{3/2}^3 3d_{3/2}^4 (3d_{5/2}^4)_2$	$3/2^-$	460.84	4.40×10^{-13}	
48	98.7	$3s^2 3p_{1/2} 3p_{3/2}^4 3d_{3/2}^4 (3d_{5/2}^4)_4$	$7/2^-$	752.35	1.56×10^{-13}	
49	96.8	$3s^2 3p_{1/2} 3p_{3/2}^4 3d_{3/2}^4 (3d_{5/2}^4)_4$	$9/2^-$	763.62	1.33×10^{-13}	
148	97.0	$3s^2 3p^6 3d_{3/2}^4 (3d_{5/2}^2)_4 4s_{1/2}$	$9/2^+$	1716.44	1.31×10^{-10}	
149	98.1	$3s^2 3p^6 3d_{3/2}^4 (3d_{5/2}^2)_4 4s_{1/2}$	$7/2^+$	1720.07	4.32×10^{-11}	
150	96.7	$3s^2 3p^6 3d_{3/2}^4 (3d_{5/2}^2)_2 4s_{1/2}$	$5/2^+$	1725.21	8.81×10^{-11}	
151	97.4	$3s^2 3p^6 3d_{3/2}^4 (3d_{5/2}^2)_2 4s_{1/2}$	$3/2^+$	1727.37	4.94×10^{-11}	
152	91.8	$3s^2 3p^6 3d_{3/2}^4 (3d_{5/2}^2)_0 4s_{1/2}$	$1/2^+$	1744.72	6.40×10^{-11}	
154	87.5	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^3)_{9/2}]_4 4s_{1/2}$	$9/2^+$	1780.54	1.18×10^{-10}	
159	85.7	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^3)_{9/2}]_5 4s_{1/2}$	$11/2^+$	1788.22	1.19×10^{-10}	
160	99.3	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^3)_{9/2}]_6 4s_{1/2}$	$13/2^+$	1788.41	9.88×10^{-11}	
161	85.6	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^3)_{9/2}]_6 4s_{1/2}$	$11/2^+$	1791.24	4.59×10^{-11}	
168	97.4	$3s^2 3p^6 3d_{3/2}^4 (3d_{5/2}^2)_4 4p_{1/2}$	$7/2^-$	1809.32	1.28×10^{-11}	
169	97.4	$3s^2 3p^6 3d_{3/2}^4 (3d_{5/2}^2)_4 4p_{1/2}$	$9/2^-$	1810.89	1.27×10^{-11}	
179	96.9	$3s^2 3p^6 3d_{3/2}^4 (3d_{5/2}^2)_2 4p_{1/2}$	$5/2^-$	1818.56	1.33×10^{-11}	
198	82.3	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^3)_{9/2}]_3 4p_{1/2}$	$5/2^-$	1871.40	1.40×10^{-12}	
200	54.2	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^3)_{9/2}]_4 4p_{1/2}$	$7/2^-$	1872.27	7.46×10^{-12}	
202	82.7	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^3)_{9/2}]_4 4p_{1/2}$	$9/2^-$	1874.83	9.07×10^{-13}	
203	42.6	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^3)_{9/2}]_3 4p_{1/2}$	$7/2^-$	1876.13	1.65×10^{-13}	
204	56.6	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^3)_{3/2}]_1 4p_{1/2}$	$1/2^-$	1877.80	4.82×10^{-13}	
205	62.1	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^3)_{3/2}]_1 4p_{1/2}$	$3/2^-$	1878.25	6.46×10^{-13}	
206	54.6	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^3)_{9/2}]_5 4p_{1/2}$	$11/2^-$	1881.17	1.30×10^{-12}	
208	93.1	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^3)_{9/2}]_5 4p_{1/2}$	$9/2^-$	1883.03	1.56×10^{-13}	
210	54.3	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^3)_{9/2}]_6 4p_{1/2}$	$11/2^-$	1884.53	1.22×10^{-13}	
213	75.9	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^3)_{3/2}]_2 4p_{1/2}$	$5/2^-$	1889.04	1.51×10^{-12}	
215	61.3	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^3)_{3/2}]_3 4p_{1/2}$	$7/2^-$	1890.91	6.85×10^{-13}	
216	73.4	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^3)_{3/2}]_2 4p_{1/2}$	$3/2^-$	1890.99	1.66×10^{-13}	
217	57.2	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^3)_{3/2}]_3 4p_{1/2}$	$5/2^-$	1892.00	1.89×10^{-13}	
218	81.7	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^3)_{3/2}]_0 4p_{1/2}$	$1/2^-$	1900.62	4.75×10^{-13}	
220	87.6	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^3)_{5/2}]_4 4p_{1/2}$	$9/2^-$	1904.52	1.81×10^{-12}	
221	61.5	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^3)_{5/2}]_4 4p_{1/2}$	$7/2^-$	1905.39	3.43×10^{-13}	
222	48.4	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^3)_{5/2}]_1 4p_{1/2}$	$1/2^-$	1905.78	2.48×10^{-13}	
223	61.3	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^3)_{5/2}]_2 4p_{1/2}$	$5/2^-$	1905.82	4.15×10^{-13}	
226	50.6	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^3)_{5/2}]_3 4p_{1/2}$	$7/2^-$	1908.32	1.78×10^{-13}	
227	33.4	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^3)_{5/2}]_1 4p_{1/2}$	$3/2^-$	1908.54	1.25×10^{-13}	
228	60.6	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^3)_{5/2}]_3 4p_{1/2}$	$5/2^-$	1909.31	1.34×10^{-13}	
229	96.2	$3s^2 3p^6 3d_{3/2}^4 (3d_{5/2}^2)_4 4p_{3/2}$	$9/2^-$	1922.48	1.23×10^{-13}	
230	97.0	$3s^2 3p^6 3d_{3/2}^4 (3d_{5/2}^2)_4 4p_{3/2}$	$11/2^-$	1922.78	9.20×10^{-13}	
234	97.2	$3s^2 3p^6 3d_{3/2}^4 (3d_{5/2}^2)_4 4p_{3/2}$	$7/2^-$	1926.27	8.01×10^{-14}	
235	71.7	$3s^2 3p^6 3d_{3/2}^4 (3d_{5/2}^2)_4 4p_{3/2}$	$5/2^-$	1926.28	1.53×10^{-13}	
236	96.1	$3s^2 3p^6 3d_{3/2}^4 (3d_{5/2}^2)_2 4p_{3/2}$	$7/2^-$	1931.06	1.80×10^{-13}	
237	96.5	$3s^2 3p^6 3d_{3/2}^4 (3d_{5/2}^2)_2 4p_{3/2}$	$1/2^-$	1931.40	1.01×10^{-13}	
238	70.7	$3s^2 3p^6 3d_{3/2}^4 (3d_{5/2}^2)_2 4p_{3/2}$	$5/2^-$	1934.65	1.44×10^{-13}	
239	95.0	$3s^2 3p^6 3d_{3/2}^4 (3d_{5/2}^2)_2 4p_{3/2}$	$3/2^-$	1935.76	6.90×10^{-14}	
252	89.5	$3s^2 3p^6 3d_{3/2}^4 (3d_{5/2}^2)_0 4p_{3/2}$	$3/2^-$	1951.43	1.74×10^{-13}	
273	51.7	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^3)_{9/2}]_4 4p_{3/2}$	$9/2^-$	1987.14	2.72×10^{-13}	
281	68.9	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^3)_{9/2}]_5 4p_{3/2}$	$13/2^-$	1993.55	5.13×10^{-13}	
282	86.9	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^3)_{9/2}]_5 4p_{3/2}$	$11/2^-$	1993.63	2.93×10^{-13}	

(continued on next page)

Table 8 (*continued*)

Index	Purity (%)	Configuration	J^{π}	E (eV)	τ_{rad} (s)	τ_{level} (s)
284	60.0	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^3)_{9/2}]_6 4p_{3/2}$	$9/2^-$	1994.86	8.83×10^{-14}	
285	68.4	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^3)_{9/2}]_6 4p_{3/2}$	$13/2^-$	1995.91	6.55×10^{-13}	
287	79.7	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^3)_{9/2}]_5 4p_{3/2}$	$7/2^-$	1998.02	1.32×10^{-13}	
288	85.2	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^3)_{9/2}]_6 4p_{3/2}$	$11/2^-$	1999.34	7.89×10^{-14}	
292	57.9	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^3)_{3/2}]_2 4p_{3/2}$	$7/2^-$	2002.95	9.40×10^{-14}	
294	53.4	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^3)_{3/2}]_3 4p_{3/2}$	$7/2^-$	2004.03	1.75×10^{-13}	
297	57.4	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^3)_{3/2}]_3 4p_{3/2}$	$9/2^-$	2005.13	1.71×10^{-13}	
391	93.9	$3s^2 3p_{1/2}^2 [3p_{3/2}^3 3d_{3/2}^4 (3d_{5/2}^3)_{9/2}]_6 4s_{1/2}$	$11/2^-$	2108.54	5.76×10^{-14}	
396	95.8	$3s^2 3p_{1/2}^2 [3p_{3/2}^3 3d_{3/2}^4 (3d_{5/2}^3)_{9/2}]_5 4s_{1/2}$	$11/2^-$	2115.30	1.28×10^{-13}	
397	64.9	$3s^2 3p_{1/2}^2 [3p_{3/2}^3 3d_{3/2}^4 (3d_{5/2}^3)_{3/2}]_3 4s_{1/2}$	$7/2^-$	2116.62	2.03×10^{-13}	
402	97.9	$3s^2 3p_{1/2}^2 [3p_{3/2}^3 3d_{3/2}^4 (3d_{5/2}^3)_{9/2}]_5 4s_{1/2}$	$9/2^-$	2119.84	7.23×10^{-14}	
403	62.2	$3s^2 3p_{1/2}^2 [3p_{3/2}^3 3d_{3/2}^4 (3d_{5/2}^3)_{3/2}]_3 4s_{1/2}$	$5/2^-$	2120.11	7.40×10^{-14}	
412	86.6	$3s^2 3p_{1/2}^2 [3p_{3/2}^3 3d_{3/2}^4 (3d_{5/2}^3)_{5/2}]_4 4s_{1/2}$	$9/2^-$	2128.23	7.40×10^{-13}	
425	70.7	$3s^2 3p_{1/2}^2 [3p_{3/2}^3 3d_{3/2}^4 (3d_{5/2}^3)_{3/2}]_2 4s_{1/2}$	$3/2^-$	2133.42	6.41×10^{-14}	
426	85.9	$3s^2 3p_{1/2}^2 [3p_{3/2}^3 3d_{3/2}^4 (3d_{5/2}^3)_{5/2}]_4 4s_{1/2}$	$7/2^-$	2133.46	5.21×10^{-14}	
461	64.0	$3s^2 3p_{1/2}^2 [3p_{3/2}^3 3d_{3/2}^4 (3d_{5/2}^3)_{5/2}]_3 4s_{1/2}$	$7/2^-$	2151.00	1.16×10^{-13}	
462	85.5	$3s^2 3p_{1/2}^2 [3p_{3/2}^3 3d_{3/2}^4 (3d_{5/2}^3)_{9/2}]_4 4s_{1/2}$	$9/2^-$	2151.61	8.70×10^{-14}	
469	58.0	$3s^2 3p_{1/2}^2 [3p_{3/2}^3 3d_{3/2}^4 (3d_{5/2}^3)_{5/2}]_3 4s_{1/2}$	$5/2^-$	2153.84	6.15×10^{-14}	
473	84.0	$3s^2 3p_{1/2}^2 [3p_{3/2}^3 3d_{3/2}^4 (3d_{5/2}^3)_{9/2}]_4 4s_{1/2}$	$7/2^-$	2154.78	1.16×10^{-13}	
491	31.0	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^3)_{3/2}]_2 4d_{5/2}$	$9/2^+$	2162.50	1.31×10^{-12}	
493	36.8	$3s^2 3p_{1/2}^2 [3p_{3/2}^3 3d_{3/2}^4 (3d_{5/2}^3)_{9/2}]_3 4s_{1/2}$	$7/2^-$	2162.92	8.62×10^{-14}	
494	12.8	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^3)_{9/2}]_4 4d_{3/2}$	$9/2^+$	2164.37	8.64×10^{-13}	
511	68.6	$3s^2 3p_{1/2}^2 [3p_{3/2}^3 3d_{3/2}^4 (3d_{5/2}^3)_{5/2}]_1 4s_{1/2}$	$3/2^-$	2176.27	6.84×10^{-14}	
512	36.9	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^3)_{3/2}]_3 4d_{3/2}$	$3/2^+$	2176.54	5.98×10^{-13}	
530	27.7	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^3)_{5/2}]_4 4d_{3/2}$	$5/2^+$	2183.83	6.62×10^{-13}	
616	86.3	$3s^2 3p^6 3d_{3/2}^4 (3d_{5/2}^2)_4 4f_{5/2}$	$9/2^-$	2220.22	9.80×10^{-13}	
625	90.6	$3s^2 3p^6 3d_{3/2}^4 (3d_{5/2}^2)_4 4f_{5/2}$	$7/2^-$	2223.48	1.43×10^{-13}	
663	68.9	$3s^2 3p^6 3d_{3/2}^4 (3d_{5/2}^2)_2 4f_{5/2}$	$9/2^-$	2231.86	1.69×10^{-13}	
671	44.4	$3s^2 3p^6 3d_{3/2}^4 (3d_{5/2}^2)_4 4f_{7/2}$	$7/2^-$	2233.05	1.08×10^{-13}	
677	50.5	$3s^2 3p^6 3d_{3/2}^4 (3d_{5/2}^2)_2 4f_{5/2}$	$7/2^-$	2235.36	1.61×10^{-13}	
693	51.8	$3s^2 3p^6 3d_{3/2}^4 (3d_{5/2}^2)_2 4f_{7/2}$	$11/2^-$	2238.63	1.94×10^{-13}	
696	69.0	$3s^2 3p^6 3d_{3/2}^4 (3d_{5/2}^2)_4 4f_{7/2}$	$9/2^-$	2239.14	2.04×10^{-14}	
706	86.9	$3s^2 3p^6 3d_{3/2}^4 (3d_{5/2}^2)_2 4f_{7/2}$	$9/2^-$	2242.32	5.50×10^{-14}	
707	62.7	$3s^2 3p^6 3d_{3/2}^4 (3d_{5/2}^2)_2 4f_{7/2}$	$3/2^-$	2242.46	2.90×10^{-14}	
708	84.9	$3s^2 3p^6 3d_{3/2}^4 (3d_{5/2}^2)_4 4f_{7/2}$	$1/2^-$	2242.69	1.58×10^{-14}	
724	55.9	$3s^2 3p_{1/2}^2 [(3p_{3/2}^3 3d_{3/2}^3)_3 (3d_{5/2}^4)_0]_3 4s_{1/2}$	$5/2^-$	2246.71	2.96×10^{-14}	
725	65.0	$3s^2 3p^6 3d_{3/2}^4 (3d_{5/2}^2)_4 4f_{7/2}$	$5/2^-$	2246.93	1.62×10^{-14}	
727	50.1	$3s^2 3p^6 3d_{3/2}^4 (3d_{5/2}^2)_0 4f_{5/2}$	$5/2^-$	2248.55	3.72×10^{-14}	
728	39.4	$3s^2 3p^6 3d_{3/2}^4 (3d_{5/2}^2)_2 4f_{7/2}$	$11/2^-$	2248.67	8.60×10^{-15}	
731	61.0	$3s^2 3p^6 3d_{3/2}^4 (3d_{5/2}^2)_4 4f_{7/2}$	$3/2^-$	2250.61	1.18×10^{-14}	
743	60.1	$3s^2 3p^6 3d_{3/2}^4 (3d_{5/2}^2)_2 4f_{7/2}$	$7/2^-$	2254.55	2.00×10^{-14}	
756	44.8	$3s^2 3p^6 3d_{3/2}^4 (3d_{5/2}^2)_2 4f_{7/2}$	$5/2^-$	2259.34	1.30×10^{-14}	
761	78.0	$3s^2 3p^6 3d_{3/2}^4 (3d_{5/2}^2)_0 4f_{7/2}$	$7/2^-$	2265.10	1.60×10^{-14}	
812	29.9	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^3)_{9/2}]_3 4f_{5/2}$	$9/2^-$	2287.65	3.89×10^{-13}	
814	52.9	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^3)_{9/2}]_4 4f_{5/2}$	$11/2^-$	2287.86	6.79×10^{-13}	
821	33.6	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^3)_{9/2}]_3 4f_{5/2}$	$11/2^-$	2289.96	1.55×10^{-13}	
891	65.7	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^3)_{3/2}]_3 4f_{5/2}$	$11/2^-$	2303.12	6.84×10^{-14}	
893	34.0	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^3)_{3/2}]_3 4f_{5/2}$	$7/2^-$	2304.07	7.65×10^{-14}	
926	88.5	$3s^2 3p_{1/2}^2 [3p_{3/2}^3 3d_{3/2}^4 (3d_{5/2}^3)_{9/2}]_6 4p_{3/2}$	$13/2^+$	2310.23	3.46×10^{-13}	
930	27.0	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^3)_{9/2}]_5 4f_{7/2}$	$9/2^-$	2312.04	9.57×10^{-15}	
938	25.9	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^3)_{3/2}]_2 4f_{7/2}$	$7/2^-$	2313.60	9.12×10^{-15}	
940	25.6	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^3)_{9/2}]_6 4f_{5/2}$	$7/2^-$	2314.59	8.55×10^{-15}	
942	24.0	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^3)_{5/2}]_4 4f_{5/2}$	$9/2^-$	2315.16	5.95×10^{-15}	
945	55.3	$3s^2 3p_{1/2}^2 [3p_{3/2}^3 3d_{3/2}^4 (3d_{5/2}^3)_{9/2}]_6 4p_{3/2}$	$9/2^+$	2315.36	2.75×10^{-13}	
948	33.9	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^3)_{9/2}]_5 4f_{7/2}$	$7/2^-$	2315.86	1.06×10^{-14}	
950	25.9	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^3)_{5/2}]_3 4f_{5/2}$	$3/2^-$	2316.32	1.64×10^{-14}	
952	30.6	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^3)_{5/2}]_2 4f_{5/2}$	$7/2^-$	2316.88	1.72×10^{-14}	
955	21.4	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^3)_{5/2}]_4 4f_{5/2}$	$9/2^-$	2317.89	9.96×10^{-15}	
958	20.9	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^3)_{9/2}]_3 4f_{5/2}$	$11/2^-$	2318.75	2.91×10^{-15}	
964	27.2	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^3)_{5/2}]_2 4f_{7/2}$	$9/2^-$	2320.26	1.57×10^{-14}	
971	30.1	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^3)_{9/2}]_5 4f_{7/2}$	$5/2^-$	2321.18	9.58×10^{-15}	
975	20.7	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^3)_{3/2}]_0 4f_{7/2}$	$7/2^-$	2321.96	2.25×10^{-14}	
976	18.0	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^3)_{5/2}]_2 4f_{5/2}$	$9/2^-$	2322.46	9.90×10^{-15}	
980	23.6	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^3)_{3/2}]_2 4f_{5/2}$	$5/2^-$	2323.24	1.19×10^{-14}	
984	25.6	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^3)_{9/2}]_6 4f_{7/2}$	$11/2^-$	2324.46	8.76×10^{-15}	
985	23.1	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^3)_{5/2}]_4 4f_{5/2}$	$5/2^-$	2324.64	1.31×10^{-14}	

(*continued on next page*)

Table 8 (*continued*)

Index	Purity (%)	Configuration	J^π	E (eV)	τ_{rad} (s)	τ_{level} (s)
986	37.4	$3s^2 3p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^3_{5/2})_{3/2}]_3 4p_{3/2}$	$9/2^+$	2324.87	1.04×10^{-13}	
988	38.0	$3s^2 3p^6[3d^3_{3/2}(3d^3_{5/2})_{3/2}]_3 4f_{5/2}$	$1/2^-$	2325.20	7.13×10^{-15}	
997	47.3	$3s^2 3p^6[3d^3_{3/2}(3d^3_{5/2})_{5/2}]_4 4f_{5/2}$	$11/2^-$	2328.05	1.64×10^{-14}	
1011	20.7	$3s^2 3p^6[3d^3_{3/2}(3d^3_{5/2})_{3/2}]_0 4f_{7/2}$	$7/2^-$	2332.10	1.04×10^{-14}	
1012	41.7	$3s^2 3p^6[3d^3_{3/2}(3d^3_{5/2})_{3/2}]_3 4f_{5/2}$	$3/2^-$	2332.13	3.61×10^{-15}	
1015	23.8	$3s^2 3p^6[3d^3_{3/2}(3d^3_{5/2})_{5/2}]_2 4f_{7/2}$	$5/2^-$	2332.68	1.28×10^{-14}	
1017	18.7	$3s^2 3p^6[3d^3_{3/2}(3d^3_{5/2})_{5/2}]_2 4f_{7/2}$	$5/2^-$	2333.01	5.03×10^{-15}	
1022	40.2	$3s^2 3p^6[3d^3_{3/2}(3d^3_{5/2})_{3/2}]_3 4f_{5/2}$	$1/2^-$	2333.60	4.58×10^{-15}	
1026	33.2	$3s^2 3p^6[3d^3_{3/2}(3d^3_{5/2})_{5/2}]_1 4f_{7/2}$	$5/2^-$	2334.73	5.85×10^{-14}	
1028	20.6	$3s^2 3p^2_{1/2}[(3p^3_{3/2}3d^3_{3/2})_1(3d^4_{5/2})_4]_4 4p_{1/2}$	$9/2^+$	2335.07	2.40×10^{-13}	
1030	32.3	$3s^2 3p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^3_{5/2})_{9/2}]_5 4p_{3/2}$	$9/2^+$	2336.00	1.09×10^{-13}	
1038	29.0	$3s^2 3p^6[3d^3_{3/2}(3d^3_{5/2})_{5/2}]_4 4f_{7/2}$	$5/2^-$	2337.48	4.95×10^{-15}	
1044	80.1	$3s^2 3p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^3_{5/2})_{5/2}]_4 4p_{3/2}$	$9/2^+$	2339.16	1.33×10^{-13}	
1045	52.1	$3s^2 3p^6[3d^3_{3/2}(3d^3_{5/2})_{5/2}]_4 4f_{5/2}$	$3/2^-$	2339.37	3.41×10^{-15}	
1048	24.6	$3s^2 3p^6[3d^3_{3/2}(3d^3_{5/2})_{5/2}]_4 4f_{5/2}$	$5/2^-$	2340.25	3.93×10^{-15}	
1050	33.0	$3s^2 3p^6[3d^3_{3/2}(3d^3_{5/2})_{5/2}]_2 4f_{5/2}$	$7/2^-$	2340.68	3.22×10^{-15}	
1054	13.5	$3s^2 3p^6[3d^3_{3/2}(3d^3_{5/2})_{3/2}]_3 4f_{7/2}$	$7/2^-$	2342.64	5.38×10^{-15}	
1099	58.9	$3s^2 3p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^3_{5/2})_{9/2}]_4 4p_{3/2}$	$9/2^+$	2364.04	2.19×10^{-13}	
1110	45.0	$3s^2 3p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^3_{5/2})_{9/2}]_3 4p_{3/2}$	$5/2^+$	2367.01	9.45×10^{-14}	
1159	37.3	$3s^2 3p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^3_{5/2})_{5/2}]_3 4p_{3/2}$	$5/2^+$	2377.30	8.27×10^{-14}	
1162	29.6	$3s^2 3p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^3_{5/2})_{3/2}]_3 4p_{3/2}$	$3/2^+$	2378.27	1.33×10^{-13}	
1201	51.8	$3s^2 3p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^3_{5/2})_{5/2}]_1 4p_{3/2}$	$5/2^+$	2386.95	2.93×10^{-13}	
1284	61.4	$3s^2 3p^6[(3d^2_{3/2})_0(3d^4_{5/2})_4]_4 4f_{5/2}$	$13/2^-$	2405.87	2.87×10^{-15}	
1464	71.7	$3s^2[3p_{1/2}3p^4_{3/2}3d^4_{3/2}(3d^3_{5/2})_{9/2}]_4 4s_{1/2}$	$7/2^-$	2464.55	4.31×10^{-14}	
1476	38.1	$3s^2 3p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^3_{5/2})_{9/2}]_6 4d_{5/2}$	$9/2^-$	2471.52	7.26×10^{-14}	
1478	80.4	$3s^2[3p_{1/2}3p^4_{3/2}3d^4_{3/2}(3d^3_{5/2})_{9/2}]_5 4s_{1/2}$	$11/2^-$	2471.86	4.46×10^{-14}	
1494	47.8	$3s^2 3p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^3_{5/2})_{9/2}]_6 4d_{5/2}$	$9/2^-$	2477.03	8.23×10^{-14}	
1498	48.5	$3s^2 3p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^3_{5/2})_{9/2}]_6 4d_{5/2}$	$11/2^-$	2478.60	6.88×10^{-14}	
1501	71.4	$3s^2 3p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^3_{5/2})_{9/2}]_6 4d_{5/2}$	$7/2^-$	2479.12	1.82×10^{-14}	
1515	42.6	$3s^2 3p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^3_{5/2})_{3/2}]_3 4d_{5/2}$	$11/2^-$	2483.41	2.97×10^{-14}	
1519	24.6	$3s^2 3p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^3_{5/2})_{9/2}]_5 4d_{5/2}$	$7/2^-$	2483.97	4.18×10^{-14}	
1543	41.8	$3s^2 3p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^3_{5/2})_{9/2}]_5 4d_{5/2}$	$9/2^-$	2490.99	3.97×10^{-14}	
1552	70.1	$3s^2 3p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^3_{5/2})_{9/2}]_4 4d_{3/2}$	$7/2^-$	2495.17	6.08×10^{-14}	
1556	26.5	$3s^2 3p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^3_{5/2})_{9/2}]_5 4d_{5/2}$	$9/2^-$	2495.85	2.33×10^{-14}	
1564	46.8	$3s^2 3p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^3_{5/2})_{3/2}]_2 4d_{5/2}$	$5/2^-$	2500.20	2.41×10^{-14}	
1576	61.7	$3s^2 3p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^3_{5/2})_{5/2}]_4 4d_{5/2}$	$5/2^-$	2503.34	2.57×10^{-14}	
1586	19.0	$3s^2[(3p_{1/2}3p^4_{3/2}3d^3_{3/2})_2(3d^4_{5/2})_4]_3 4s_{1/2}$	$7/2^-$	2505.93	5.79×10^{-14}	
1587	33.9	$3s^2 3p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^3_{5/2})_{3/2}]_2 4d_{5/2}$	$3/2^-$	2506.35	1.44×10^{-14}	
1610	54.4	$3s^2 3p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^3_{5/2})_{5/2}]_2 4d_{5/2}$	$7/2^-$	2514.60	4.97×10^{-14}	
1623	28.3	$3s^2 3p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^3_{5/2})_{5/2}]_3 4d_{5/2}$	$11/2^-$	2517.97	2.80×10^{-14}	
1629	51.5	$3s^2 3p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^3_{5/2})_{9/2}]_4 4d_{5/2}$	$11/2^-$	2519.40	7.69×10^{-14}	
1638	42.2	$3s^2 3p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^3_{5/2})_{5/2}]_3 4d_{5/2}$	$7/2^-$	2522.31	4.64×10^{-14}	
1644	61.7	$3s^2 3p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^3_{5/2})_{9/2}]_4 4d_{5/2}$	$7/2^-$	2524.20	3.30×10^{-14}	
1651	73.0	$3s^2 3p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^3_{5/2})_{5/2}]_3 4d_{5/2}$	$5/2^-$	2526.17	3.05×10^{-14}	
1671	50.6	$3s^2 3p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^3_{5/2})_{3/2}]_1 4d_{5/2}$	$5/2^-$	2531.01	2.64×10^{-14}	
1673	35.0	$3s^2 3p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^3_{5/2})_{5/2}]_3 4d_{5/2}$	$11/2^-$	2531.33	9.48×10^{-14}	
2112	45.5	$3s^2 3p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^3_{5/2})_{9/2}]_5 4f_{7/2}$	$13/2^+$	2629.88	1.04×10^{-12}	
2139	48.7	$3s^2 3p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^3_{5/2})_{9/2}]_6 4f_{7/2}$	$5/2^+$	2635.79	3.29×10^{-14}	
2153	56.5	$3s^2 3p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^3_{5/2})_{9/2}]_5 4f_{7/2}$	$11/2^+$	2638.78	5.22×10^{-14}	
2182	61.8	$3s^2 3p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^3_{5/2})_{9/2}]_5 4f_{7/2}$	$7/2^+$	2643.84	2.06×10^{-14}	
2184	57.3	$3s^2 3p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^3_{5/2})_{9/2}]_5 4f_{7/2}$	$9/2^+$	2644.23	2.26×10^{-14}	
2189	37.5	$3s^2 3p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^3_{5/2})_{5/2}]_4 4f_{7/2}$	$11/2^+$	2645.25	3.19×10^{-14}	
2258	13.6	$3s^2 3p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^3_{5/2})_{9/2}]_4 4f_{5/2}$	$9/2^+$	2659.24	1.39×10^{-14}	
2270	47.3	$3s^2 3p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^3_{5/2})_{5/2}]_2 4f_{7/2}$	$11/2^+$	2662.29	6.27×10^{-14}	
2292	54.2	$3s^2 3p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^3_{5/2})_{5/2}]_3 4f_{7/2}$	$13/2^+$	2665.36	1.47×10^{-13}	
2333	32.9	$3s^2 3p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^3_{5/2})_{9/2}]_4 4f_{7/2}$	$9/2^+$	2673.28	6.91×10^{-14}	
2408	37.5	$3s^2 3p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^3_{5/2})_{5/2}]_1 4f_{7/2}$	$9/2^+$	2687.77	2.95×10^{-14}	
2418	57.5	$[3s_{1/2}3p^6 3d^4_{3/2}(3d^3_{5/2})_{9/2}]_5 4s_{1/2}$	$9/2^+$	2689.01	8.94×10^{-14}	
2902	94.0	$[3s_{1/2}3p^6 3d^4_{3/2}(3d^3_{5/2})_{9/2}]_5 4p_{1/2}$	$9/2^-$	2766.38	4.45×10^{-14}	
2908	91.5	$[3s_{1/2}3p^6 3d^4_{3/2}(3d^3_{5/2})_{9/2}]_5 4p_{1/2}$	$11/2^-$	2766.88	2.49×10^{-14}	
3011	83.6	$[3s_{1/2}3p^6 3d^4_{3/2}(3d^3_{5/2})_{9/2}]_4 4p_{1/2}$	$7/2^-$	2785.66	2.09×10^{-14}	
3024	85.2	$[3s_{1/2}3p^6 3d^4_{3/2}(3d^3_{5/2})_{9/2}]_4 4p_{1/2}$	$9/2^-$	2787.85	3.28×10^{-14}	
3041	87.8	$[3s_{1/2}3p^6 3d^4_{3/2}(3d^3_{5/2})_{5/2}]_3 4p_{1/2}$	$7/2^-$	2791.19	2.43×10^{-14}	
3113	88.7	$3s^2[3p_{1/2}3p^4_{3/2}3d^4_{3/2}(3d^3_{5/2})_{9/2}]_4 4d_{3/2}$	$11/2^-$	2806.07	4.24×10^{-14}	
3161	87.2	$3s^2[3p_{1/2}3p^4_{3/2}3d^4_{3/2}(3d^3_{5/2})_{9/2}]_5 4d_{3/2}$	$11/2^-$	2816.32	3.30×10^{-14}	
3162	80.5	$3s^2[3p_{1/2}3p^4_{3/2}3d^4_{3/2}(3d^3_{5/2})_{9/2}]_5 4d_{3/2}$	$9/2^-$	2816.67	2.74×10^{-14}	

(*continued on next page*)

Table 8 (*continued*)

Index	Purity (%)	Configuration	J^{π}	E (eV)	τ_{rad} (s)	τ_{level} (s)
3171	78.3	$3s^2[3p_{1/2}3p_{3/2}^4 3d_{3/2}^4(3d_{5/2}^3)_{9/2}]_5 4d_{3/2}$	$7/2^-$	2818.33	2.61×10^{-14}	
3744	71.3	$3s^2[3p_{1/2}3p_{3/2}^4 3d_{3/2}^4(3d_{5/2}^3)_{9/2}]_5 4f_{5/2}$	$5/2^+$	2983.05	4.38×10^{-14}	
5116	89.2	$3s^2 3p^6 3d_{3/2}^4(3d_{5/2}^2)_2 5d_{5/2}$	$9/2^+$	2976.70	1.05×10^{-13}	
5236	63.3	$3s^2 3p^6 3d_{3/2}^4(3d_{5/2}^2)_4 5f_{7/2}$	$9/2^-$	3036.47	2.67×10^{-14}	
5237	42.2	$3s^2 3p^6[3d_{3/2}^3(3d_{5/2}^3)_{3/2}]_3 5d_{3/2}$	$9/2^+$	3037.18	1.20×10^{-13}	
5250	72.4	$3s^2 3p^6 3d_{3/2}^4(3d_{5/2}^2)_4 5f_{7/2}$	$11/2^-$	3038.94	2.56×10^{-14}	
5251	62.1	$3s^2 3p^6 3d_{3/2}^4(3d_{5/2}^2)_2 5f_{5/2}$	$9/2^-$	3039.21	2.72×10^{-14}	
5262	91.3	$3s^2 3p^6 3d_{3/2}^4(3d_{5/2}^2)_4 5f_{7/2}$	$5/2^-$	3041.47	1.61×10^{-14}	
5280	73.9	$3s^2 3p^6 3d_{3/2}^4(3d_{5/2}^2)_2 5f_{7/2}$	$11/2^-$	3045.55	1.20×10^{-14}	
5281	77.1	$3s^2 3p^6 3d_{3/2}^4(3d_{5/2}^2)_2 5f_{7/2}$	$3/2^-$	3045.75	1.60×10^{-14}	
5289	77.0	$3s^2 3p^6 3d_{3/2}^4(3d_{5/2}^2)_2 5f_{7/2}$	$7/2^-$	3048.36	1.76×10^{-14}	
5291	86.9	$3s^2 3p^6 3d_{3/2}^4(3d_{5/2}^2)_2 5f_{7/2}$	$5/2^-$	3048.99	1.31×10^{-14}	
5333	89.6	$3s^2 3p^6 3d_{3/2}^4(3d_{5/2}^2)_0 5f_{7/2}$	$7/2^-$	3064.01	2.06×10^{-14}	
5403	35.7	$3s^2 3p^6[3d_{3/2}^3(3d_{5/2}^3)_{9/2}]_4 5f_{5/2}$	$11/2^-$	3095.88	2.72×10^{-14}	
5463	40.2	$3s^2 3p^6[3d_{3/2}^3(3d_{5/2}^3)_{9/2}]_5 5f_{5/2}$	$11/2^-$	3105.73	1.15×10^{-14}	
5477	36.9	$3s^2 3p^6[3d_{3/2}^3(3d_{5/2}^3)_{9/2}]_5 5f_{5/2}$	$9/2^-$	3107.82	1.17×10^{-14}	
5493	60.8	$3s^2 3p^6[3d_{3/2}^3(3d_{5/2}^3)_{9/2}]_6 5f_{5/2}$	$7/2^-$	3108.95	8.97×10^{-15}	
5503	27.3	$3s^2 3p^6[3d_{3/2}^3(3d_{5/2}^3)_{3/2}]_3 5f_{5/2}$	$9/2^-$	3110.44	1.77×10^{-14}	
5511	55.2	$3s^2 3p^6[3d_{3/2}^3(3d_{5/2}^3)_{3/2}]_3 5f_{5/2}$	$11/2^-$	3111.81	1.93×10^{-14}	
5604	61.5	$3s^2 3p^6[3d_{3/2}^3(3d_{5/2}^3)_{5/2}]_4 5f_{5/2}$	$3/2^-$	3131.79	8.12×10^{-15}	
5607	26.1	$3s^2 3p^6[3d_{3/2}^3(3d_{5/2}^3)_{5/2}]_3 5f_{5/2}$	$5/2^-$	3132.51	1.45×10^{-14}	
5609	43.8	$3s^2 3p^6[3d_{3/2}^3(3d_{5/2}^3)_{5/2}]_3 5f_{5/2}$	$7/2^-$	3132.87	1.02×10^{-14}	
6485	81.1	$3s^2 3p_{1/2}^2[3p_{3/2}^3 3d_{3/2}^4(3d_{5/2}^3)_{9/2}]_6 5d_{5/2}$	$7/2^-$	3356.50	1.86×10^{-14}	
6551	77.6	$3s^2 3p_{1/2}^2[3p_{3/2}^3 3d_{3/2}^4(3d_{5/2}^3)_{9/2}]_5 5d_{5/2}$	$9/2^-$	3368.96	2.35×10^{-14}	
12102	93.4	$3s^2 3p^6 3d_{3/2}^4(3d_{5/2}^2)_4 6f_{7/2}$	$9/2^-$	3469.60	2.80×10^{-14}	
12104	87.3	$3s^2 3p^6 3d_{3/2}^4(3d_{5/2}^2)_4 6f_{7/2}$	$11/2^-$	3470.95	2.53×10^{-14}	
12120	90.8	$3s^2 3p^6 3d_{3/2}^4(3d_{5/2}^2)_2 6f_{7/2}$	$11/2^-$	3477.45	2.41×10^{-14}	
12366	58.8	$3s^2 3p^6[3d_{3/2}^3(3d_{5/2}^3)_{9/2}]_4 6f_{5/2}$	$11/2^-$	3530.64	3.09×10^{-14}	
12410	59.8	$3s^2 3p^6[3d_{3/2}^3(3d_{5/2}^3)_{9/2}]_5 6f_{5/2}$	$11/2^-$	3538.70	2.27×10^{-14}	
12419	54.1	$3s^2 3p^6[3d_{3/2}^3(3d_{5/2}^3)_{9/2}]_5 6f_{5/2}$	$9/2^-$	3539.98	1.65×10^{-14}	
12424	57.3	$3s^2 3p^6[3d_{3/2}^3(3d_{5/2}^3)_{9/2}]_6 6f_{5/2}$	$7/2^-$	3540.56	1.52×10^{-14}	

Table 9
Energy levels in Cr-like tungsten, W^{50+}.

Index	Purity (%)	Configuration	J^π	E (eV)	τ_{rad} (s)	τ_{level} (s)
0	97.7	$3s^2 3p^6 3d_{3/2}^4 3d_{5/2}^2$	4^+	0.00		
1	97.1	$3s^2 3p^6 3d_{3/2}^4 3d_{5/2}^2$	2^+	7.68	4.56×10	1.93×10^{-5}
2	92.2	$3s^2 3p^6 3d_{3/2}^4 3d_{5/2}^2$	0^+	25.36	2.01×10^{-1}	1.93×10^{-5}
3	78.3	$3s^2 3p^6 3d_{3/2}^3 (3d_{5/2}^3)_{9/2}$	3^+	63.03	2.93×10^{-7}	2.89×10^{-7}
4	88.8	$3s^2 3p^6 3d_{3/2}^3 (3d_{5/2}^3)_{9/2}$	4^+	64.58	3.26×10^{-7}	3.21×10^{-7}
6	99.8	$3s^2 3p^6 3d_{3/2}^3 (3d_{5/2}^3)_{9/2}$	5^+	72.71	1.49×10^{-6}	1.38×10^{-6}
7	99.5	$3s^2 3p^6 3d_{3/2}^3 (3d_{5/2}^3)_{9/2}$	6^+	72.74	2.43×10^{-2}	1.93×10^{-5}
8	76.7	$3s^2 3p^6 3d_{3/2}^3 (3d_{5/2}^3)_{3/2}$	2^+	79.33	4.86×10^{-7}	4.74×10^{-7}
9	62.2	$3s^2 3p^6 3d_{3/2}^3 (3d_{5/2}^3)_{3/2}$	3^+	80.89	7.34×10^{-7}	7.07×10^{-7}
10	90.1	$3s^2 3p^6 3d_{3/2}^3 (3d_{5/2}^3)_{3/2}$	0^+	90.37	1.44×10^{-5}	8.24×10^{-6}
11	88.7	$3s^2 3p^6 3d_{3/2}^3 (3d_{5/2}^3)_{5/2}$	4^+	94.67	1.46×10^{-5}	8.30×10^{-6}
12	71.9	$3s^2 3p^6 3d_{3/2}^3 (3d_{5/2}^3)_{5/2}$	2^+	95.31	2.56×10^{-6}	2.27×10^{-6}
13	58.3	$3s^2 3p^6 3d_{3/2}^3 (3d_{5/2}^3)_{5/2}$	1^+	95.50	6.41×10^{-7}	6.21×10^{-7}
14	68.8	$3s^2 3p^6 3d_{3/2}^3 (3d_{5/2}^3)_{5/2}$	3^+	97.39	1.11×10^{-6}	1.05×10^{-6}
17	70.3	$3s^2 3p^6 (3d_{3/2}^2)_2 (3d_{5/2}^4)_4$	4^+	137.87	1.68×10^{-7}	1.67×10^{-7}
20	99.5	$3s^2 3p^6 (3d_{3/2}^2)_2 (3d_{5/2}^4)_4$	6^+	145.70	4.99×10^{-7}	4.87×10^{-7}
26	80.1	$3s^2 3p^6 (3d_{3/2}^2)_0 (3d_{5/2}^4)_4$	4^+	171.10	3.07×10^{-7}	3.02×10^{-7}
34	95.7	$3s^2 3p_{1/2}^2 3p_{3/2}^3 3d_{3/2}^4 (3d_{5/2}^3)_{9/2}$	6^-	384.84	3.71×10^{-11}	
36	98.3	$3s^2 3p_{1/2}^2 3p_{3/2}^3 3d_{3/2}^4 (3d_{5/2}^3)_{9/2}$	5^-	396.48	2.93×10^{-12}	
37	63.8	$3s^2 3p_{1/2}^2 3p_{3/2}^3 3d_{3/2}^4 (3d_{5/2}^3)_{3/2}$	3^-	397.00	7.12×10^{-12}	
38	87.5	$3s^2 3p_{1/2}^2 3p_{3/2}^3 3d_{3/2}^4 (3d_{5/2}^3)_{5/2}$	4^-	409.52	2.38×10^{-11}	
39	72.8	$3s^2 3p_{1/2}^2 3p_{3/2}^3 3d_{3/2}^4 (3d_{5/2}^3)_{3/2}$	2^-	410.19	1.08×10^{-11}	
40	72.4	$3s^2 3p_{1/2}^2 3p_{3/2}^3 3d_{3/2}^4 (3d_{5/2}^3)_{5/2}$	2^-	423.73	9.84×10^{-13}	
41	57.1	$3s^2 3p_{1/2}^2 3p_{3/2}^3 3d_{3/2}^4 (3d_{5/2}^3)_{5/2}$	3^-	430.39	1.66×10^{-12}	
42	87.6	$3s^2 3p_{1/2}^2 3p_{3/2}^3 3d_{3/2}^4 (3d_{5/2}^3)_{9/2}$	4^-	430.56	5.97×10^{-13}	
43	36.3	$3s^2 3p_{1/2}^2 3p_{3/2}^3 3d_{3/2}^4 (3d_{5/2}^3)_{5/2}$	3^-	442.65	4.45×10^{-13}	
44	73.6	$3s^2 3p_{1/2}^2 3p_{3/2}^3 3d_{3/2}^4 (3d_{5/2}^3)_{3/2}$	1^-	443.57	9.64×10^{-13}	
45	69.8	$3s^2 3p_{1/2}^2 3p_{3/2}^3 3d_{3/2}^4 (3d_{5/2}^3)_{5/2}$	1^-	451.95	4.66×10^{-13}	
46	57.7	$3s^2 3p_{1/2}^2 (3p_{3/2}^3 3d_{3/2}^3)_2 (3d_{5/2}^4)_4$	5^-	455.14	9.25×10^{-12}	
55	57.0	$3s^2 3p_{1/2}^2 (3p_{3/2}^3 3d_{3/2}^3)_1 (3d_{5/2}^4)_4$	5^-	482.42	1.44×10^{-12}	
58	49.1	$3s^2 3p_{1/2}^2 (3p_{3/2}^3 3d_{3/2}^3)_1 (3d_{5/2}^4)_2$	3^-	485.58	1.41×10^{-12}	
59	56.6	$3s^2 3p_{1/2}^2 (3p_{3/2}^3 3d_{3/2}^3)_3 (3d_{5/2}^4)_4$	5^-	487.28	2.51×10^{-12}	
61	71.3	$3s^2 3p_{1/2}^2 (3p_{3/2}^3 3d_{3/2}^3)_3 (3d_{5/2}^4)_4$	6^-	493.07	8.62×10^{-13}	
69	37.0	$3s^2 3p_{1/2}^2 (3p_{3/2}^3 3d_{3/2}^3)_2 (3d_{5/2}^4)_4$	5^-	513.65	4.71×10^{-13}	
106	97.5	$3s^2 3p_{1/2} 3p_{3/2}^4 3d_{3/2}^4 (3d_{5/2}^3)_{9/2}$	4^-	741.25	1.56×10^{-13}	
107	95.8	$3s^2 3p_{1/2} 3p_{3/2}^4 3d_{3/2}^4 (3d_{5/2}^3)_{9/2}$	5^-	753.31	1.32×10^{-13}	
108	97.6	$3s^2 3p_{1/2} 3p_{3/2}^4 3d_{3/2}^4 (3d_{5/2}^3)_{3/2}$	1^-	757.50	1.51×10^{-13}	
111	93.1	$3s^2 3p_{1/2} 3p_{3/2}^4 3d_{3/2}^4 (3d_{5/2}^3)_{5/2}$	3^-	770.38	1.40×10^{-13}	
179	95.5	$3s_{1/2} 3p^6 3d_{3/2}^4 (3d_{5/2}^3)_{9/2}$	5^+	954.12	2.02×10^{-13}	
183	89.3	$3s_{1/2} 3p^6 3d_{3/2}^4 (3d_{5/2}^3)_{9/2}$	4^+	974.62	2.03×10^{-13}	
518	95.8	$3s^2 3p^6 3d_{3/2}^4 3d_{5/2} 4s_{1/2}$	3^+	1771.25	6.65×10^{-11}	
519	97.4	$3s^2 3p^6 3d_{3/2}^4 3d_{5/2} 4s_{1/2}$	2^+	1774.08	3.52×10^{-11}	
523	98.6	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^2)_4]_{11/2} 4s_{1/2}$	6^+	1841.99	6.15×10^{-11}	
526	90.9	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^2)_4]_{11/2} 4s_{1/2}$	5^+	1843.90	4.52×10^{-11}	
528	89.4	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^2)_4]_{9/2} 4s_{1/2}$	5^+	1848.10	4.78×10^{-11}	
533	81.8	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^2)_2]_{7/2} 4s_{1/2}$	4^+	1856.84	4.83×10^{-11}	
537	96.5	$3s^2 3p^6 3d_{3/2}^4 3d_{5/2} 4p_{1/2}$	3^-	1863.42	8.23×10^{-12}	
556	77.0	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^2)_4]_{5/2} 4p_{1/2}$	2^-	1919.55	1.37×10^{-12}	
558	68.9	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^2)_4]_{5/2} 4p_{1/2}$	3^-	1922.09	3.88×10^{-13}	
566	75.3	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^2)_4]_{7/2} 4p_{1/2}$	4^-	1932.97	1.05×10^{-12}	
567	83.1	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^2)_4]_{7/2} 4p_{1/2}$	3^-	1933.01	2.26×10^{-13}	
568	98.8	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^2)_4]_{11/2} 4p_{1/2}$	6^-	1933.68	1.86×10^{-11}	
571	90.0	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^2)_4]_{11/2} 4p_{1/2}$	5^-	1934.55	2.01×10^{-13}	
572	83.1	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^2)_2]_{3/2} 4p_{1/2}$	2^-	1934.69	9.09×10^{-13}	
574	85.7	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^2)_2]_{3/2} 4p_{1/2}$	1^-	1935.10	3.50×10^{-13}	
576	88.8	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^2)_4]_{9/2} 4p_{1/2}$	5^-	1940.51	2.28×10^{-13}	
577	89.2	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^2)_4]_{9/2} 4p_{1/2}$	4^-	1940.52	1.54×10^{-13}	
579	68.8	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^2)_2]_{5/2} 4p_{1/2}$	3^-	1943.51	8.24×10^{-13}	
581	79.0	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^2)_2]_{5/2} 4p_{1/2}$	2^-	1944.57	1.66×10^{-13}	
583	75.6	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^2)_2]_{7/2} 4p_{1/2}$	4^-	1947.87	7.31×10^{-13}	
584	89.7	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^2)_2]_{1/2} 4p_{1/2}$	1^-	1948.73	1.81×10^{-13}	
585	78.0	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^2)_2]_{7/2} 4p_{1/2}$	3^-	1949.90	1.14×10^{-13}	
590	79.6	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^2)_0]_{3/2} 4p_{1/2}$	2^-	1964.89	1.30×10^{-12}	
591	81.6	$3s^2 3p^6 [3d_{3/2}^3 (3d_{5/2}^2)_0]_{3/2} 4p_{1/2}$	1^-	1968.21	1.14×10^{-13}	
594	94.8	$3s^2 3p^6 3d_{3/2}^4 3d_{5/2} 4p_{3/2}$	4^-	1979.03	2.78×10^{-13}	
595	95.8	$3s^2 3p^6 3d_{3/2}^4 3d_{5/2} 4p_{3/2}$	2^-	1979.44	1.22×10^{-13}	

(continued on next page)

Table 9 (*continued*)

Index	Purity (%)	Configuration	J^{π}	E (eV)	τ_{rad} (s)	τ_{level} (s)
596	96.5	$3s^23p^63d^4_{3/2}3d_{5/2}4p_{3/2}$	3^-	1980.39	6.84×10^{-14}	
598	95.4	$3s^23p^63d^4_{3/2}3d_{5/2}4p_{3/2}$	1^-	1986.10	8.67×10^{-14}	
616	99.7	$3s^23p^6[(3d^2_{3/2})_2(3d^3_{5/2})_{9/2}]_{13/2}4p_{1/2}$	7^-	2003.58	4.44×10^{-13}	
620	92.9	$3s^23p^6[(3d^2_{3/2})_2(3d^3_{5/2})_{9/2}]_{13/2}4p_{1/2}$	6^-	2006.30	7.76×10^{-14}	
642	54.4	$3s^23p^6[(3d^2_{3/2})_0(3d^3_{5/2})_{9/2}]_{9/2}4p_{1/2}$	5^-	2034.66	2.12×10^{-13}	
648	77.0	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_4]_{7/2}4p_{3/2}$	4^-	2047.05	1.30×10^{-13}	
649	74.7	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_4]_{7/2}4p_{3/2}$	5^-	2048.48	4.54×10^{-13}	
650	98.5	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_4]_{11/2}4p_{3/2}$	7^-	2048.66	8.94×10^{-13}	
652	94.1	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_4]_{11/2}4p_{3/2}$	6^-	2049.81	1.17×10^{-13}	
653	58.7	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_4]_{7/2}4p_{3/2}$	3^-	2049.86	8.22×10^{-14}	
655	76.5	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_4]_{11/2}4p_{3/2}$	4^-	2050.88	1.03×10^{-13}	
657	65.9	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_4]_{11/2}4p_{3/2}$	5^-	2051.84	9.06×10^{-14}	
658	57.8	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_2]_{3/2}4p_{3/2}$	3^-	2051.86	3.47×10^{-13}	
663	93.2	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_4]_{9/2}4p_{3/2}$	6^-	2055.63	9.04×10^{-13}	
664	69.9	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_4]_{9/2}4p_{3/2}$	5^-	2055.66	9.01×10^{-14}	
666	51.7	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_4]_{9/2}4p_{3/2}$	4^-	2057.87	7.54×10^{-14}	
669	46.7	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_2]_{5/2}4p_{3/2}$	4^-	2060.83	2.42×10^{-13}	
673	77.1	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_2]_{7/2}4p_{3/2}$	5^-	2063.47	2.22×10^{-13}	
676	79.3	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_2]_{7/2}4p_{3/2}$	4^-	2066.60	1.91×10^{-13}	
680	71.8	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_2]_{7/2}4p_{3/2}$	3^-	2069.18	7.32×10^{-14}	
689	78.9	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_0]_{3/2}4p_{3/2}$	3^-	2082.57	1.57×10^{-13}	
719	99.1	$3s^23p^6[(3d^2_{3/2})_2(3d^3_{5/2})_{9/2}]_{13/2}4p_{3/2}$	7^-	2118.53	2.83×10^{-13}	
759	86.3	$3s^23p^63d^4_{3/2}3d_{5/2}4d_{5/2}$	4^+	2143.45	3.07×10^{-12}	
767	89.8	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_4]_{11/2}4s_{1/2}$	5^-	2151.30	6.22×10^{-14}	
769	65.4	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_2]_{5/2}4s_{1/2}$	3^-	2155.48	1.57×10^{-13}	
770	89.7	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_4]_{9/2}4s_{1/2}$	5^-	2156.05	1.08×10^{-13}	
773	64.5	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_2]_{5/2}4s_{1/2}$	2^-	2158.60	8.63×10^{-14}	
776	90.8	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_4]_{9/2}4s_{1/2}$	4^-	2161.14	6.64×10^{-14}	
779	87.1	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_2]_{7/2}4s_{1/2}$	3^-	2165.14	4.76×10^{-14}	
786	93.3	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_2]_{1/2}4s_{1/2}$	1^-	2168.89	8.26×10^{-14}	
803	91.9	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_4]_{7/2}4s_{1/2}$	4^-	2184.50	9.20×10^{-14}	
810	90.0	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_4]_{7/2}4s_{1/2}$	3^-	2187.01	9.26×10^{-14}	
812	61.2	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_0]_{3/2}4s_{1/2}$	1^-	2189.39	4.44×10^{-14}	
846	60.0	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_4]_{5/2}4s_{1/2}$	3^-	2204.38	7.28×10^{-14}	
852	40.6	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_4]_{5/2}4s_{1/2}$	2^-	2207.20	8.79×10^{-14}	
857	64.9	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_2]_{3/2}4s_{1/2}$	1^-	2207.94	5.90×10^{-14}	
873	25.4	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_4]_{9/2}4d_{3/2}$	4^+	2213.37	5.88×10^{-13}	
894	17.7	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_4]_{7/2}4d_{5/2}$	2^+	2221.16	1.38×10^{-12}	
897	19.6	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_2]_{7/2}4d_{3/2}$	2^+	2221.84	8.28×10^{-13}	
914	96.6	$3s^23p^2_{1/2}[(3p^3_{3/2}3d^3_{3/2})_3(3d^3_{5/2})_{9/2}]_{15/2}4s_{1/2}$	7^-	2229.90	4.99×10^{-14}	
937	92.7	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_4]_{11/2}4p_{1/2}$	6^+	2239.45	5.03×10^{-12}	
939	83.0	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_0]_{3/2}4d_{3/2}$	0^+	2240.15	5.79×10^{-13}	
1017	95.7	$3s^23p^63d^4_{3/2}3d_{5/2}4f_{5/2}$	4^-	2267.91	2.52×10^{-13}	
1021	95.3	$3s^23p^63d^4_{3/2}3d_{5/2}4f_{5/2}$	3^-	2269.40	1.62×10^{-13}	
1038	84.7	$3s^23p^63d^4_{3/2}3d_{5/2}4f_{5/2}$	5^-	2272.33	5.18×10^{-13}	
1056	93.6	$3s^23p^63d^4_{3/2}3d_{5/2}4f_{5/2}$	1^-	2275.24	7.87×10^{-14}	
1070	40.8	$3s^23p^6[(3d^2_{3/2})_2(3d^3_{5/2})_{9/2}]_{13/2}4d_{3/2}$	6^+	2277.96	7.94×10^{-13}	
1080	93.9	$3s^23p^63d^4_{3/2}3d_{5/2}4f_{7/2}$	4^-	2281.25	2.65×10^{-14}	
1103	88.7	$3s^23p^63d^4_{3/2}3d_{5/2}4f_{7/2}$	2^-	2287.72	1.65×10^{-14}	
1120	89.1	$3s^23p^63d^4_{3/2}3d_{5/2}4f_{7/2}$	3^-	2291.47	1.17×10^{-14}	
1122	27.5	$3s^23p^2_{1/2}\{[3p^3_{3/2}(3d^2_{3/2})_2]_{3/2}(3d^4_{5/2})_4\}_{9/2}4s_{1/2}$	5^-	2291.81	1.06×10^{-13}	
1123	75.3	$3s^23p^63d^4_{3/2}3d_{5/2}4f_{7/2}$	5^-	2291.93	9.82×10^{-15}	
1150	89.8	$3s^23p^63d^4_{3/2}3d_{5/2}4f_{7/2}$	1^-	2298.31	1.30×10^{-14}	
1249	66.0	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_4]_{5/2}4f_{5/2}$	4^-	2327.32	2.97×10^{-13}	
1257	72.5	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_4]_{5/2}4f_{5/2}$	2^-	2329.34	1.19×10^{-13}	
1264	45.6	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_4]_{5/2}4f_{5/2}$	5^-	2331.52	1.25×10^{-13}	
1284	33.9	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_4]_{5/2}4f_{7/2}$	5^-	2336.87	1.85×10^{-13}	
1288	50.8	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_4]_{7/2}4f_{5/2}$	3^-	2337.62	1.11×10^{-13}	
1290	57.2	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_4]_{11/2}4f_{5/2}$	6^-	2338.42	1.49×10^{-12}	
1292	33.5	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_4]_{7/2}4f_{5/2}$	5^-	2338.58	3.41×10^{-13}	
1293	61.0	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_4]_{7/2}4f_{5/2}$	4^-	2338.61	1.28×10^{-13}	
1309	41.6	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_4]_{7/2}4f_{5/2}$	6^-	2341.54	2.08×10^{-12}	
1311	34.4	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_2]_{3/2}4f_{5/2}$	3^-	2341.99	2.08×10^{-13}	
1315	62.1	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_4]_{11/2}4f_{5/2}$	5^-	2343.60	9.16×10^{-14}	
1319	59.8	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_4]_{9/2}4f_{5/2}$	6^-	2343.83	7.88×10^{-13}	
1332	33.7	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_4]_{11/2}4f_{5/2}$	4^-	2345.67	4.37×10^{-13}	

(*continued on next page*)

Table 9 (*continued*)

Index	Purity (%)	Configuration	J^{π}	E (eV)	τ_{rad} (s)	τ_{level} (s)
1366	35.2	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_4]_{9/2}4f_{5/2}$	3^-	2349.87	1.15×10^{-13}	
1369	23.0	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_4]_{7/2}4f_{7/2}$	4^-	2350.48	4.30×10^{-14}	
1376	39.9	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_2]_{5/2}4f_{5/2}$	5^-	2351.56	1.22×10^{-13}	
1382	28.1	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_4]_{9/2}4f_{5/2}$	7^-	2352.19	8.04×10^{-13}	
1383	19.9	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_2]_{5/2}4f_{5/2}$	4^-	2352.32	9.80×10^{-14}	
1389	44.5	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_2]_{3/2}4f_{7/2}$	5^-	2353.64	1.29×10^{-13}	
1393	86.1	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_4]_{11/2}4p_{3/2}$	6^+	2354.16	1.35×10^{-13}	
1394	37.7	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_2]_{7/2}4f_{5/2}$	3^-	2354.67	5.55×10^{-14}	
1397	49.4	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_4]_{11/2}4f_{7/2}$	5^-	2354.96	3.20×10^{-14}	
1403	30.4	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_2]_{7/2}4f_{5/2}$	6^-	2355.25	8.07×10^{-14}	
1415	20.2	$3s^23p^2_{1/2}\{[3p^3_{3/2}(3d^2_{3/2})_2]_{5/2}(3d^4_{5/2})_0\}_{5/2}4s_{1/2}$	3^-	2357.53	2.03×10^{-14}	
1417	24.9	$3s^23p^2_{1/2}\{[3p^3_{3/2}(3d^2_{3/2})_2]_{5/2}(3d^4_{5/2})_0\}_{5/2}4s_{1/2}$	3^-	2357.69	2.48×10^{-14}	
1420	49.3	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_2]_{7/2}4f_{5/2}$	4^-	2358.02	6.90×10^{-14}	
1426	42.0	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_2]_{7/2}4f_{5/2}$	5^-	2358.78	1.28×10^{-14}	
1431	48.1	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_2]_{5/2}4f_{7/2}$	6^-	2359.59	4.64×10^{-14}	
1439	21.9	$3s^23p^2_{1/2}\{[3p^3_{3/2}(3d^2_{3/2})_2]_{7/2}(3d^4_{5/2})_2\}_{5/2}4s_{1/2}$	3^-	2360.88	2.38×10^{-14}	
1442	49.0	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_4]_{9/2}4f_{7/2}$	6^-	2361.11	2.38×10^{-14}	
1443	14.4	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_4]_{9/2}4f_{7/2}$	3^-	2361.16	1.40×10^{-14}	
1444	27.0	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_4]_{9/2}4f_{5/2}$	4^-	2361.26	4.62×10^{-15}	
1446	30.3	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_4]_{11/2}4f_{7/2}$	7^-	2361.47	4.81×10^{-14}	
1458	49.4	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_4]_{11/2}4f_{5/2}$	3^-	2364.13	4.34×10^{-15}	
1460	31.6	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_2]_{7/2}4f_{7/2}$	5^-	2364.57	5.30×10^{-14}	
1462	32.9	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_4]_{11/2}4f_{7/2}$	2^-	2364.82	1.11×10^{-14}	
1463	86.3	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_4]_{9/2}4p_{3/2}$	6^+	2364.84	9.49×10^{-13}	
1465	31.2	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_2]_{1/2}4f_{7/2}$	3^-	2364.92	1.59×10^{-14}	
1467	26.5	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_2]_{5/2}4f_{7/2}$	4^-	2365.08	7.61×10^{-15}	
1470	24.7	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_2]_{1/2}4f_{7/2}$	4^-	2365.93	1.05×10^{-14}	
1477	29.9	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_2]_{5/2}4p_{3/2}$	4^+	2367.19	1.75×10^{-13}	
1478	17.9	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_2]_{5/2}4f_{7/2}$	5^-	2367.42	5.48×10^{-15}	
1479	34.8	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_4]_{7/2}4f_{7/2}$	2^-	2367.44	9.01×10^{-15}	
1482	27.2	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_4]_{7/2}4f_{7/2}$	1^-	2368.10	9.04×10^{-15}	
1485	50.9	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_2]_{7/2}4f_{7/2}$	7^-	2369.10	9.38×10^{-15}	
1488	26.7	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_4]_{7/2}4f_{5/2}$	5^-	2369.43	3.51×10^{-15}	
1491	31.0	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_0]_{3/2}4f_{5/2}$	4^-	2369.81	2.06×10^{-14}	
1496	22.3	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_2]_{7/2}4f_{7/2}$	6^-	2370.87	8.06×10^{-15}	
1497	44.2	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_2]_{7/2}4f_{5/2}$	1^-	2370.91	4.99×10^{-15}	
1500	35.7	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_4]_{11/2}4f_{7/2}$	3^-	2371.20	9.36×10^{-15}	
1510	23.9	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_2]_{7/2}4f_{5/2}$	3^-	2373.40	3.80×10^{-15}	
1512	44.1	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_2]_{7/2}4f_{5/2}$	2^-	2374.25	3.54×10^{-15}	
1518	32.6	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_4]_{9/2}4f_{7/2}$	1^-	2375.82	6.72×10^{-15}	
1520	43.3	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_2]_{7/2}4f_{7/2}$	5^-	2376.41	1.87×10^{-14}	
1523	23.5	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_0]_{3/2}4f_{5/2}$	3^-	2376.51	9.26×10^{-15}	
1525	18.5	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_4]_{9/2}4p_{3/2}$	4^+	2376.99	1.72×10^{-13}	
1526	46.5	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_2]_{5/2}4f_{7/2}$	1^-	2377.28	6.79×10^{-15}	
1532	19.5	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_4]_{9/2}4p_{3/2}$	4^+	2378.94	9.04×10^{-14}	
1533	32.7	$3s^23p^2_{1/2}\{[3p^3_{3/2}(3d^2_{3/2})_2]_{3/2}(3d^4_{5/2})_4\}_{7/2}4p_{1/2}$	4^+	2379.45	1.67×10^{-13}	
1536	20.9	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_2]_{7/2}4f_{7/2}$	3^-	2380.17	1.16×10^{-14}	
1537	25.2	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_0]_{3/2}4f_{5/2}$	2^-	2380.21	7.55×10^{-15}	
1549	19.8	$3s^23p^2_{1/2}[(3p^3_{3/2}3d^3_{3/2})_3(3d^3_{5/2})_{5/2}]_{3/2}4p_{1/2}$	2^+	2384.88	1.51×10^{-13}	
1552	30.7	$3s^23p^2_{1/2}[(3p^3_{3/2}3d^3_{3/2})_3(3d^3_{5/2})_{5/2}]_{3/2}4p_{1/2}$	2^+	2385.94	1.68×10^{-13}	
1556	38.8	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_0]_{3/2}4f_{5/2}$	3^-	2387.50	1.13×10^{-14}	
1558	64.1	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_0]_{3/2}4f_{7/2}$	5^-	2387.75	1.24×10^{-14}	
1564	11.0	$3s^23p^2_{1/2}[(3p^3_{3/2}3d^3_{3/2})_2(3d^3_{5/2})_{5/2}]_{5/2}4p_{1/2}$	2^+	2389.00	1.12×10^{-13}	
1578	83.9	$3s^23p^6[3d^3_{3/2}(3d^2_{5/2})_0]_{3/2}4f_{5/2}$	1^-	2393.16	3.17×10^{-15}	
1598	67.1	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_4]_{7/2}4p_{3/2}$	4^+	2398.77	1.11×10^{-13}	
1606	42.8	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_0]_{3/2}4p_{3/2}$	2^+	2401.20	9.38×10^{-14}	
1649	70.9	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_2]_{3/2}4p_{3/2}$	0^+	2411.29	5.99×10^{-14}	
1666	36.4	$3s^23p^2_{1/2}\{[3p^3_{3/2}(3d^2_{3/2})_2]_{7/2}(3d^4_{5/2})_4\}_{9/2}4p_{1/2}$	4^+	2414.58	1.06×10^{-13}	
1667	47.1	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_4]_{5/2}4p_{3/2}$	4^+	2414.81	2.12×10^{-13}	
1673	19.6	$3s^23p^6[(3d^2_{3/2})_2(3d^3_{5/2})_{9/2}]_{9/2}4f_{5/2}$	5^-	2415.51	1.85×10^{-14}	
1702	30.6	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_2]_{3/2}4p_{3/2}$	2^+	2420.82	2.01×10^{-13}	
1746	17.4	$3s^23p^6[(3d^2_{3/2})_2(3d^3_{5/2})_{9/2}]_{5/2}4f_{5/2}$	5^-	2426.81	5.62×10^{-15}	
1767	25.8	$3s^23p^6[(3d^2_{3/2})_2(3d^3_{5/2})_{3/2}]_{7/2}4f_{7/2}$	6^-	2429.88	1.32×10^{-14}	
1774	18.2	$3s^23p^6[(3d^2_{3/2})_2(3d^3_{5/2})_{9/2}]_{9/2}4f_{5/2}$	6^-	2431.01	5.03×10^{-15}	
1776	62.8	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_0]_{3/2}4p_{3/2}$	0^+	2431.17	1.53×10^{-13}	
1780	46.0	$3s^23p^6[(3d^2_{3/2})_2(3d^3_{5/2})_{9/2}]_{13/2}4f_{5/2}$	5^-	2431.71	6.52×10^{-15}	

(*continued on next page*)

Table 9 (*continued*)

Index	Purity (%)	Configuration	J^{π}	E (eV)	τ_{rad} (s)	τ_{level} (s)
1804	39.4	$3s^23p^6[(3d^2_{3/2})_2(3d^3_{5/2})_{5/2}]_{7/2}4f_{5/2}$	6^-	2434.73	1.14×10^{-14}	
1812	25.5	$3s^23p^6[(3d^2_{3/2})_2(3d^3_{5/2})_{9/2}]_{13/2}4f_{5/2}$	7^-	2435.79	4.00×10^{-15}	
1898	64.5	$3s^23p^6[(3d^2_{3/2})_0(3d^3_{5/2})_{9/2}]_{9/2}4f_{5/2}$	7^-	2448.66	5.73×10^{-15}	
1939	18.8	$3s^23p^2_{1/2}[(3p^3_{3/2}3d^3_{3/2})_3(3d^3_{5/2})_{9/2}]_{13/2}4p_{3/2}$	6^+	2457.67	1.05×10^{-13}	
1986	66.1	$3s^23p^6[(3d^2_{3/2})_0(3d^3_{5/2})_{5/2}]_{5/2}4f_{5/2}$	5^-	2470.51	5.94×10^{-15}	
2041	24.9	$3s^23p^2_{1/2}[(3p^3_{3/2}3d^3_{3/2})_2(3d^3_{5/2})_{9/2}]_{11/2}4p_{3/2}$	6^+	2482.99	2.61×10^{-13}	
2055	88.1	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_4]_{11/2}4d_{3/2}$	5^-	2485.55	2.45×10^{-13}	
2203	86.2	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_4]_{11/2}4d_{5/2}$	7^-	2511.32	1.95×10^{-12}	
2204	85.9	$3s^2[3p_{1/2}3p^4_{3/2}3d^4_{3/2}(3d^2_{5/2})_4]_{7/2}4s_{1/2}$	4^-	2511.65	4.72×10^{-14}	
2219	72.5	$3s^2[3p_{1/2}3p^4_{3/2}3d^4_{3/2}(3d^2_{5/2})_4]_{7/2}4s_{1/2}$	3^-	2513.95	2.72×10^{-14}	
2221	81.0	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_4]_{11/2}4d_{5/2}$	5^-	2514.39	1.57×10^{-13}	
2232	51.0	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_4]_{11/2}4d_{5/2}$	4^-	2517.10	3.76×10^{-14}	
2251	40.3	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_2]_{5/2}4d_{5/2}$	4^-	2520.48	7.99×10^{-14}	
2254	67.5	$3s^2[3p_{1/2}3p^4_{3/2}3d^4_{3/2}(3d^2_{5/2})_4]_{9/2}4s_{1/2}$	5^-	2520.68	3.12×10^{-14}	
2255	26.0	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_2]_{5/2}4d_{5/2}$	1^-	2520.89	3.14×10^{-14}	
2257	49.4	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_4]_{11/2}4d_{5/2}$	3^-	2521.19	2.71×10^{-14}	
2263	34.7	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_4]_{7/2}4d_{3/2}$	4^-	2522.23	4.27×10^{-14}	
2267	48.8	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_2]_{5/2}4d_{5/2}$	5^-	2522.99	2.42×10^{-13}	
2285	33.0	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_2]_{7/2}4d_{5/2}$	3^-	2525.51	2.41×10^{-14}	
2291	34.4	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_4]_{7/2}4d_{3/2}$	5^-	2526.42	2.85×10^{-14}	
2301	26.2	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_4]_{7/2}4d_{3/2}$	3^-	2527.70	4.86×10^{-14}	
2309	39.2	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_4]_{7/2}4d_{3/2}$	5^-	2528.77	3.26×10^{-14}	
2313	46.6	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_4]_{9/2}4d_{5/2}$	4^-	2529.95	5.15×10^{-14}	
2315	50.4	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_4]_{9/2}4d_{5/2}$	3^-	2530.15	2.33×10^{-14}	
2321	66.4	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_2]_{7/2}4d_{5/2}$	1^-	2532.16	1.47×10^{-14}	
2323	53.6	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_2]_{7/2}4d_{5/2}$	5^-	2532.44	6.83×10^{-14}	
2335	29.8	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_2]_{7/2}4d_{5/2}$	3^-	2536.59	1.20×10^{-13}	
2337	75.2	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_2]_{1/2}4d_{5/2}$	3^-	2537.24	3.00×10^{-14}	
2341	54.5	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_2]_{7/2}4d_{5/2}$	2^-	2539.49	1.20×10^{-14}	
2344	33.7	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_2]_{7/2}4d_{5/2}$	4^-	2539.71	2.25×10^{-13}	
2386	31.6	$3s^23p^2_{1/2}[(3p^3_{3/2}3d^3_{3/2})_2(3d^3_{5/2})_{9/2}]_{11/2}4d_{3/2}$	5^-	2549.96	1.25×10^{-13}	
2391	67.3	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_4]_{7/2}4d_{5/2}$	5^-	2551.43	3.76×10^{-14}	
2396	37.0	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_0]_{3/2}4d_{5/2}$	4^-	2552.85	7.69×10^{-14}	
2400	28.0	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_4]_{7/2}4d_{5/2}$	4^-	2553.31	6.98×10^{-14}	
2410	30.0	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_4]_{7/2}4d_{5/2}$	4^-	2554.65	4.68×10^{-14}	
2420	25.6	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_0]_{3/2}4d_{5/2}$	1^-	2555.58	2.09×10^{-14}	
2435	45.5	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_0]_{3/2}4d_{5/2}$	3^-	2558.16	4.89×10^{-14}	
2446	41.0	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_4]_{7/2}4d_{5/2}$	3^-	2560.35	7.53×10^{-14}	
2467	41.6	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_4]_{7/2}4d_{5/2}$	1^-	2564.93	1.89×10^{-14}	
2495	51.6	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_4]_{5/2}4d_{5/2}$	5^-	2569.37	4.25×10^{-14}	
2516	19.1	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_2]_{3/2}4d_{5/2}$	3^-	2573.36	4.88×10^{-14}	
2522	30.8	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_2]_{3/2}4d_{5/2}$	2^-	2574.25	5.31×10^{-14}	
2644	34.1	$3s^23p^2_{1/2}[(3p^3_{3/2}3d^3_{3/2})_3(3d^3_{5/2})_{9/2}]_{15/2}4d_{5/2}$	5^-	2595.92	1.61×10^{-14}	
2658	15.4	$3s^23p^2_{1/2}[(3p^3_{3/2}3d^3_{3/2})_3(3d^3_{5/2})_{3/2}]_{9/2}4d_{5/2}$	7^-	2598.15	2.12×10^{-14}	
2934	29.7	$3s^23p^2_{1/2}[(3p^3_{3/2}3d^3_{3/2})_2(3d^3_{5/2})_{9/2}]_{11/2}4d_{5/2}$	7^-	2635.46	2.34×10^{-14}	
3149	30.9	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_4]_{11/2}4f_{7/2}$	6^+	2664.48	3.27×10^{-14}	
3156	42.6	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_4]_{11/2}4f_{7/2}$	4^+	2665.60	3.56×10^{-14}	
3176	26.0	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_2]_{7/2}4f_{7/2}$	5^+	2668.01	3.81×10^{-14}	
3188	30.7	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_2]_{5/2}4f_{7/2}$	4^+	2669.28	3.39×10^{-14}	
3190	46.1	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_2]_{7/2}4f_{7/2}$	6^+	2669.46	5.42×10^{-14}	
3198	42.8	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_4]_{11/2}4f_{7/2}$	3^+	2670.82	2.59×10^{-14}	
3203	76.5	$3s^2[(3p_{1/2}3p^4_{3/2}3d^3_{3/2})_2(3d^3_{5/2})_{9/2}]_{13/2}4p_{1/2}$	6^+	2671.28	7.94×10^{-14}	
3207	16.8	$3s^2[(3p_{1/2}3p^4_{3/2}3d^3_{3/2})_2(3d^3_{5/2})_{5/2}]_{5/2}4p_{1/2}$	3^+	2671.67	4.79×10^{-14}	
3221	49.1	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_4]_{9/2}4f_{7/2}$	5^+	2673.29	1.98×10^{-14}	
3222	48.8	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_4]_{11/2}4f_{7/2}$	2^+	2673.60	1.73×10^{-14}	
3243	43.9	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_4]_{9/2}4f_{7/2}$	3^+	2676.56	1.45×10^{-14}	
3255	31.9	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_2]_{1/2}4f_{7/2}$	4^+	2678.14	1.60×10^{-14}	
3265	26.8	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_2]_{7/2}4f_{7/2}$	6^+	2679.29	1.07×10^{-14}	
3276	37.8	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_2]_{7/2}4f_{7/2}$	2^+	2680.28	2.22×10^{-14}	
3294	36.1	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_4]_{9/2}4f_{7/2}$	2^+	2682.00	2.52×10^{-14}	
3300	25.8	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_2]_{1/2}4f_{7/2}$	3^+	2682.55	2.74×10^{-14}	
3310	52.1	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_4]_{7/2}4f_{5/2}$	3^+	2683.62	2.40×10^{-14}	
3341	25.1	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_2]_{1/2}4f_{7/2}$	4^+	2686.36	2.15×10^{-14}	
3365	22.2	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_2]_{1/2}4f_{7/2}$	3^+	2689.15	1.77×10^{-14}	
3367	29.0	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_0]_{3/2}4f_{5/2}$	4^+	2689.34	2.36×10^{-14}	
3372	29.4	$3s^23p^2_{1/2}[3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_2]_{7/2}4f_{7/2}$	2^+	2690.31	1.78×10^{-14}	

(*continued on next page*)

Table 9 (*continued*)

Index	Purity (%)	Configuration	J^π	E (eV)	τ_{rad} (s)	τ_{level} (s)
3397	54.1	$3s^2 3p_{1/2}^2[3p_{3/2}^3 3d_{3/2}^4(3d_{5/2}^2)_4]_{7/2}4f_{7/2}$	5^+	2694.58	4.99×10^{-14}	
3402	73.8	$3s^2 3p_{1/2}^2[3p_{3/2}^3 3d_{3/2}^4(3d_{5/2}^2)_4]_{7/2}4f_{7/2}$	6^+	2695.48	6.50×10^{-14}	
3408	48.1	$3s^2 3p_{1/2}^2[3p_{3/2}^3 3d_{3/2}^4(3d_{5/2}^2)_0]_{3/2}4f_{7/2}$	5^+	2696.46	1.42×10^{-14}	
3464	41.3	$3s^2 3p_{1/2}^2[3p_{3/2}^3 3d_{3/2}^4(3d_{5/2}^2)_4]_{5/2}4f_{5/2}$	5^+	2703.64	1.79×10^{-13}	
3467	20.0	$3s^2 3p_{1/2}^2[3p_{3/2}^3 3d_{3/2}^4(3d_{5/2}^2)_4]_{7/2}4f_{7/2}$	4^+	2703.92	1.57×10^{-14}	
3484	24.3	$3s^2 3p_{1/2}^2[3p_{3/2}^3 3d_{3/2}^4(3d_{5/2}^2)_2]_{3/2}4f_{5/2}$	4^+	2705.86	3.61×10^{-14}	
3529	54.6	$3s^2 3p_{1/2}^2[3p_{3/2}^3 3d_{3/2}^4(3d_{5/2}^2)_4]_{5/2}4f_{7/2}$	6^+	2711.22	2.74×10^{-13}	
3532	44.4	$3s^2 3p_{1/2}^2[3p_{3/2}^3 3d_{3/2}^4(3d_{5/2}^2)_0]_{3/2}4f_{7/2}$	2^+	2711.41	1.39×10^{-14}	
3587	26.6	$3s^2 3p_{1/2}^2[3p_{3/2}^3 3d_{3/2}^4(3d_{5/2}^2)_4]_{5/2}4f_{7/2}$	4^+	2717.10	3.11×10^{-14}	
3662	17.8	$3s^2 3p_{1/2}^2[3p_{3/2}^3 3d_{3/2}^4(3d_{5/2}^2)_2]_{3/2}4f_{7/2}$	4^+	2724.90	1.36×10^{-14}	
3778	76.0	$3s^2[3p_{1/2}3p_{3/2}^4 3d_{3/2}^4(3d_{5/2}^2)_2]_{5/2}4p_{3/2}$	4^+	2736.13	6.51×10^{-14}	
3780	41.6	$3s^2[3p_{1/2}3p_{3/2}^4 3d_{3/2}^4(3d_{5/2}^2)_4]_{9/2}4p_{3/2}$	4^+	2736.33	9.99×10^{-14}	
3873	69.8	$[3s_{1/2}3p^6 3d_{3/2}^4(3d_{5/2}^2)_4]_{7/2}4s_{1/2}$	4^+	2746.18	1.46×10^{-13}	
3915	57.4	$[3s_{1/2}3p^6 3d_{3/2}^4(3d_{5/2}^2)_2]_{3/2}4s_{1/2}$	2^+	2751.87	1.07×10^{-13}	
4513	91.1	$[3s_{1/2}3p^6 3d_{3/2}^4(3d_{5/2}^2)_4]_{9/2}4p_{1/2}$	4^-	2808.60	4.42×10^{-14}	
4518	89.6	$[3s_{1/2}3p^6 3d_{3/2}^4(3d_{5/2}^2)_4]_{9/2}4p_{1/2}$	5^-	2809.12	2.55×10^{-14}	
4639	88.8	$[3s_{1/2}3p^6 3d_{3/2}^4(3d_{5/2}^2)_2]_{5/2}4p_{1/2}$	3^-	2821.57	2.40×10^{-14}	
4701	86.7	$[3s_{1/2}3p^6 3d_{3/2}^4(3d_{5/2}^2)_4]_{7/2}4p_{1/2}$	3^-	2827.89	2.25×10^{-14}	
4721	87.3	$[3s_{1/2}3p^6 3d_{3/2}^4(3d_{5/2}^2)_4]_{7/2}4p_{1/2}$	4^-	2829.68	3.28×10^{-14}	
4755	87.0	$[3s_{1/2}3p^6 3d_{3/2}^4(3d_{5/2}^2)_2]_{3/2}4p_{1/2}$	1^-	2832.77	2.21×10^{-14}	
4766	88.7	$[3s_{1/2}3p^6 3d_{3/2}^4(3d_{5/2}^2)_2]_{3/2}4p_{1/2}$	2^-	2834.18	3.68×10^{-14}	
4966	78.5	$3s^2[3p_{1/2}3p_{3/2}^4 3d_{3/2}^4(3d_{5/2}^2)_4]_{7/2}4d_{3/2}$	5^-	2854.81	5.14×10^{-14}	
5024	76.8	$3s^2[3p_{1/2}3p_{3/2}^4 3d_{3/2}^4(3d_{5/2}^2)_4]_{9/2}4d_{3/2}$	5^-	2862.27	2.53×10^{-14}	
5025	64.5	$3s^2[3p_{1/2}3p_{3/2}^4 3d_{3/2}^4(3d_{5/2}^2)_4]_{9/2}4d_{3/2}$	4^-	2862.34	2.88×10^{-14}	
5058	64.1	$3s^2[3p_{1/2}3p_{3/2}^4 3d_{3/2}^4(3d_{5/2}^2)_4]_{9/2}4d_{3/2}$	3^-	2866.10	2.35×10^{-14}	
5097	80.4	$3s^2[3p_{1/2}3p_{3/2}^4 3d_{3/2}^4(3d_{5/2}^2)_2]_{5/2}4d_{3/2}$	1^-	2870.75	2.14×10^{-14}	
5104	66.7	$3s^2[3p_{1/2}3p_{3/2}^4 3d_{3/2}^4(3d_{5/2}^2)_2]_{5/2}4d_{3/2}$	2^-	2871.61	2.04×10^{-14}	
5110	72.8	$3s^2[3p_{1/2}3p_{3/2}^4 3d_{3/2}^4(3d_{5/2}^2)_2]_{5/2}4d_{3/2}$	3^-	2872.26	2.84×10^{-14}	
5638	79.1	$[3s_{1/2}3p^6 3d_{3/2}^4(3d_{5/2}^2)_4]_{7/2}4p_{3/2}$	5^-	2947.57	5.43×10^{-14}	
5995	61.0	$3s^2[3p_{1/2}3p_{3/2}^4 3d_{3/2}^4(3d_{5/2}^2)_4]_{9/2}4f_{5/2}$	5^+	3017.65	8.42×10^{-14}	
6017	42.3	$3s^2[3p_{1/2}3p_{3/2}^4 3d_{3/2}^4(3d_{5/2}^2)_4]_{7/2}4f_{7/2}$	4^+	3020.53	3.74×10^{-14}	
6028	72.6	$3s^2[3p_{1/2}3p_{3/2}^4 3d_{3/2}^4(3d_{5/2}^2)_4]_{9/2}4f_{5/2}$	4^+	3021.77	6.98×10^{-14}	
6041	77.5	$3s^2[3p_{1/2}3p_{3/2}^4 3d_{3/2}^4(3d_{5/2}^2)_4]_{9/2}4f_{5/2}$	3^+	3024.75	6.92×10^{-14}	
6099	28.5	$3s^2[3p_{1/2}3p_{3/2}^4 3d_{3/2}^4(3d_{5/2}^2)_2]_{5/2}4f_{7/2}$	4^+	3032.41	4.53×10^{-14}	
6208	47.3	$3s^2[3p_{1/2}3p_{3/2}^4 3d_{3/2}^4(3d_{5/2}^2)_0]_{1/2}4f_{5/2}$	2^+	3052.96	2.02×10^{-14}	
7378	63.9	$[3s_{1/2}3p^6 3d_{3/2}^4(3d_{5/2}^2)_4]_{7/2}4f_{5/2}$	5^-	3235.73	6.71×10^{-14}	
7416	42.2	$[3s_{1/2}3p^6 3d_{3/2}^4(3d_{5/2}^2)_4]_{7/2}4f_{7/2}$	6^-	3242.08	2.69×10^{-14}	
7458	28.0	$[3s_{1/2}3p^6 3d_{3/2}^4(3d_{5/2}^2)_4]_{7/2}4f_{7/2}$	4^-	3248.59	2.21×10^{-14}	
7480	36.1	$[3s_{1/2}3p^6 3d_{3/2}^4(3d_{5/2}^2)_2]_{3/2}4f_{7/2}$	4^-	3252.68	1.97×10^{-14}	
7516	43.2	$[3s_{1/2}3p^6 3d_{3/2}^4(3d_{5/2}^2)_4]_{7/2}4f_{7/2}$	5^-	3259.58	8.13×10^{-15}	
8412	94.6	$3s^2 3p^6 3d_{3/2}^4 3d_{5/2}5d_{5/2}$	4^+	3051.79	9.70×10^{-14}	
8420	95.3	$3s^2 3p^6 3d_{3/2}^4 3d_{5/2}5d_{5/2}$	2^+	3053.50	9.63×10^{-14}	
8533	96.5	$3s^2 3p^6 3d_{3/2}^4 3d_{5/2}5f_{7/2}$	4^-	3114.23	2.45×10^{-14}	
8543	79.8	$3s^2 3p^6 3d_{3/2}^4 3d_{5/2}5f_{7/2}$	2^-	3117.23	2.08×10^{-14}	
8547	47.1	$3s^2 3p^6[3d_{3/2}^3(3d_{5/2}^2)_4]_{9/2}5d_{3/2}$	4^+	3117.82	1.09×10^{-13}	
8555	95.0	$3s^2 3p^6 3d_{3/2}^4 3d_{5/2}5f_{7/2}$	3^-	3119.03	1.36×10^{-14}	
8556	87.8	$3s^2 3p^6 3d_{3/2}^4 3d_{5/2}5f_{7/2}$	5^-	3119.38	1.10×10^{-14}	
8585	50.1	$3s^2 3p^6[3d_{3/2}^3(3d_{5/2}^2)_2]_{7/2}5d_{3/2}$	2^+	3126.81	1.08×10^{-13}	
8677	59.7	$3s^2 3p^6[3d_{3/2}^3(3d_{5/2}^2)_4]_{5/2}5f_{5/2}$	5^-	3168.40	3.29×10^{-14}	
8722	72.6	$3s^2 3p^6[3d_{3/2}^3(3d_{5/2}^2)_4]_{11/2}5f_{5/2}$	5^-	3180.89	2.73×10^{-14}	
8733	64.4	$3s^2 3p^6[3d_{3/2}^3(3d_{5/2}^2)_4]_{11/2}5f_{5/2}$	4^-	3182.39	2.95×10^{-14}	
8762	52.2	$3s^2 3p^6[3d_{3/2}^3(3d_{5/2}^2)_4]_{11/2}5f_{7/2}$	5^-	3186.47	1.72×10^{-14}	
8791	59.4	$3s^2 3p^6[3d_{3/2}^3(3d_{5/2}^2)_4]_{9/2}5f_{5/2}$	4^-	3189.12	9.94×10^{-15}	
8801	31.7	$3s^2 3p^6[3d_{3/2}^3(3d_{5/2}^2)_2]_{5/2}5f_{5/2}$	5^-	3189.84	1.43×10^{-14}	
8802	41.7	$3s^2 3p^6[3d_{3/2}^3(3d_{5/2}^2)_4]_{9/2}5f_{5/2}$	3^-	3189.92	1.01×10^{-14}	
8807	26.1	$3s^2 3p^6[3d_{3/2}^3(3d_{5/2}^2)_4]_{11/2}5f_{7/2}$	4^-	3190.76	1.16×10^{-14}	
8816	42.8	$3s^2 3p^6[3d_{3/2}^3(3d_{5/2}^2)_2]_{5/2}5f_{5/2}$	3^-	3191.95	2.34×10^{-14}	
8850	42.5	$3s^2 3p^6[3d_{3/2}^3(3d_{5/2}^2)_2]_{7/2}5f_{5/2}$	5^-	3197.03	2.75×10^{-14}	
8853	38.5	$3s^2 3p^6[3d_{3/2}^3(3d_{5/2}^2)_2]_{1/2}5f_{5/2}$	3^-	3197.88	1.08×10^{-14}	
8858	67.2	$3s^2 3p^6[3d_{3/2}^3(3d_{5/2}^2)_2]_{7/2}5f_{5/2}$	1^-	3198.53	9.06×10^{-15}	
8860	51.6	$3s^2 3p^6[3d_{3/2}^3(3d_{5/2}^2)_2]_{7/2}5f_{5/2}$	2^-	3199.03	9.71×10^{-15}	
8864	75.1	$3s^2 3p^6[3d_{3/2}^3(3d_{5/2}^2)_2]_{7/2}5f_{7/2}$	7^-	3199.89	1.51×10^{-14}	
8937	85.8	$3s^2 3p^6[3d_{3/2}^3(3d_{5/2}^2)_0]_{3/2}5f_{5/2}$	1^-	3217.83	7.76×10^{-15}	
9145	45.1	$3s^2 3p^6[(3d_{3/2}^2)_2(3d_{5/2}^3)_{9/2}]_{13/2}5f_{5/2}$	7^-	3254.48	1.10×10^{-14}	
10117	58.9	$3s^2 3p_{1/2}^2[3p_{3/2}^3 3d_{3/2}^4(3d_{5/2}^2)_4]_{11/2}5d_{5/2}$	4^-	3425.46	3.79×10^{-14}	
10122	83.8	$3s^2 3p_{1/2}^2[3p_{3/2}^3 3d_{3/2}^4(3d_{5/2}^2)_4]_{11/2}5d_{5/2}$	3^-	3426.02	1.85×10^{-14}	
10172	77.0	$3s^2 3p_{1/2}^2[3p_{3/2}^3 3d_{3/2}^4(3d_{5/2}^2)_4]_{9/2}5d_{5/2}$	5^-	3434.28	2.72×10^{-14}	

(*continued on next page*)

Table 9 (*continued*)

Index	Purity (%)	Configuration	J^{π}	E (eV)	τ_{rad} (s)	τ_{level} (s)
10193	87.5	$3s^2 3p_{1/2}^2[3p_{3/2}^3 3d_{3/2}^4(3d_{5/2}^2)_2]_{7/2}5d_{5/2}$	1^-	3437.53	1.66×10^{-14}	
10209	76.3	$3s^2 3p_{1/2}^2[3p_{3/2}^3 3d_{3/2}^4(3d_{5/2}^2)_2]_{7/2}5d_{5/2}$	2^-	3440.66	1.80×10^{-14}	
10321	90.1	$3s^2 3p_{1/2}^2[3p_{3/2}^3 3d_{3/2}^4(3d_{5/2}^2)_4]_{7/2}5d_{5/2}$	5^-	3459.83	3.39×10^{-14}	

Table 10
Energy levels in V-like tungsten, W^{51+}.

Index	Purity (%)	Configuration	J^π	E (eV)	τ_{rad} (s)	τ_{level} (s)
0	96.6	$3s^23p^63d^4_{3/2}3d_{5/2}$	$5/2^+$	0.00		
1	74.2	$3s^23p^63d^3_{3/2}(3d^2_{5/2})_4$	$5/2^+$	58.55	2.89×10^{-7}	2.85×10^{-7}
2	82.6	$3s^23p^63d^3_{3/2}(3d^2_{5/2})_4$	$7/2^+$	70.48	6.14×10^{-7}	5.94×10^{-7}
3	99.0	$3s^23p^63d^3_{3/2}(3d^2_{5/2})_4$	$11/2^+$	71.99	2.20×10^{7}	1.87×10^{-5}
4	86.3	$3s^23p^63d^3_{3/2}(3d^2_{5/2})_2$	$3/2^+$	72.13	2.63×10^{-7}	2.59×10^{-7}
5	97.6	$3s^23p^63d^3_{3/2}(3d^2_{5/2})_4$	$9/2^+$	77.56	3.76×10^{-4}	1.78×10^{-5}
6	78.0	$3s^23p^63d^3_{3/2}(3d^2_{5/2})_2$	$5/2^+$	81.15	1.15×10^{-5}	7.11×10^{-6}
7	92.3	$3s^23p^63d^3_{3/2}(3d^2_{5/2})_2$	$1/2^+$	84.62	4.36×10^{-5}	1.31×10^{-5}
8	81.1	$3s^23p^63d^3_{3/2}(3d^2_{5/2})_2$	$7/2^+$	85.81	7.81×10^{-6}	5.51×10^{-6}
9	80.5	$3s^23p^63d^3_{3/2}(3d^2_{5/2})_0$	$3/2^+$	102.41	3.15×10^{-6}	2.69×10^{-6}
12	99.0	$3s^23p^6(3d^2_{3/2})_2(3d^3_{5/2})_{9/2}$	$11/2^+$	137.35	3.67×10^{-7}	3.60×10^{-7}
13	97.4	$3s^23p^6(3d^2_{3/2})_2(3d^3_{5/2})_{9/2}$	$9/2^+$	139.29	3.69×10^{-7}	3.62×10^{-7}
14	99.9	$3s^23p^6(3d^2_{3/2})_2(3d^3_{5/2})_{9/2}$	$13/2^+$	142.59	1.90×10^{-6}	1.73×10^{-6}
18	51.5	$3s^23p^6(3d^2_{3/2})_2(3d^3_{5/2})_{5/2}$	$9/2^+$	151.53	2.20×10^{-7}	2.17×10^{-7}
24	50.0	$3s^23p^6(3d^2_{3/2})_0(3d^3_{5/2})_{9/2}$	$9/2^+$	171.89	6.99×10^{-7}	6.74×10^{-7}
37	94.0	$3s^23p^2_{1/2}3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_4$	$11/2^-$	373.28	5.57×10^{-11}	
38	65.7	$3s^23p^2_{1/2}3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_2$	$5/2^-$	381.53	4.87×10^{-11}	
39	94.7	$3s^23p^2_{1/2}3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_4$	$9/2^-$	383.67	5.80×10^{-11}	
40	88.0	$3s^23p^2_{1/2}3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_2$	$7/2^-$	386.81	6.63×10^{-12}	
41	95.0	$3s^23p^2_{1/2}3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_2$	$1/2^-$	393.06	6.25×10^{-11}	
42	91.0	$3s^23p^2_{1/2}3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_4$	$7/2^-$	409.73	1.53×10^{-12}	
43	63.7	$3s^23p^2_{1/2}3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_0$	$3/2^-$	411.60	6.37×10^{-11}	
44	61.6	$3s^23p^2_{1/2}3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_4$	$5/2^-$	427.27	5.31×10^{-13}	
45	66.4	$3s^23p^2_{1/2}3p^3_{3/2}3d^4_{3/2}(3d^2_{5/2})_2$	$3/2^-$	429.54	5.71×10^{-13}	
76	37.6	$3s^23p^2_{1/2}(3p^3_{3/2}3d^3_{3/2})_3(3d^3_{5/2})_{9/2}$	$11/2^-$	495.13	6.21×10^{-13}	
81	21.6	$3s^23p^2_{1/2}(3p^3_{3/2}3d^3_{3/2})_3(3d^3_{5/2})_{3/2}$	$9/2^-$	506.94	5.04×10^{-13}	
146	51.2	$3s^23p^2_{1/2}(3p^3_{3/2}3d_{3/2})_33d^5_{5/2}$	$5/2^-$	636.41	6.30×10^{-13}	
147	72.6	$3s^23p^2_{1/2}(3p^3_{3/2}3d_{3/2})_13d^5_{5/2}$	$3/2^-$	641.15	5.84×10^{-13}	
154	95.1	$3s^23p_{1/2}3p^4_{3/2}3d^4_{3/2}(3d^2_{5/2})_4$	$7/2^-$	737.97	1.56×10^{-13}	
155	94.7	$3s^23p_{1/2}3p^4_{3/2}3d^4_{3/2}(3d^2_{5/2})_2$	$3/2^-$	747.65	1.53×10^{-13}	
156	94.3	$3s^23p_{1/2}3p^4_{3/2}3d^4_{3/2}(3d^2_{5/2})_4$	$9/2^-$	748.54	1.35×10^{-13}	
157	93.8	$3s^23p_{1/2}3p^4_{3/2}3d^4_{3/2}(3d^2_{5/2})_2$	$5/2^-$	754.02	1.41×10^{-13}	
282	91.4	$3s_{1/2}3p^63d^4_{3/2}(3d^2_{5/2})_4$	$9/2^+$	943.02	2.01×10^{-13}	
290	86.7	$3s_{1/2}3p^63d^4_{3/2}(3d^2_{5/2})_2$	$5/2^+$	955.47	2.06×10^{-13}	
295	88.1	$3s_{1/2}3p^63d^4_{3/2}(3d^2_{5/2})_4$	$7/2^+$	963.05	2.04×10^{-13}	
299	86.4	$3s_{1/2}3p^63d^4_{3/2}(3d^2_{5/2})_2$	$3/2^+$	967.55	2.04×10^{-13}	
1313	98.5	$3s^23p^63d^4_{3/2}4s_{1/2}$	$1/2^+$	1824.16	3.61×10^{-11}	
1316	98.3	$3s^23p^6(3d^3_{3/2}3d_{5/2})_44s_{1/2}$	$9/2^+$	1898.95	3.81×10^{-11}	
1320	91.5	$3s^23p^6(3d^3_{3/2}3d_{5/2})_34s_{1/2}$	$7/2^+$	1905.72	3.46×10^{-11}	
1322	98.4	$3s^23p^63d^4_{3/2}4p_{1/2}$	$1/2^-$	1913.03	1.61×10^{-11}	
1340	96.0	$3s^23p^6(3d^3_{3/2}3d_{5/2})_14p_{1/2}$	$3/2^-$	1977.65	3.30×10^{-13}	
1344	98.4	$3s^23p^6(3d^3_{3/2}3d_{5/2})_44p_{1/2}$	$9/2^-$	1988.12	1.58×10^{-11}	
1345	90.5	$3s^23p^6(3d^3_{3/2}3d_{5/2})_44p_{1/2}$	$7/2^-$	1989.75	1.81×10^{-13}	
1346	78.8	$3s^23p^6(3d^3_{3/2}3d_{5/2})_24p_{1/2}$	$5/2^-$	1991.55	1.99×10^{-12}	
1348	91.9	$3s^23p^6(3d^3_{3/2}3d_{5/2})_24p_{1/2}$	$3/2^-$	1992.41	1.98×10^{-13}	
1350	88.0	$3s^23p^6(3d^3_{3/2}3d_{5/2})_34p_{1/2}$	$7/2^-$	1995.69	2.48×10^{-13}	
1352	79.6	$3s^23p^6(3d^3_{3/2}3d_{5/2})_34p_{1/2}$	$5/2^-$	1997.20	1.11×10^{-13}	
1357	97.5	$3s^23p^63d^4_{3/2}4p_{3/2}$	$3/2^-$	2033.61	9.52×10^{-14}	
1379	88.4	$3s^23p^6[(3d^2_{3/2})_2(3d^2_{5/2})_4]_54p_{1/2}$	$11/2^-$	2057.11	4.70×10^{-13}	
1381	99.2	$3s^23p^6[(3d^2_{3/2})_2(3d^2_{5/2})_4]_64p_{1/2}$	$13/2^-$	2060.11	4.13×10^{-13}	
1384	88.1	$3s^23p^6[(3d^2_{3/2})_2(3d^2_{5/2})_4]_64p_{1/2}$	$11/2^-$	2063.24	7.34×10^{-14}	
1403	79.4	$3s^23p^6[(3d^2_{3/2})_0(3d^2_{5/2})_4]_44p_{1/2}$	$9/2^-$	2088.02	1.55×10^{-13}	
1404	94.1	$3s^23p^6(3d^3_{3/2}3d_{5/2})_14p_{3/2}$	$5/2^-$	2095.39	1.65×10^{-13}	
1405	97.4	$3s^23p^6(3d^3_{3/2}3d_{5/2})_14p_{3/2}$	$3/2^-$	2096.56	8.44×10^{-14}	
1409	97.5	$3s^23p^6(3d^3_{3/2}3d_{5/2})_44p_{3/2}$	$11/2^-$	2107.13	2.58×10^{-13}	
1410	83.6	$3s^23p^6(3d^3_{3/2}3d_{5/2})_44p_{3/2}$	$7/2^-$	2107.50	1.18×10^{-13}	
1411	68.3	$3s^23p^6(3d^3_{3/2}3d_{5/2})_44p_{3/2}$	$5/2^-$	2107.76	9.01×10^{-14}	
1412	95.9	$3s^23p^6(3d^3_{3/2}3d_{5/2})_44p_{3/2}$	$9/2^-$	2109.50	7.03×10^{-14}	
1413	89.6	$3s^23p^6(3d^3_{3/2}3d_{5/2})_24p_{3/2}$	$5/2^-$	2110.79	9.20×10^{-14}	
1414	67.2	$3s^23p^6(3d^3_{3/2}3d_{5/2})_24p_{3/2}$	$3/2^-$	2110.93	9.09×10^{-14}	
1415	80.1	$3s^23p^6(3d^3_{3/2}3d_{5/2})_24p_{3/2}$	$7/2^-$	2111.96	1.23×10^{-13}	
1416	91.7	$3s^23p^6(3d^3_{3/2}3d_{5/2})_34p_{3/2}$	$9/2^-$	2114.58	2.32×10^{-13}	
1417	94.9	$3s^23p^6(3d^3_{3/2}3d_{5/2})_34p_{3/2}$	$7/2^-$	2114.95	9.18×10^{-14}	
1421	69.6	$3s^23p^6(3d^3_{3/2}3d_{5/2})_34p_{3/2}$	$5/2^-$	2118.79	8.41×10^{-14}	
1445	97.4	$3s^23p^63d^4_{3/2}4d_{3/2}$	$3/2^+$	2159.63	1.66×10^{-12}	
1466	97.6	$3s^23p^6[(3d^2_{3/2})_2(3d^2_{5/2})_4]_64p_{3/2}$	$13/2^-$	2178.08	1.14×10^{-13}	

(*continued on next page*)

Table 10 (*continued*)

Index	Purity (%)	Configuration	J^{π}	E (eV)	τ_{rad} (s)	τ_{level} (s)
1488	93.7	$3s^2 3p^6 3d_{3/2}^4 4d_{5/2}$	$5/2^+$	2191.53	3.48×10^{-12}	
1489	92.8	$3s^2 3p_{1/2}^2(3p_{3/2}^3 3d_{3/2}^4 3d_{5/2})_4 4s_{1/2}$	$7/2^-$	2197.93	4.95×10^{-14}	
1490	92.9	$3s^2 3p_{1/2}^2(3p_{3/2}^3 3d_{3/2}^4 3d_{5/2})_2 4s_{1/2}$	$5/2^-$	2200.07	1.59×10^{-13}	
1495	86.5	$3s^2 3p_{1/2}^2(3p_{3/2}^3 3d_{3/2}^4 3d_{5/2})_2 4s_{1/2}$	$3/2^-$	2202.87	9.23×10^{-14}	
1499	89.0	$3s^2 3p_{1/2}^2(3p_{3/2}^3 3d_{3/2}^4 3d_{5/2})_3 4s_{1/2}$	$7/2^-$	2208.31	1.67×10^{-13}	
1503	92.7	$3s^2 3p_{1/2}^2(3p_{3/2}^3 3d_{3/2}^4 3d_{5/2})_3 4s_{1/2}$	$5/2^-$	2212.92	5.02×10^{-14}	
1512	84.8	$3s^2 3p^6(3d_{3/2}^3 3d_{5/2})_1 4d_{3/2}$	$5/2^+$	2224.56	1.64×10^{-12}	
1531	94.3	$3s^2 3p_{1/2}^2(3p_{3/2}^3 3d_{3/2}^4 3d_{5/2})_1 4s_{1/2}$	$3/2^-$	2245.05	6.67×10^{-14}	
1566	24.9	$3s^2 3p^6(3d_{3/2}^3 3d_{5/2})_3 4d_{3/2}$	$5/2^+$	2264.14	6.55×10^{-13}	
1568	39.3	$3s^2 3p^6(3d_{3/2}^3 3d_{5/2})_4 4d_{5/2}$	$5/2^+$	2264.51	1.56×10^{-12}	
1589	95.3	$3s^2 3p_{1/2}^2[(3p_{3/2}^3 3d_{3/2}^3)_3(3d_{5/2}^2)_4]_7 4s_{1/2}$	$13/2^-$	2272.83	4.38×10^{-14}	
1619	90.0	$3s^2 3p_{1/2}^2(3p_{3/2}^3 3d_{3/2}^4 3d_{5/2})_4 4p_{1/2}$	$9/2^+$	2284.51	3.57×10^{-12}	
1644	89.8	$3s^2 3p_{1/2}^2(3p_{3/2}^3 3d_{3/2}^4 3d_{5/2})_3 4p_{1/2}$	$7/2^+$	2299.90	4.10×10^{-12}	
1676	97.7	$3s^2 3p^6 3d_{3/2}^4 4f_{5/2}$	$5/2^-$	2314.75	1.24×10^{-13}	
1715	48.2	$3s^2 3p^6[(3d_{3/2}^2)_2(3d_{5/2}^2)_4]_6 4d_{3/2}$	$11/2^+$	2329.18	7.08×10^{-13}	
1724	93.4	$3s^2 3p^6 3d_{3/2}^4 4f_{7/2}$	$7/2^-$	2331.68	1.42×10^{-14}	
1895	90.7	$3s^2 3p^6(3d_{3/2}^3 3d_{5/2})_1 4f_{5/2}$	$5/2^-$	2376.53	1.07×10^{-13}	
1908	40.5	$3s^2 3p^6(3d_{3/2}^3 3d_{5/2})_1 4f_{5/2}$	$7/2^-$	2379.79	7.67×10^{-14}	
1928	69.5	$3s^2 3p^6(3d_{3/2}^3 3d_{5/2})_4 4f_{5/2}$	$11/2^-$	2386.17	2.50×10^{-13}	
1934	61.9	$3s^2 3p^6(3d_{3/2}^3 3d_{5/2})_4 4f_{5/2}$	$9/2^-$	2388.73	1.53×10^{-13}	
1949	41.4	$3s^2 3p^6(3d_{3/2}^3 3d_{5/2})_3 4f_{5/2}$	$9/2^-$	2391.63	3.35×10^{-13}	
1958	39.8	$3s^2 3p^6(3d_{3/2}^3 3d_{5/2})_1 4f_{7/2}$	$7/2^-$	2393.48	2.71×10^{-14}	
1968	69.8	$3s^2 3p^6(3d_{3/2}^3 3d_{5/2})_1 4f_{7/2}$	$5/2^-$	2394.84	1.69×10^{-14}	
1973	29.0	$3s^2 3p^6(3d_{3/2}^3 3d_{5/2})_1 4f_{7/2}$	$7/2^-$	2395.87	3.80×10^{-14}	
1977	38.9	$3s^2 3p^6(3d_{3/2}^3 3d_{5/2})_3 4f_{5/2}$	$9/2^-$	2397.05	1.69×10^{-13}	
1986	57.5	$3s^2 3p^6(3d_{3/2}^3 3d_{5/2})_3 4f_{5/2}$	$11/2^-$	2399.27	2.57×10^{-13}	
1999	43.7	$3s^2 3p^6(3d_{3/2}^3 3d_{5/2})_3 4f_{5/2}$	$5/2^-$	2400.77	4.51×10^{-14}	
2004	59.9	$3s^2 3p^6(3d_{3/2}^3 3d_{5/2})_4 4f_{7/2}$	$11/2^-$	2401.70	2.85×10^{-14}	
2017	55.4	$3s^2 3p^6(3d_{3/2}^3 3d_{5/2})_2 4f_{7/2}$	$9/2^-$	2404.46	2.40×10^{-14}	
2019	89.2	$3s^2 3p_{1/2}^2(3p_{3/2}^3 3d_{3/2}^4 3d_{5/2})_4 4p_{3/2}$	$9/2^+$	2405.00	7.73×10^{-14}	
2033	49.2	$3s^2 3p^6(3d_{3/2}^3 3d_{5/2})_3 4f_{7/2}$	$13/2^-$	2406.84	1.05×10^{-13}	
2035	48.5	$3s^2 3p^6(3d_{3/2}^3 3d_{5/2})_4 4f_{7/2}$	$7/2^-$	2406.90	6.34×10^{-15}	
2039	56.8	$3s^2 3p^6(3d_{3/2}^3 3d_{5/2})_3 4f_{7/2}$	$11/2^-$	2407.29	9.43×10^{-14}	
2041	60.1	$3s^2 3p^6(3d_{3/2}^3 3d_{5/2})_4 4f_{7/2}$	$3/2^-$	2407.92	9.70×10^{-15}	
2053	31.6	$3s^2 3p^6(3d_{3/2}^3 3d_{5/2})_4 4f_{7/2}$	$5/2^-$	2410.05	4.74×10^{-15}	
2056	72.0	$3s^2 3p_{1/2}^2(3p_{3/2}^3 3d_{3/2}^4 3d_{5/2})_2 4p_{3/2}$	$7/2^+$	2410.86	1.27×10^{-13}	
2060	43.0	$3s^2 3p^6(3d_{3/2}^3 3d_{5/2})_4 4f_{7/2}$	$13/2^-$	2411.53	9.64×10^{-15}	
2063	40.8	$3s^2 3p^6(3d_{3/2}^3 3d_{5/2})_4 4f_{7/2}$	$9/2^-$	2412.11	1.20×10^{-14}	
2064	49.3	$3s^2 3p^6(3d_{3/2}^3 3d_{5/2})_2 4f_{7/2}$	$7/2^-$	2412.49	9.70×10^{-15}	
2066	41.1	$3s^2 3p^6(3d_{3/2}^3 3d_{5/2})_4 4f_{7/2}$	$5/2^-$	2412.55	5.55×10^{-15}	
2067	56.6	$3s^2 3p^6(3d_{3/2}^3 3d_{5/2})_4 4f_{5/2}$	$3/2^-$	2412.59	3.81×10^{-15}	
2073	59.6	$3s^2 3p_{1/2}^2\{[3p_{3/2}^3(3d_{3/2}^2)_0]_{3/2}(3d_{5/2}^3)_{9/2}\}_4 4s_{1/2}$	$7/2^-$	2414.41	6.64×10^{-14}	
2075	29.1	$3s^2 3p^6(3d_{3/2}^3 3d_{5/2})_3 4f_{5/2}$	$7/2^-$	2414.74	4.34×10^{-15}	
2083	68.4	$3s^2 3p^6(3d_{3/2}^3 3d_{5/2})_2 4f_{7/2}$	$3/2^-$	2416.59	7.55×10^{-15}	
2085	25.9	$3s^2 3p^6(3d_{3/2}^3 3d_{5/2})_2 4f_{7/2}$	$7/2^-$	2416.97	6.35×10^{-15}	
2089	22.6	$3s^2 3p_{1/2}^2\{[3p_{3/2}^3(3d_{3/2}^2)_0]_{3/2}(3d_{5/2}^3)_{9/2}\}_3 4s_{1/2}$	$7/2^-$	2417.32	2.83×10^{-14}	
2092	29.1	$3s^2 3p^6(3d_{3/2}^3 3d_{5/2})_3 4f_{7/2}$	$11/2^-$	2417.91	8.26×10^{-15}	
2094	33.2	$3s^2 3p_{1/2}^2(3p_{3/2}^3 3d_{3/2}^4 3d_{5/2})_4 4p_{3/2}$	$5/2^+$	2418.02	1.06×10^{-13}	
2102	71.8	$3s^2 3p^6(3d_{3/2}^3 3d_{5/2})_3 4f_{7/2}$	$9/2^-$	2419.85	8.02×10^{-15}	
2119	55.1	$3s^2 3p^6(3d_{3/2}^3 3d_{5/2})_3 4f_{7/2}$	$5/2^-$	2423.76	1.09×10^{-14}	
2124	66.1	$3s^2 3p^6(3d_{3/2}^3 3d_{5/2})_3 4f_{7/2}$	$3/2^-$	2424.91	9.99×10^{-15}	
2167	53.3	$3s^2 3p_{1/2}^2(3p_{3/2}^3 3d_{3/2}^4 3d_{5/2})_3 4p_{3/2}$	$5/2^+$	2436.42	6.94×10^{-14}	
2250	81.2	$3s^2 3p_{1/2}^2(3p_{3/2}^3 3d_{3/2}^4 3d_{5/2})_1 4p_{3/2}$	$5/2^+$	2458.05	1.46×10^{-13}	
2366	22.8	$3s^2 3p^6[(3d_{3/2}^2)_2(3d_{5/2}^2)_4]_6 4f_{7/2}$	$11/2^-$	2476.42	8.70×10^{-15}	
2383	37.1	$3s^2 3p^6[(3d_{3/2}^2)_2(3d_{5/2}^2)_4]_6 4f_{5/2}$	$9/2^-$	2478.46	7.78×10^{-15}	
2386	50.3	$3s^2 3p^6[(3d_{3/2}^2)_2(3d_{5/2}^2)_4]_6 4f_{5/2}$	$11/2^-$	2478.61	5.18×10^{-15}	
2399	34.0	$3s^2 3p^6[(3d_{3/2}^2)_2(3d_{5/2}^2)_2]_2 4f_{7/2}$	$11/2^-$	2479.86	2.39×10^{-14}	
2407	21.4	$3s^2 3p^6[(3d_{3/2}^2)_2(3d_{5/2}^2)_2]_4 4f_{7/2}$	$11/2^-$	2480.73	1.06×10^{-14}	
2413	24.9	$3s^2 3p^6[(3d_{3/2}^2)_2(3d_{5/2}^2)_4]_4 4f_{5/2}$	$13/2^-$	2481.46	4.72×10^{-15}	
2455	14.6	$3s^2 3p^6[(3d_{3/2}^2)_0(3d_{5/2}^2)_4]_4 4f_{5/2}$	$9/2^-$	2487.81	4.27×10^{-15}	
2458	31.5	$3s^2 3p^6[(3d_{3/2}^2)_2(3d_{5/2}^2)_4]_6 4f_{7/2}$	$13/2^-$	2488.19	4.00×10^{-15}	
2466	19.4	$3s^2 3p^6[(3d_{3/2}^2)_2(3d_{5/2}^2)_4]_5 4f_{7/2}$	$11/2^-$	2489.18	4.47×10^{-15}	
2500	39.0	$3s^2 3p^6[(3d_{3/2}^2)_0(3d_{5/2}^2)_4]_4 4f_{7/2}$	$13/2^-$	2494.74	1.37×10^{-14}	
2505	35.4	$3s^2 3p^6[(3d_{3/2}^2)_0(3d_{5/2}^2)_4]_4 4f_{5/2}$	$11/2^-$	2495.45	4.15×10^{-15}	
2518	25.7	$3s^2 3p^6[(3d_{3/2}^2)_2(3d_{5/2}^2)_2]_4 4f_{5/2}$	$9/2^-$	2497.88	5.44×10^{-15}	
2519	54.1	$3s^2 3p^6[(3d_{3/2}^2)_0(3d_{5/2}^2)_4]_4 4f_{5/2}$	$13/2^-$	2498.01	1.48×10^{-14}	

(*continued on next page*)

Table 10 (*continued*)

Index	Purity (%)	Configuration	J^π	E (eV)	τ_{rad} (s)	τ_{level} (s)
2523	38.3	$3s^23p^6[(3d^2_{3/2})_2(3d^2_{5/2})_0]_24f_{7/2}$	$11/2^-$	2498.28	8.51×10^{-15}	
2535	44.6	$3s^23p^2_{1/2}[(3p^3_{3/2}3d^3_{3/2})_3(3d^2_{5/2})_2]_54p_{3/2}$	$11/2^+$	2502.77	1.38×10^{-13}	
2588	30.7	$3s^23p^2_{1/2}[(3p^3_{3/2}3d^3_{3/2})_3(3d^2_{5/2})_4]_54p_{3/2}$	$11/2^+$	2517.89	1.51×10^{-13}	
2634	87.5	$3s^23p^2_{1/2}(3p^3_{3/2}3d^4_{3/2}3d_{5/2})_44d_{3/2}$	$7/2^-$	2529.85	2.19×10^{-13}	
2648	22.1	$3s^23p^2_{1/2}[(3p^3_{3/2}3d^3_{3/2})_3(3d^2_{5/2})_2]_34p_{3/2}$	$9/2^+$	2531.77	1.62×10^{-13}	
2833	60.1	$3s^23p^2_{1/2}(3p^3_{3/2}3d^4_{3/2}3d_{5/2})_44d_{5/2}$	$7/2^-$	2561.27	2.37×10^{-13}	
2838	57.2	$3s^23p^2_{1/2}(3p^3_{3/2}3d^4_{3/2}3d_{5/2})_44d_{5/2}$	$5/2^-$	2562.05	1.25×10^{-14}	
2852	45.1	$3s^23p^2_{1/2}(3p^3_{3/2}3d^4_{3/2}3d_{5/2})_24d_{5/2}$	$3/2^-$	2564.31	3.19×10^{-14}	
2868	56.4	$3s^2(3p_{1/2}3p^4_{3/2}3d^4_{3/2}3d_{5/2})_24s_{1/2}$	$3/2^-$	2566.67	1.87×10^{-14}	
2881	51.5	$3s^23p^2_{1/2}(3p^3_{3/2}3d^4_{3/2}3d_{5/2})_24d_{5/2}$	$7/2^-$	2568.69	1.20×10^{-14}	
2909	35.7	$3s^23p^2_{1/2}(3p^3_{3/2}3d^4_{3/2}3d_{5/2})_44d_{5/2}$	$3/2^-$	2573.04	1.51×10^{-14}	
2940	71.6	$3s^23p^2_{1/2}(3p^3_{3/2}3d^4_{3/2}3d_{5/2})_34d_{5/2}$	$5/2^-$	2578.27	2.60×10^{-14}	
2963	75.2	$3s^23p^2_{1/2}(3p^3_{3/2}3d^4_{3/2}3d_{5/2})_34d_{5/2}$	$7/2^-$	2582.23	2.33×10^{-14}	
2965	82.4	$3s^23p^2_{1/2}(3p^3_{3/2}3d^4_{3/2}3d_{5/2})_14d_{3/2}$	$5/2^-$	2582.39	6.50×10^{-14}	
3101	73.3	$3s^23p^2_{1/2}(3p^3_{3/2}3d^4_{3/2}3d_{5/2})_14d_{5/2}$	$7/2^-$	2610.10	4.51×10^{-14}	
3109	83.1	$3s^23p^2_{1/2}(3p^3_{3/2}3d^4_{3/2}3d_{5/2})_14d_{5/2}$	$5/2^-$	2611.22	8.38×10^{-14}	
3278	27.6	$3s^23p^2_{1/2}[(3p^3_{3/2}3d^2_{3/2})_2(3d^2_{5/2})_4]_64d_{5/2}$	$13/2^-$	2638.37	3.48×10^{-14}	
3279	22.9	$3s^23p^2_{1/2}[(3p^3_{3/2}3d^3_{3/2})_3(3d^2_{5/2})_4]_74d_{5/2}$	$11/2^-$	2638.37	3.42×10^{-14}	
3303	35.2	$3s^23p^2_{1/2}[(3p^3_{3/2}3d^3_{3/2})_3(3d^2_{5/2})_4]_74d_{5/2}$	$9/2^-$	2641.66	1.62×10^{-14}	
3358	60.2	$3s^23p^2_{1/2}[(3p^3_{3/2}3d^3_{3/2})_3(3d^2_{5/2})_4]_64d_{5/2}$	$13/2^-$	2648.59	2.20×10^{-14}	
3385	17.4	$3s^23p^2_{1/2}[(3p^3_{3/2}3d^3_{3/2})_1(3d^2_{5/2})_4]_54d_{5/2}$	$11/2^-$	2651.92	2.44×10^{-14}	
3526	20.2	$3s^2(3p_{1/2}3p^4_{3/2}3d^4_{3/2}3d_{5/2})_34p_{1/2}$	$5/2^+$	2674.79	1.00×10^{-13}	
3527	47.8	$3s^2(3p_{1/2}3p^4_{3/2}3d^4_{3/2}3d_{5/2})_34p_{1/2}$	$5/2^+$	2674.81	1.16×10^{-13}	
3604	80.8	$3s^23p^2_{1/2}(3p^3_{3/2}3d^4_{3/2}3d_{5/2})_44f_{5/2}$	$13/2^+$	2683.82	6.57×10^{-13}	
3774	74.7	$3s^23p^2_{1/2}(3p^3_{3/2}3d^4_{3/2}3d_{5/2})_44f_{7/2}$	$13/2^+$	2703.71	1.31×10^{-14}	
3783	78.3	$3s^23p^2_{1/2}(3p^3_{3/2}3d^4_{3/2}3d_{5/2})_44f_{7/2}$	$7/2^+$	2705.05	1.44×10^{-14}	
3816	75.3	$3s^23p^2_{1/2}(3p^3_{3/2}3d^4_{3/2}3d_{5/2})_24f_{7/2}$	$7/2^+$	2708.72	1.32×10^{-14}	
3824	36.5	$3s^23p^2_{1/2}(3p^3_{3/2}3d^4_{3/2}3d_{5/2})_24f_{7/2}$	$9/2^+$	2709.50	1.27×10^{-14}	
3842	48.1	$3s^23p^2_{1/2}(3p^3_{3/2}3d^4_{3/2}3d_{5/2})_24f_{7/2}$	$3/2^+$	2711.16	1.53×10^{-14}	
3844	38.7	$3s^23p^2_{1/2}(3p^3_{3/2}3d^4_{3/2}3d_{5/2})_44f_{7/2}$	$5/2^+$	2711.20	1.85×10^{-14}	
3908	42.5	$3s^23p^2_{1/2}(3p^3_{3/2}3d^4_{3/2}3d_{5/2})_44f_{7/2}$	$3/2^+$	2718.66	1.20×10^{-14}	
3917	77.6	$3s^23p^2_{1/2}(3p^3_{3/2}3d^4_{3/2}3d_{5/2})_34f_{7/2}$	$7/2^+$	2719.71	1.52×10^{-14}	
3920	46.4	$3s^23p^2_{1/2}(3p^3_{3/2}3d^4_{3/2}3d_{5/2})_34f_{7/2}$	$1/2^+$	2719.85	1.42×10^{-14}	
3933	69.6	$3s^2[(3p_{1/2}3p^4_{3/2}3d^3_{3/2})_2(3d^2_{5/2})_4]_64p_{1/2}$	$11/2^+$	2720.79	7.93×10^{-14}	
3963	61.9	$3s^23p^2_{1/2}(3p^3_{3/2}3d^4_{3/2}3d_{5/2})_34f_{7/2}$	$9/2^+$	2724.22	1.20×10^{-14}	
3972	66.0	$3s^23p^2_{1/2}(3p^3_{3/2}3d^4_{3/2}3d_{5/2})_34f_{7/2}$	$5/2^+$	2725.35	1.42×10^{-14}	
3975	80.2	$3s^23p^2_{1/2}(3p^3_{3/2}3d^4_{3/2}3d_{5/2})_34f_{7/2}$	$3/2^+$	2725.91	1.29×10^{-14}	
4036	77.1	$3s^23p^2_{1/2}(3p^3_{3/2}3d^4_{3/2}3d_{5/2})_14f_{5/2}$	$5/2^+$	2733.51	2.98×10^{-14}	
4168	77.2	$3s^23p^2_{1/2}(3p^3_{3/2}3d^4_{3/2}3d_{5/2})_14f_{7/2}$	$9/2^+$	2747.92	3.49×10^{-14}	
4195	68.3	$3s^23p^2_{1/2}(3p^3_{3/2}3d^4_{3/2}3d_{5/2})_14f_{7/2}$	$7/2^+$	2750.43	1.27×10^{-14}	
4580	41.4	$(3s_{1/2}3p^63d^4_{3/2}3d_{5/2})_34s_{1/2}$	$5/2^+$	2783.85	1.07×10^{-13}	
4664	57.8	$(3s_{1/2}3p^63d^4_{3/2}3d_{5/2})_24s_{1/2}$	$5/2^+$	2791.67	9.55×10^{-14}	
5379	87.5	$(3s_{1/2}3p^63d^4_{3/2}3d_{5/2})_34p_{1/2}$	$5/2^-$	2853.86	4.51×10^{-14}	
5384	86.9	$(3s_{1/2}3p^63d^4_{3/2}3d_{5/2})_34p_{1/2}$	$7/2^-$	2854.18	2.50×10^{-14}	
5552	90.7	$(3s_{1/2}3p^63d^4_{3/2}3d_{5/2})_24p_{1/2}$	$3/2^-$	2869.27	2.33×10^{-14}	
5570	91.0	$(3s_{1/2}3p^63d^4_{3/2}3d_{5/2})_24p_{1/2}$	$5/2^-$	2870.50	3.40×10^{-14}	
6012	40.2	$3s^2(3p_{1/2}3p^4_{3/2}3d^4_{3/2}3d_{5/2})_34d_{3/2}$	$7/2^-$	2909.16	1.90×10^{-14}	
6037	37.7	$[(3s_{1/2}3p^63d^3_{3/2})_1(3d^2_{5/2})_4]_34p_{1/2}$	$7/2^-$	2911.46	2.36×10^{-14}	
6038	80.3	$3s^2(3p_{1/2}3p^4_{3/2}3d^4_{3/2}3d_{5/2})_34d_{3/2}$	$5/2^-$	2911.94	2.32×10^{-14}	
6062	84.5	$3s^2(3p_{1/2}3p^4_{3/2}3d^4_{3/2}3d_{5/2})_34d_{3/2}$	$3/2^-$	2914.80	1.90×10^{-14}	
6779	83.3	$(3s_{1/2}3p^63d^4_{3/2}3d_{5/2})_24p_{3/2}$	$7/2^-$	2992.83	4.80×10^{-14}	
7221	49.0	$3s^2(3p_{1/2}3p^4_{3/2}3d^4_{3/2}3d_{5/2})_34f_{5/2}$	$9/2^+$	3061.93	6.84×10^{-14}	
7225	81.5	$3s^2(3p_{1/2}3p^4_{3/2}3d^4_{3/2}3d_{5/2})_34f_{5/2}$	$7/2^+$	3062.62	7.20×10^{-14}	
7235	82.8	$3s^2(3p_{1/2}3p^4_{3/2}3d^4_{3/2}3d_{5/2})_34f_{5/2}$	$5/2^+$	3064.71	7.58×10^{-14}	
7261	80.2	$3s^2(3p_{1/2}3p^4_{3/2}3d^4_{3/2}3d_{5/2})_34f_{5/2}$	$3/2^+$	3068.58	4.99×10^{-14}	
7306	36.0	$3s^2(3p_{1/2}3p^4_{3/2}3d^4_{3/2}3d_{5/2})_34f_{7/2}$	$9/2^+$	3075.99	1.35×10^{-14}	
8785	70.8	$(3s_{1/2}3p^63d^4_{3/2}3d_{5/2})_34f_{7/2}$	$5/2^-$	3274.31	1.64×10^{-14}	
8798	61.3	$(3s_{1/2}3p^63d^4_{3/2}3d_{5/2})_34f_{7/2}$	$11/2^-$	3276.09	1.06×10^{-14}	
8806	59.9	$(3s_{1/2}3p^63d^4_{3/2}3d_{5/2})_34f_{7/2}$	$7/2^-$	3276.72	1.32×10^{-14}	
8852	92.3	$(3s_{1/2}3p^63d^4_{3/2}3d_{5/2})_24f_{7/2}$	$11/2^-$	3283.12	5.90×10^{-14}	
8855	47.6	$(3s_{1/2}3p^63d^4_{3/2}3d_{5/2})_34f_{7/2}$	$3/2^-$	3283.29	1.41×10^{-14}	
8917	76.6	$(3s_{1/2}3p^63d^4_{3/2}3d_{5/2})_24f_{7/2}$	$9/2^-$	3290.91	8.77×10^{-15}	
10137	98.2	$3s^23p^63d^4_{3/2}5d_{5/2}$	$5/2^+$	3129.09	8.99×10^{-14}	
10191	98.7	$3s^23p^63d^4_{3/2}5f_{5/2}$	$5/2^-$	3184.49	4.36×10^{-14}	
10213	97.9	$3s^23p^63d^4_{3/2}5f_{7/2}$	$7/2^-$	3193.21	1.56×10^{-14}	
10239	61.6	$3s^23p^6(3d^3_{3/2}3d_{5/2})_35d_{3/2}$	$5/2^+$	3201.59	1.01×10^{-13}	
10313	90.6	$3s^23p^6(3d^3_{3/2}3d_{5/2})_15f_{5/2}$	$7/2^-$	3249.54	3.08×10^{-14}	

(*continued on next page*)

Table 10 (*continued*)

Index	Purity (%)	Configuration	J^{π}	E (eV)	τ_{rad} (s)	τ_{level} (s)
10353	43.8	$3s^2 3p^6 (3d^3_{3/2} 3d_{5/2})_2 5f_{5/2}$	$7/2^-$	3263.70	3.14×10^{-14}	
10369	42.8	$3s^2 3p^6 (3d^3_{3/2} 3d_{5/2})_4 5f_{5/2}$	$5/2^-$	3265.93	1.82×10^{-14}	
10377	39.4	$3s^2 3p^6 (3d^3_{3/2} 3d_{5/2})_4 5f_{5/2}$	$3/2^-$	3266.89	2.28×10^{-14}	
10388	64.6	$3s^2 3p^6 (3d^3_{3/2} 3d_{5/2})_4 5f_{7/2}$	$3/2^-$	3268.55	1.22×10^{-14}	
10392	85.2	$3s^2 3p^6 (3d^3_{3/2} 3d_{5/2})_4 5f_{7/2}$	$13/2^-$	3269.31	1.80×10^{-14}	
10398	41.3	$3s^2 3p^6 (3d^3_{3/2} 3d_{5/2})_3 5f_{5/2}$	$5/2^-$	3270.24	1.34×10^{-14}	
10405	59.7	$3s^2 3p^6 (3d^3_{3/2} 3d_{5/2})_3 5f_{5/2}$	$3/2^-$	3270.83	1.04×10^{-14}	
10411	59.5	$3s^2 3p^6 (3d^3_{3/2} 3d_{5/2})_3 5f_{5/2}$	$7/2^-$	3271.11	8.86×10^{-15}	
10414	41.1	$3s^2 3p^6 (3d^3_{3/2} 3d_{5/2})_3 5f_{5/2}$	$5/2^-$	3271.81	1.14×10^{-14}	
10423	82.7	$3s^2 3p^6 (3d^3_{3/2} 3d_{5/2})_3 5f_{7/2}$	$13/2^-$	3273.43	1.65×10^{-14}	
10433	54.8	$3s^2 3p^6 (3d^3_{3/2} 3d_{5/2})_3 5f_{7/2}$	$11/2^-$	3275.98	1.08×10^{-14}	
10639	41.2	$3s^2 3p^6 [(3d^2_{3/2})_2 (3d^2_{5/2})_4]_5 5f_{7/2}$	$13/2^-$	3335.94	1.13×10^{-14}	
10655	43.6	$3s^2 3p^6 [(3d^2_{3/2})_2 (3d^2_{5/2})_4]_6 5f_{5/2}$	$11/2^-$	3337.69	1.48×10^{-14}	
11250	85.4	$3s^2 3p^2_{1/2} (3p^3_{3/2} 3d^4_{3/2} 3d_{5/2})_3 5p_{3/2}$	$5/2^+$	3439.59	8.61×10^{-14}	
11578	59.6	$3s^2 3p^2_{1/2} (3p^3_{3/2} 3d^4_{3/2} 3d_{5/2})_4 5d_{5/2}$	$5/2^-$	3497.91	2.61×10^{-14}	
11597	40.3	$3s^2 3p^2_{1/2} (3p^3_{3/2} 3d^4_{3/2} 3d_{5/2})_3 5d_{3/2}$	$3/2^-$	3500.52	2.61×10^{-14}	
11610	81.7	$3s^2 3p^2_{1/2} (3p^3_{3/2} 3d^4_{3/2} 3d_{5/2})_2 5d_{5/2}$	$7/2^-$	3503.60	2.30×10^{-14}	
11616	71.1	$3s^2 3p^2_{1/2} (3p^3_{3/2} 3d^4_{3/2} 3d_{5/2})_2 5d_{5/2}$	$3/2^-$	3504.19	2.25×10^{-14}	
11663	92.8	$3s^2 3p^2_{1/2} (3p^3_{3/2} 3d^4_{3/2} 3d_{5/2})_3 5d_{5/2}$	$5/2^-$	3512.41	2.68×10^{-14}	
11681	89.3	$3s^2 3p^2_{1/2} (3p^3_{3/2} 3d^4_{3/2} 3d_{5/2})_3 5d_{5/2}$	$7/2^-$	3514.64	2.88×10^{-14}	
12163	81.5	$3s^2 3p^2_{1/2} (3p^3_{3/2} 3d^4_{3/2} 3d_{5/2})_3 5f_{7/2}$	$9/2^+$	3579.30	1.30×10^{-14}	

Table 11
Radiative transitions in Ge-like tungsten, W^{42+}.

i	k	ΔE (eV)	λ (Å)	gf	A (s^{-1})	ϵ (γ/ion/s)
0	4453	1018.01	12.1791	1.60×10^{-1}	2.39×10^{12}	344
8	4873	1038.69	11.9366	2.81×10^{-2}	1.32×10^{12}	194
10	4875	1053.47	11.7691	7.79×10^{-2}	7.50×10^{11}	40
26	4944	1135.59	10.9181	5.99×10^{-1}	4.79×10^{12}	105
10	4891	1142.00	10.8568	7.20×10^{-1}	4.53×10^{12}	50
8	4889	1148.19	10.7982	3.85×10^{-1}	4.40×10^{12}	210
18	4937	1163.36	10.6574	6.37×10^{-1}	5.34×10^{12}	51
6	4883	1170.20	10.5951	5.25×10^{-2}	3.12×10^{12}	236
2	4871	1178.21	10.5231	1.26×10^{-1}	2.53×10^{12}	54
6	4917	1265.39	9.79809	2.22×10^{-1}	3.08×10^{12}	86
2	4880	1275.27	9.72223	3.47×10^{-1}	3.50×10^{12}	62
0	4876	1365.13	9.08222	1.23×10^{-1}	3.31×10^{12}	138
0	4895	1422.35	8.71689	6.03×10^{-2}	1.76×10^{12}	50
6	5425	1483.71	8.35637	1.12×10^{-4}	1.53×10^{-9}	55
3	5422	1494.45	8.29630	3.92×10^{-4}	4.22×10^{9}	350
3	5425	1498.99	8.27121	1.90×10^{-4}	2.65×10^{9}	95
2	5423	1587.72	7.80894	3.17×10^{-4}	6.93×10^{9}	78
2	5425	1590.56	7.79499	1.16×10^{-4}	1.83×10^{9}	66
8	5470	1618.93	7.65843	3.25×10^{-3}	3.70×10^{11}	117
6	5442	1628.50	7.61338	4.73×10^{-4}	1.81×10^{10}	34
6	5444	1633.49	7.59013	2.51×10^{-3}	5.81×10^{10}	80
8	5479	1637.06	7.57357	7.97×10^{-2}	3.09×10^{12}	89
8	5480	1642.36	7.54913	8.13×10^{-2}	1.90×10^{12}	78
3	5445	1650.44	7.51218	1.32×10^{-3}	2.22×10^{10}	44
16	5534	1650.71	7.51098	2.82×10^{-3}	3.34×10^{11}	46
45	5810	1653.11	7.50004	1.04×10^{-1}	2.46×10^{12}	30
16	5544	1654.06	7.49577	1.31×10^{-2}	1.56×10^{12}	58
2	5428	1654.18	7.49521	2.43×10^{-1}	4.12×10^{12}	130
10	5486	1654.73	7.49270	2.88×10^{-1}	3.80×10^{12}	53
47	5821	1655.04	7.49132	3.49×10^{-1}	3.77×10^{12}	34
14	5534	1655.48	7.48931	4.99×10^{-3}	5.93×10^{11}	81
7	5478	1656.26	7.48577	2.18×10^{-1}	3.71×10^{12}	57
9	5482	1656.79	7.48341	8.34×10^{-2}	3.31×10^{12}	42
45	5828	1658.08	7.47759	1.36×10^{-1}	2.32×10^{12}	39
16	5551	1658.34	7.47643	9.21×10^{-3}	1.10×10^{12}	324
1	5427	1658.42	7.47605	1.00×10^{-1}	3.99×10^{12}	132
9	5488	1660.01	7.46888	1.26×10^{-1}	3.01×10^{12}	55
7	5480	1661.68	7.46138	7.81×10^{-2}	1.87×10^{12}	77
38	5807	1662.24	7.45885	1.20×10^{-1}	2.06×10^{12}	35
14	5551	1663.11	7.45496	1.05×10^{-2}	1.26×10^{12}	371
39	5813	1663.61	7.45274	3.57×10^{-2}	1.43×10^{12}	37
50	5897	1665.03	7.44637	4.37×10^{-2}	1.75×10^{12}	43
6	5461	1666.75	7.43870	1.19×10^{-2}	1.43×10^{12}	135
3	5456	1670.66	7.42127	8.26×10^{-3}	3.33×10^{11}	67
25	5681	1674.08	7.40613	3.49×10^{-2}	6.06×10^{11}	51
3	5458	1674.13	7.40589	5.22×10^{-2}	9.07×10^{11}	70
25	5687	1675.42	7.40019	1.36×10^{-1}	2.36×10^{12}	68
8	5503	1675.46	7.40001	7.62×10^{-2}	9.28×10^{12}	1166
3	5460	1675.58	7.39946	4.51×10^{-2}	1.10×10^{12}	164
6	5470	1680.02	7.37994	1.38×10^{-3}	1.69×10^{11}	53
18	5645	1683.71	7.36376	1.20×10^{-1}	4.92×10^{12}	39
18	5646	1684.67	7.35957	1.77×10^{-2}	3.11×10^{11}	45
1	5432	1685.08	7.35775	7.59×10^{-2}	3.12×10^{12}	56
0	5424	1685.32	7.35674	2.11×10^{-1}	8.65×10^{12}	864
2	5438	1687.14	7.34880	4.64×10^{-1}	8.18×10^{12}	52
26	5749	1687.24	7.34834	7.23×10^{-2}	2.98×10^{12}	69
2	5439	1687.61	7.34675	2.66×10^{-1}	6.57×10^{12}	50
8	5534	1689.98	7.33643	3.48×10^{-3}	4.31×10^{11}	59
3	5466	1692.16	7.32700	2.05×10^{-1}	5.10×10^{12}	57
8	5544	1693.33	7.32192	6.99×10^{-3}	8.70×10^{11}	33
18	5668	1694.32	7.31762	2.26×10^{-2}	5.62×10^{11}	42
26	5761	1695.80	7.31124	4.56×10^{-2}	1.90×10^{12}	49
1	5440	1698.29	7.30054	2.27×10^{-2}	5.69×10^{11}	58
17	5705	1705.65	7.26904	5.46×10^{-2}	2.30×10^{12}	57
6	5503	1736.55	7.13968	2.21×10^{-3}	2.90×10^{11}	36
0	5427	1749.84	7.08546	3.09×10^{-2}	1.37×10^{12}	45
6	5551	1758.70	7.04977	2.41×10^{-3}	3.23×10^{11}	95
30	7013	1937.91	6.39784	1.88×10^{-1}	1.02×10^{13}	35
6	6043	1944.49	6.37618	1.90×10^{-1}	6.24×10^{12}	38

(continued on next page)

Table 11 (*continued*)

i	k	ΔE (eV)	λ (Å)	gf	A (s^{-1})	ϵ (γ/ion/s)
26	6880	1947.03	6.36785	2.03×10^{-1}	1.11×10^{13}	75
98	7775	1948.16	6.36417	1.60×10^{-1}	5.25×10^{12}	50
18	6728	1949.43	6.36002	4.50×10^{-1}	1.06×10^{13}	62
4485	11126	1959.73	6.32661	2.28×10^{-1}	1.26×10^{13}	34
3	6043	1959.77	6.32648	2.09×10^{-1}	6.95×10^{12}	42
4530	11178	1961.84	6.31978	3.23×10^{-1}	1.08×10^{13}	53
6	6132	1964.89	6.30998	1.08×10^{-1}	1.81×10^{13}	34
0	5705	2047.37	6.05577	1.59×10^{-1}	9.62×10^{12}	240
0	5727	2053.38	6.03807	9.11×10^{-1}	5.55×10^{13}	1749
1	6032	2054.17	6.03574	2.02×10^{-1}	1.23×10^{13}	90
2	6070	2056.26	6.02959	9.12×10^{-2}	5.58×10^{12}	64
1	6062	2059.23	6.02089	4.04×10^{-1}	2.48×10^{13}	33
0	5743	2060.76	6.01643	1.13×10^{-1}	6.97×10^{12}	187
0	5749	2062.08	6.01258	1.89×10^{-1}	1.16×10^{13}	270
2	6093	2062.51	6.01132	2.63	6.92×10^{13}	165
0	5761	2070.64	5.98772	3.29×10^{-1}	2.04×10^{13}	529
0	5788	2088.29	5.93712	1.85×10^{-1}	1.17×10^{13}	260
0	5813	2104.37	5.89175	7.85×10^{-1}	5.03×10^{13}	1303
0	5854	2114.61	5.86322	1.69×10^{-1}	1.09×10^{13}	214
2	6307	2118.38	5.85278	8.55×10^{-1}	3.33×10^{13}	47
2	6312	2119.44	5.84986	8.97×10^{-1}	2.50×10^{13}	46
2	6313	2119.48	5.84973	9.20×10^{-1}	5.98×10^{13}	43
0	5884	2120.65	5.84651	7.11×10^{-2}	4.62×10^{12}	77
0	5891	2122.30	5.84198	8.64×10^{-2}	5.63×10^{12}	82
0	5897	2123.47	5.83874	7.06×10^{-1}	4.61×10^{13}	1140
2	6348	2125.78	5.83242	1.33	5.23×10^{13}	49
0	5907	2126.12	5.83147	1.19	7.76×10^{13}	2032
0	5911	2126.75	5.82974	1.75	1.14×10^{14}	2989
2	6354	2127.13	5.82870	1.44	5.67×10^{13}	63
2	6358	2127.64	5.82730	1.47	5.77×10^{13}	84
2	6362	2128.27	5.82558	1.00	2.81×10^{13}	52
2	6369	2128.73	5.82433	1.15	3.24×10^{13}	65
2	6372	2129.38	5.82254	1.41	3.95×10^{13}	78
1	6348	2130.16	5.82041	8.58×10^{-1}	3.38×10^{13}	32
2	6381	2130.41	5.81974	4.02	1.13×10^{14}	237
2	6386	2131.37	5.81712	1.42	9.34×10^{13}	73
0	6027	2144.82	5.78063	1.10×10^{-1}	7.29×10^{12}	105
0	6032	2145.59	5.77857	9.06×10^{-2}	6.03×10^{12}	44
0	6056	2149.59	5.76782	8.66×10^{-2}	5.79×10^{12}	61
0	6070	2152.07	5.76116	2.50×10^{-1}	1.67×10^{13}	192
6	7775	2302.43	5.38492	1.44×10^{-1}	6.63×10^{12}	63
3	7775	2317.71	5.34943	1.65×10^{-1}	7.68×10^{12}	73
0	6880	2321.87	5.33984	8.36×10^{-1}	6.52×10^{13}	440
0	7013	2337.16	5.30490	1.96×10^{-1}	1.55×10^{13}	54
0	10262	2689.33	4.61023	8.55×10^{-1}	8.95×10^{13}	868
2	10529	2691.82	4.60596	1.28	8.02×10^{13}	42
2	10537	2693.02	4.60391	1.92	8.64×10^{13}	70
0	10381	2751.73	4.50568	9.97×10^{-1}	1.09×10^{14}	923
2	10746	2753.82	4.50227	1.57	1.03×10^{14}	51
2	10750	2755.19	4.50002	2.13	1.00×10^{14}	72
0	12059	3019.93	4.10553	3.91×10^{-1}	5.16×10^{13}	358
0	11126	3060.36	4.05129	3.72×10^{-1}	5.05×10^{13}	136
0	12237	3083.87	4.02041	3.52×10^{-1}	4.84×10^{13}	274
0	13330	3430.29	3.61439	1.55×10^{-1}	2.64×10^{13}	39

Table 12
Radiative transitions in Ga-like tungsten, W^{43+}.

i	k	ΔE (eV)	λ (Å)	gf	A (s^{-1})	ϵ (γ/ion/s)
1	706	1007.30	12.3085	2.90×10^{-1}	3.19×10^{12}	43
0	687	1010.14	12.2739	2.20×10^{-1}	2.44×10^{12}	281
0	689	1023.44	12.1144	8.18×10^{-2}	9.30×10^{11}	53
24	3767	1025.77	12.0869	5.55×10^{-1}	3.17×10^{12}	42
0	690	1026.57	12.0775	9.90×10^{-2}	2.26×10^{12}	102
0	692	1031.59	12.0188	1.55×10^{-1}	1.78×10^{12}	167
7	3751	1069.67	11.5909	5.69×10^{-2}	1.41×10^{12}	113
20	3794	1161.12	10.6780	4.22×10^{-1}	4.11×10^{12}	49
19	3796	1161.49	10.6746	6.38×10^{-1}	4.67×10^{12}	41
7	3761	1180.76	10.5004	5.47×10^{-1}	5.52×10^{12}	154
6	3756	1191.72	10.4038	4.35×10^{-2}	1.34×10^{12}	98
14	3791	1191.74	10.4036	7.52×10^{-1}	5.79×10^{12}	41
5	3756	1194.73	10.3776	5.45×10^{-2}	1.69×10^{12}	123
6	3778	1287.84	9.62732	1.56×10^{-1}	2.81×10^{12}	40
0	3754	1394.20	8.89289	1.34×10^{-1}	2.83×10^{12}	83
5	7806	1502.28	8.25307	1.38×10^{-4}	1.69×10^{9}	57
1	7797	1506.97	8.22739	2.68×10^{-4}	4.40×10^{9}	321
4	7802	1510.72	8.20698	4.55×10^{-4}	4.51×10^{9}	242
3	7799	1514.40	8.18703	3.40×10^{-4}	4.23×10^{9}	156
4	7806	1514.67	8.18556	2.24×10^{-4}	2.78×10^{9}	95
5	7810	1564.48	7.92495	1.81×10^{-4}	2.40×10^{9}	48
2	7804	1604.86	7.72556	2.97×10^{-4}	5.54×10^{9}	56
7	7869	1641.10	7.55494	8.10×10^{-3}	4.74×10^{11}	108
7	7883	1656.10	7.48651	1.02×10^{-1}	3.04×10^{12}	84
7	7884	1659.11	7.47292	1.18×10^{-1}	2.35×10^{12}	103
12	7930	1662.18	7.45913	4.59×10^{-3}	2.75×10^{11}	97
2	7809	1666.21	7.44110	1.20×10^{-1}	2.40×10^{12}	55
7	7885	1666.44	7.44006	6.60×10^{-2}	3.98×10^{12}	168
8	7894	1670.14	7.42359	1.61×10^{-1}	4.88×10^{12}	39
2	7811	1670.27	7.42299	1.02×10^{-1}	6.19×10^{12}	46
0	7798	1670.59	7.42159	1.38×10^{-1}	4.17×10^{12}	503
2	7812	1672.19	7.41447	1.71×10^{-1}	3.46×10^{12}	41
8	7898	1672.69	7.41228	2.44×10^{-1}	4.95×10^{12}	38
2	7813	1672.89	7.41138	2.00×10^{-1}	6.08×10^{12}	94
6	7854	1673.25	7.40977	5.20×10^{-2}	1.58×10^{12}	40
12	7956	1673.53	7.40856	3.73×10^{-2}	2.27×10^{12}	239
11	7951	1674.85	7.40270	4.09×10^{-2}	2.49×10^{12}	316
34	8295	1674.99	7.40210	6.75×10^{-2}	4.11×10^{12}	42
11	7956	1677.73	7.38998	3.12×10^{-2}	1.90×10^{12}	200
7	7888	1678.12	7.38829	4.78×10^{-2}	1.46×10^{12}	46
35	8324	1679.23	7.38340	6.51×10^{-2}	3.98×10^{12}	39
6	7858	1679.24	7.38337	2.08×10^{-2}	1.27×10^{12}	60
4	7855	1688.83	7.34143	4.85×10^{-2}	7.50×10^{11}	44
4	7857	1689.85	7.33699	4.60×10^{-2}	9.51×10^{11}	106
3	7846	1692.99	7.32338	1.83×10^{-2}	5.70×10^{11}	51
7	7907	1697.61	7.30346	7.74×10^{-2}	4.84×10^{12}	293
1	7816	1697.87	7.30235	1.07×10^{-1}	3.36×10^{12}	68
5	7869	1698.31	7.30045	4.19×10^{-3}	2.62×10^{11}	60
0	7800	1698.55	7.29942	1.06×10^{-1}	3.31×10^{12}	373
1	7818	1699.30	7.29619	1.38×10^{-1}	8.63×10^{12}	46
7	7911	1700.22	7.29226	4.05×10^{-2}	2.54×10^{12}	248
14	8039	1700.74	7.29003	1.67×10^{-1}	5.23×10^{12}	57
0	7803	1702.61	7.28201	2.14×10^{-1}	6.74×10^{12}	515
0	7805	1703.16	7.27966	1.40×10^{-1}	8.79×10^{12}	582
7	7930	1709.95	7.25076	1.66×10^{-2}	1.06×10^{12}	373
1	7825	1711.18	7.24553	1.79×10^{-1}	5.67×10^{12}	48
3	7861	1711.51	7.24412	1.16×10^{-1}	3.67×10^{12}	39
3	7863	1712.11	7.24159	2.43×10^{-2}	1.55×10^{12}	49
0	7807	1759.64	7.04599	5.36×10^{-3}	3.60×10^{11}	44
0	7808	1763.70	7.02977	2.52×10^{-2}	8.52×10^{11}	173
5	7930	1767.15	7.01604	3.25×10^{-3}	2.20×10^{11}	78
6	7956	1775.49	6.98309	6.46×10^{-3}	4.42×10^{11}	46
5	7951	1775.62	6.98260	6.75×10^{-3}	4.62×10^{11}	58
7	8486	1922.57	6.44887	1.64×10^{-2}	1.31×10^{12}	115
19	9147	1962.93	6.31627	2.15×10^{-1}	8.99×10^{12}	54
14	9009	1965.26	6.30880	5.60×10^{-1}	1.17×10^{13}	50
1	8106	1966.15	6.30592	3.38×10^{-1}	1.42×10^{13}	83
6	8486	1976.77	6.27206	6.72×10^{-2}	5.70×10^{12}	501
5	8486	1979.78	6.26253	1.63×10^{-1}	1.39×10^{13}	1219

(continued on next page)

Table 12 (*continued*)

i	k	ΔE (eV)	λ (Å)	gf	A (s^{-1})	ϵ (γ/ion/s)
0	8039	2042.37	6.07061	8.44×10^{-2}	3.82×10^{12}	41
2	8377	2056.65	6.02845	8.78×10^{-2}	4.03×10^{12}	43
0	8090	2059.10	6.02127	1.96×10^{-1}	1.81×10^{13}	181
0	8092	2059.47	6.02019	7.73×10^{-2}	3.56×10^{12}	49
0	8095	2060.44	6.01735	6.23×10^{-2}	5.74×10^{12}	52
0	8105	2062.82	6.01042	1.70×10^{-1}	1.57×10^{13}	181
0	8111	2066.27	6.00040	7.12×10^{-1}	3.30×10^{13}	812
0	8113	2066.84	5.99874	2.72×10^{-1}	2.52×10^{13}	314
0	8116	2067.95	5.99553	3.53×10^{-1}	1.64×10^{13}	369
0	8120	2068.74	5.99323	5.76×10^{-1}	2.67×10^{13}	636
0	8124	2071.75	5.98451	1.99×10^{-1}	1.85×10^{13}	207
2	8446	2072.15	5.98337	1.10×10^{-1}	5.11×10^{12}	46
2	8447	2072.53	5.98227	3.88×10^{-1}	3.62×10^{13}	116
0	8147	2078.76	5.96433	1.06×10^{-1}	9.96×10^{12}	93
0	8161	2084.33	5.94840	6.62×10^{-2}	3.12×10^{12}	46
0	8168	2085.70	5.94449	8.77×10^{-2}	4.14×10^{12}	61
0	8169	2085.92	5.94387	1.59×10^{-1}	1.50×10^{13}	139
0	8171	2087.65	5.93893	1.67×10^{-1}	7.89×10^{12}	134
0	8209	2105.63	5.88822	2.49×10^{-1}	1.20×10^{13}	227
0	8211	2106.85	5.88481	8.92×10^{-2}	8.59×10^{12}	75
0	8232	2117.53	5.85514	9.04×10^{-1}	4.40×10^{13}	913
0	8241	2120.51	5.84690	1.13×10^{-1}	5.49×10^{12}	59
0	8243	2121.07	5.84537	7.54×10^{-2}	7.36×10^{12}	57
0	8255	2125.40	5.83344	1.86×10^{-1}	1.82×10^{13}	160
0	8257	2126.58	5.83021	1.80×10^{-1}	1.77×10^{13}	171
0	8258	2127.29	5.82828	1.76×10^{-1}	8.66×10^{12}	152
0	8265	2130.50	5.81950	8.01×10^{-1}	7.89×10^{13}	832
0	8266	2130.97	5.81821	5.03×10^{-1}	2.48×10^{13}	468
0	8275	2134.97	5.80731	8.40×10^{-1}	4.15×10^{13}	860
0	8291	2140.29	5.79286	3.64	1.81×10^{14}	3804
0	8295	2140.48	5.79235	9.47×10^{-1}	9.42×10^{13}	973
0	8307	2142.83	5.78599	5.51×10^{-1}	5.49×10^{13}	559
0	8308	2142.93	5.78573	1.53×10^{-1}	7.64×10^{12}	88
0	8311	2143.32	5.78469	3.70×10^{-1}	1.84×10^{13}	295
0	8324	2145.98	5.77752	5.29×10^{-1}	5.29×10^{13}	511
0	8377	2154.78	5.75391	1.25×10^{-1}	6.28×10^{12}	66
0	8407	2160.43	5.73887	1.08×10^{-1}	5.47×10^{12}	58
0	8415	2161.27	5.73663	1.10×10^{-1}	5.56×10^{12}	65
0	8446	2170.28	5.71283	1.82×10^{-1}	9.28×10^{12}	83
0	8447	2170.66	5.71182	1.95×10^{-1}	1.99×10^{13}	64
0	8502	2185.86	5.67211	8.69×10^{-2}	4.50×10^{12}	44
0	8504	2186.59	5.67022	7.29×10^{-2}	7.56×10^{12}	39
0	9132	2334.88	5.31009	4.19×10^{-1}	4.95×10^{13}	127
0	9147	2336.94	5.30542	1.21	7.19×10^{13}	430
0	9224	2349.15	5.27782	3.25×10^{-1}	3.89×10^{13}	84
0	9253	2354.36	5.26615	2.50×10^{-1}	1.51×10^{13}	41
0	11806	2716.89	4.56346	4.68×10^{-1}	7.49×10^{13}	250
0	11808	2718.08	4.56146	1.06	8.51×10^{13}	688
0	12028	2777.86	4.46330	5.26×10^{-1}	8.81×10^{13}	255
0	12033	2781.22	4.45791	1.22	1.02×10^{14}	723
0	12038	2786.03	4.45022	1.14×10^{-1}	1.92×10^{13}	43
0	18686	3062.11	4.04898	5.31×10^{-1}	5.40×10^{13}	315
0	18687	3062.22	4.04883	2.60×10^{-1}	5.29×10^{13}	140
0	14464	3088.74	4.01407	2.21×10^{-1}	4.57×10^{13}	46
0	14473	3089.75	4.01276	4.93×10^{-1}	5.10×10^{13}	115
0	18884	3124.81	3.96773	2.28×10^{-1}	4.84×10^{13}	110
0	18894	3126.72	3.96531	4.27×10^{-1}	4.53×10^{13}	213

Table 13
Radiative transitions in Zn-like tungsten, W^{44+}.

i	k	ΔE (eV)	λ (Å)	gf	A (s^{-1})	ϵ (γ/ion/s)
2	11476	1024.48	12.1022	3.80×10^{-1}	3.46×10^{12}	269
0	11470	1041.05	11.9096	1.25×10^{-1}	1.96×10^{12}	181
11	11715	1189.34	10.4246	5.96×10^{-1}	5.23×10^{12}	131
9	11713	1210.76	10.2402	6.52×10^{-1}	5.93×10^{12}	63
5	11699	1219.16	10.1696	5.24×10^{-2}	3.38×10^{12}	250
5	11708	1315.78	9.42287	2.21×10^{-1}	3.33×10^{12}	110
0	11703	1473.71	8.41306	6.71×10^{-2}	2.11×10^{12}	72
7	98	1493.47	8.30173	4.70×10^{-4}	6.49×10^{9}	146
5	91	1516.69	8.17467	1.50×10^{-4}	2.99×10^{9}	71
5	93	1519.53	8.15939	1.21×10^{-4}	1.74×10^{9}	62
2	84	1525.51	8.12741	8.79×10^{-5}	1.78×10^{9}	78
2	85	1526.49	8.12218	3.10×10^{-4}	4.47×10^{9}	391
3	90	1532.22	8.09181	4.09×10^{-4}	4.63×10^{9}	297
1	84	1532.57	8.08997	1.36×10^{-4}	2.78×10^{9}	122
3	93	1537.06	8.06631	1.97×10^{-4}	2.89×10^{9}	104
5	98	1582.18	7.83630	1.73×10^{-4}	2.69×10^{9}	60
2	86	1591.43	7.79072	1.29×10^{-4}	2.84×10^{9}	122
1	86	1598.50	7.75630	8.99×10^{-5}	1.99×10^{9}	85
3	118	1683.44	7.36494	1.49×10^{-1}	2.61×10^{12}	61
0	87	1688.07	7.34473	1.36×10^{-1}	5.59×10^{12}	1865
3	124	1692.63	7.32493	5.68×10^{-2}	1.41×10^{12}	61
3	125	1692.75	7.32445	1.83×10^{-1}	3.25×10^{12}	61
3	126	1693.48	7.32126	1.61×10^{-1}	4.00×10^{12}	61
5	139	1702.07	7.28432	2.46×10^{-2}	3.10×10^{12}	152
3	133	1706.51	7.26536	1.04×10^{-2}	4.39×10^{11}	62
3	136	1710.05	7.25034	6.63×10^{-2}	1.20×10^{12}	62
3	138	1711.60	7.24376	5.52×10^{-2}	1.40×10^{12}	173
2	105	1718.77	7.21355	9.17×10^{-2}	2.35×10^{12}	71
0	92	1722.01	7.19996	2.30×10^{-1}	9.85×10^{12}	1492
3	144	1731.03	7.16246	2.28×10^{-1}	5.93×10^{12}	65
13	392	1736.67	7.13918	1.08×10^{-1}	4.73×10^{12}	81
5	191	1782.22	6.95674	8.21×10^{-4}	1.13×10^{11}	130
0	97	1785.84	6.94261	2.68×10^{-2}	1.24×10^{12}	703
5	214	1797.42	6.89789	3.31×10^{-3}	4.63×10^{11}	178
2	191	1892.73	6.55054	1.38×10^{-3}	2.15×10^{11}	247
25	2224	1978.81	6.26561	1.35×10^{-1}	4.57×10^{12}	98
11	1098	1981.74	6.25633	2.48×10^{-1}	1.41×10^{13}	146
22	2159	1981.77	6.25623	1.62×10^{-1}	5.51×10^{12}	62
2	298	1983.51	6.25074	4.25×10^{-1}	1.45×10^{13}	160
21	2159	1986.14	6.24247	1.90×10^{-1}	6.50×10^{12}	73
9	1021	1987.21	6.23910	5.58×10^{-1}	1.37×10^{13}	77
21	2224	1992.97	6.22109	1.09×10^{-1}	3.75×10^{12}	80
5	544	1996.40	6.21038	1.32×10^{-1}	2.28×10^{13}	1667
11488	13911	1996.87	6.20892	3.22×10^{-1}	1.12×10^{13}	88
0	292	2075.15	5.97472	3.05×10^{-1}	1.90×10^{13}	649
0	303	2082.57	5.95341	7.74×10^{-1}	4.86×10^{13}	1844
0	308	2085.35	5.94549	1.86×10^{-1}	1.17×10^{13}	390
0	327	2090.99	5.92946	5.43×10^{-2}	3.43×10^{12}	62
0	344	2103.23	5.89495	2.15×10^{-1}	1.38×10^{13}	403
0	365	2124.57	5.83574	1.69×10^{-1}	1.10×10^{13}	309
0	392	2139.87	5.79400	1.16×10^{-1}	7.70×10^{12}	132
0	394	2141.32	5.79009	1.57	1.04×10^{14}	3431
0	414	2150.58	5.76514	6.36×10^{-1}	4.25×10^{13}	1374
0	418	2151.04	5.76392	1.38×10^{-1}	9.26×10^{12}	269
1	630	2153.92	5.75621	1.57	1.05×10^{14}	58
0	448	2158.98	5.74273	2.69	1.81×10^{14}	5787
0	484	2171.12	5.71060	4.59×10^{-2}	3.13×10^{12}	65
0	489	2172.86	5.70603	4.33×10^{-2}	2.96×10^{12}	64
0	508	2178.77	5.69056	1.61×10^{-1}	1.11×10^{13}	283
0	535	2192.47	5.65501	2.93×10^{-1}	2.04×10^{13}	496
0	555	2204.63	5.62381	6.68×10^{-2}	4.70×10^{12}	79
5	2224	2328.60	5.32441	1.81×10^{-1}	8.52×10^{12}	182
0	1098	2353.47	5.26816	8.25×10^{-1}	6.61×10^{13}	686
16	4806	2355.41	5.26381	3.80×10^{-1}	1.83×10^{13}	70
0	1189	2370.77	5.22970	2.12×10^{-1}	1.73×10^{13}	80
0	2945	2624.83	4.72352	4.24×10^{-1}	4.22×10^{13}	80
0	12148	2748.78	4.51052	1.58×10^{-1}	1.72×10^{13}	169
0	12154	2750.19	4.50821	5.15×10^{-1}	5.63×10^{13}	590
0	12276	2811.57	4.40978	7.87×10^{-1}	9.00×10^{13}	908

(*continued on next page*)

Table 13 (*continued*)

i	k	ΔE (eV)	λ (Å)	gf	A (s^{-1})	ϵ (γ/ion/s)
0	12289	2819.19	4.39787	1.98×10^{-1}	2.28×10^{13}	157
0	15691	3107.86	3.98937	4.10×10^{-1}	5.73×10^{13}	476
0	13626	3121.26	3.97225	3.40×10^{-1}	4.79×10^{13}	152
0	15817	3171.04	3.90989	3.69×10^{-1}	5.37×10^{13}	401
0	17820	3517.26	3.52502	1.79×10^{-1}	3.21×10^{13}	61

Table 14
Radiative transitions in Cu-like tungsten, W^{45+}.

i	k	ΔE (eV)	λ (Å)	gf	A (s^{-1})	ϵ (γ/ion/s)
6	7	1010.01	12.2756	7.81×10^{-5}	5.76×10^{8}	206
0	1302	1016.17	12.2011	2.05×10^{-1}	4.60×10^{12}	247
1	1304	1037.82	11.9466	3.04×10^{-1}	3.55×10^{12}	179
0	1303	1063.73	11.6556	1.88×10^{-1}	2.31×10^{12}	241
4	1316	1218.18	10.1778	8.90×10^{-1}	7.16×10^{12}	80
3	1315	1237.76	10.0169	6.02×10^{-1}	6.67×10^{12}	66
2	1310	1250.77	9.91261	9.85×10^{-2}	3.34×10^{12}	114
2	1314	1349.55	9.18709	3.11×10^{-1}	4.10×10^{12}	67
1	8	1516.36	8.17645	2.64×10^{-4}	6.58×10^{9}	416
1	9	1534.54	8.07957	7.10×10^{-5}	1.21×10^{9}	294
2	18	1537.86	8.06211	1.77×10^{-4}	3.03×10^{9}	54
2	20	1538.63	8.05809	1.78×10^{-4}	2.28×10^{9}	104
1	11	1541.98	8.04059	2.39×10^{-4}	4.11×10^{9}	67
0	7	1547.67	8.01105	2.79×10^{-4}	4.82×10^{9}	1726
2	28	1602.77	7.73562	2.97×10^{-4}	4.14×10^{9}	205
1	14	1608.27	7.70917	2.27×10^{-4}	4.25×10^{9}	57
0	8	1613.95	7.68204	1.78×10^{-4}	5.02×10^{9}	318
0	13	1698.73	7.29865	2.57×10^{-2}	8.04×10^{11}	379
0	15	1707.30	7.26201	1.63×10^{-1}	5.14×10^{12}	1427
0	16	1708.40	7.25733	8.61×10^{-2}	5.45×10^{12}	857
2	56	1710.85	7.24693	1.92×10^{-1}	4.06×10^{12}	74
2	57	1711.76	7.24308	1.14×10^{-1}	3.62×10^{12}	64
4	145	1712.40	7.24040	2.67×10^{-2}	4.25×10^{11}	91
2	58	1712.48	7.24004	7.42×10^{-2}	2.36×10^{12}	103
2	64	1721.93	7.20030	4.82×10^{-2}	1.03×10^{12}	75
2	65	1721.94	7.20025	2.08×10^{-2}	6.69×10^{11}	76
2	67	1733.73	7.15132	1.64×10^{-2}	1.07×10^{12}	267
0	19	1736.99	7.13786	1.24×10^{-1}	4.07×10^{12}	513
0	21	1738.13	7.13320	1.54×10^{-1}	1.01×10^{13}	517
4	174	1738.26	7.13264	1.28×10^{-1}	4.19×10^{12}	82
3	158	1745.43	7.10337	8.60×10^{-2}	2.84×10^{12}	71
0	24	1752.57	7.07443	2.09×10^{-1}	6.97×10^{12}	740
3	168	1753.17	7.07200	1.57×10^{-1}	5.22×10^{12}	100
0	26	1797.62	6.89715	5.14×10^{-3}	3.61×10^{11}	179
0	27	1801.43	6.88255	2.88×10^{-2}	1.01×10^{12}	302
2	97	1803.82	6.87342	4.62×10^{-3}	3.26×10^{11}	410
0	31	1817.19	6.82285	2.32×10^{-2}	1.66×10^{12}	229
2	111	1818.42	6.81824	1.71×10^{-2}	1.23×10^{12}	353
1	97	1905.14	6.50789	6.53×10^{-4}	5.14×10^{10}	65
2	251	1993.28	6.22012	3.00×10^{-1}	8.63×10^{12}	63
1	159	1997.50	6.20698	3.87×10^{-1}	1.67×10^{13}	68
2	256	1998.07	6.20520	2.20×10^{-1}	1.91×10^{13}	166
4	437	1999.00	6.20233	4.14×10^{-1}	1.79×10^{13}	136
0	96	2002.59	6.19121	3.53×10^{-1}	1.54×10^{13}	396
6	662	2003.65	6.18792	5.15×10^{-1}	1.50×10^{13}	423
5	663	2009.24	6.17072	6.76×10^{-2}	2.96×10^{12}	152
1307	1954	2010.87	6.16571	4.72×10^{-1}	1.38×10^{13}	75
2	264	2023.50	6.12723	6.11×10^{-2}	5.42×10^{12}	1232
0	151	2089.44	5.93386	5.08×10^{-2}	4.81×10^{12}	54
0	152	2090.51	5.93081	1.16×10^{-1}	5.49×10^{12}	124
0	158	2094.94	5.91827	1.58	7.52×10^{13}	1876
0	163	2097.71	5.91045	1.04	9.97×10^{13}	1293
0	168	2102.68	5.89647	3.86×10^{-1}	1.85×10^{13}	354
0	174	2109.31	5.87795	4.05×10^{-1}	1.96×10^{13}	385
0	190	2137.04	5.80167	1.35×10^{-1}	6.67×10^{12}	130
0	205	2155.20	5.75278	7.73×10^{-1}	3.90×10^{13}	871
0	206	2155.72	5.75140	1.86×10^{-1}	1.87×10^{13}	199
0	209	2158.35	5.74441	1.55	7.85×10^{13}	1743
0	218	2168.60	5.71725	3.78	3.86×10^{14}	4236
0	222	2169.76	5.71418	4.65	2.38×10^{14}	5242
0	238	2178.58	5.69107	1.40×10^{-1}	7.20×10^{12}	136
0	248	2188.43	5.66545	1.63×10^{-1}	8.47×10^{12}	141
0	262	2209.85	5.61053	3.87×10^{-1}	2.05×10^{13}	353
1	454	2316.72	5.35171	2.97×10^{-2}	3.46×10^{12}	315
2	662	2342.40	5.29305	1.99×10^{-1}	7.90×10^{12}	224
2	663	2342.56	5.29268	2.21×10^{-2}	1.31×10^{12}	67
0	417	2351.40	5.27279	1.85×10^{-1}	2.21×10^{13}	69
0	437	2370.04	5.23131	1.34	8.14×10^{13}	617
0	441	2373.80	5.22303	5.38×10^{-1}	6.58×10^{13}	306

(continued on next page)

Table 14 (*continued*)

i	k	ΔE (eV)	λ (Å)	gf	A (s^{-1})	ϵ (γ/ion/s)
0	442	2375.32	5.21968	2.14×10^{-1}	1.31×10^{13}	97
2	907	2634.26	4.70660	2.47×10^{-1}	1.24×10^{13}	71
2	909	2636.48	4.70264	3.78×10^{-1}	1.90×10^{13}	62
0	773	2638.29	4.69942	5.36×10^{-1}	4.05×10^{13}	178
0	781	2662.95	4.65589	1.71×10^{-1}	1.32×10^{13}	53
0	1448	2780.50	4.45906	5.10×10^{-1}	8.55×10^{13}	360
0	1451	2783.11	4.45488	1.11	9.30×10^{13}	801
0	1542	2843.41	4.36040	6.17×10^{-1}	1.08×10^{14}	455
0	1543	2844.69	4.35844	1.37	1.20×10^{14}	928
0	1912	3150.21	3.93575	2.41×10^{-1}	5.19×10^{13}	74
0	2460	3150.67	3.93517	2.71×10^{-1}	5.83×10^{13}	181
0	2461	3151.94	3.93359	5.38×10^{-1}	5.80×10^{13}	347
0	1917	3154.74	3.93010	3.94×10^{-1}	4.26×10^{13}	89
0	2582	3214.74	3.85674	4.87×10^{-1}	5.46×10^{13}	288
0	2583	3215.02	3.85641	2.52×10^{-1}	5.65×10^{13}	165

Table 15
Radiative transitions in Ni-like tungsten, W^{46+}.

i	k	ΔE (eV)	λ (Å)	gf	A (s^{-1})	ϵ (γ/ion/s)
8	141	1071.37	11.5725	7.70×10^{-2}	3.84×10^{12}	231
0	1	1562.15	7.93677	6.05×10^{-10}	9.15×10^{3}	532
0	2	1564.07	7.92700	2.76×10^{-4}	5.86×10^{9}	4686
0	4	1629.99	7.60645	1.93×10^{-4}	4.46×10^{9}	1359
0	8	1728.69	7.17216	1.43×10^{-1}	6.17×10^{12}	4204
0	11	1764.83	7.02527	2.58×10^{-1}	1.16×10^{13}	3574
0	14	1829.45	6.77713	2.66×10^{-2}	1.29×10^{12}	570
0	35	2017.40	6.14576	3.58×10^{-1}	2.11×10^{13}	1722
0	50	2112.57	5.86887	1.98	1.28×10^{14}	5149
0	58	2181.36	5.68380	5.89	4.05×10^{14}	13257
0	71	2386.03	5.19627	1.16	9.52×10^{13}	1748
0	84	2554.73	4.85313	9.61×10^{-3}	5.44×10^{11}	348
0	87	2655.04	4.66977	4.28×10^{-1}	4.37×10^{13}	335
0	90	2678.60	4.62870	1.62×10^{-1}	1.68×10^{13}	171
0	94	2765.65	4.48301	1.31×10^{-1}	1.44×10^{13}	133
0	152	2814.90	4.40456	8.91×10^{-1}	1.02×10^{14}	1469
0	172	2877.30	4.30905	1.11	1.33×10^{14}	1769
0	195	3183.88	3.89412	4.18×10^{-1}	6.13×10^{13}	303
0	286	3195.47	3.88000	4.11×10^{-1}	6.07×10^{13}	571
0	326	3258.94	3.80444	3.80×10^{-1}	5.84×10^{13}	502

Table 16
Radiative transitions in Co-like tungsten, W^{47+}.

i	k	ΔE (eV)	λ (Å)	gf	A (s^{-1})	ϵ (γ/ion/s)
38	854	1000.60	12.3910	3.85×10^{-1}	2.79×10^{12}	66
32	902	1095.64	11.3162	2.96×10^{-1}	2.57×10^{12}	112
0	5	1604.91	7.72530	6.99×10^{-5}	7.81×10^{8}	1165
1	11	1604.92	7.72524	2.67×10^{-4}	4.97×10^{9}	93
0	6	1608.03	7.71034	8.31×10^{-4}	1.17×10^{10}	815
1	12	1613.55	7.68392	1.07×10^{-4}	2.01×10^{9}	65
0	7	1614.52	7.67931	1.95×10^{-4}	3.67×10^{9}	696
0	8	1615.99	7.67234	3.17×10^{-4}	8.99×10^{9}	343
2	126	1618.19	7.66190	7.08×10^{-3}	1.34×10^{11}	227
1	14	1618.70	7.65949	9.41×10^{-5}	2.68×10^{9}	68
1	16	1619.74	7.65457	4.96×10^{-4}	7.05×10^{9}	304
0	9	1634.29	7.58644	1.07×10^{-4}	6.20×10^{9}	118
0	10	1670.95	7.41999	2.87×10^{-4}	4.35×10^{9}	280
0	12	1680.32	7.37860	1.79×10^{-4}	3.65×10^{9}	118
0	14	1685.47	7.35606	1.37×10^{-4}	4.22×10^{9}	108
0	15	1685.90	7.35419	4.52×10^{-4}	5.58×10^{9}	589
0	18	1700.37	7.29159	1.55×10^{-3}	2.44×10^{10}	129
0	25	1766.52	7.01854	3.51×10^{-2}	5.94×10^{11}	341
0	26	1767.01	7.01661	1.24×10^{-1}	2.79×10^{12}	670
0	28	1775.37	6.98359	3.41×10^{-2}	1.16×10^{12}	210
0	29	1776.99	6.97719	1.70×10^{-1}	3.87×10^{12}	711
0	32	1783.01	6.95366	3.99×10^{-1}	6.89×10^{12}	1756
0	33	1783.09	6.95333	1.66×10^{-1}	5.72×10^{12}	689
2	234	1791.91	6.91913	2.14×10^{-1}	4.98×10^{12}	94
2	239	1802.95	6.87675	3.10×10^{-1}	7.29×10^{12}	226
1	47	1806.38	6.86367	4.30×10^{-2}	1.01×10^{12}	66
1	49	1808.28	6.85647	1.85×10^{-1}	6.54×10^{12}	69
0	36	1810.14	6.84944	3.44×10^{-1}	6.11×10^{12}	1089
0	37	1810.53	6.84797	3.20×10^{-1}	7.59×10^{12}	623
1	50	1814.51	6.83294	4.35×10^{-2}	1.04×10^{12}	81
0	38	1816.45	6.82562	3.24×10^{-1}	7.73×10^{12}	779
1	52	1817.49	6.82172	1.99×10^{-1}	7.14×10^{12}	83
0	39	1818.92	6.81637	1.37×10^{-2}	2.46×10^{11}	160
0	41	1820.29	6.81122	2.84×10^{-1}	1.02×10^{13}	596
1	55	1820.44	6.81068	4.21×10^{-1}	1.01×10^{13}	116
0	42	1837.84	6.74619	4.04×10^{-2}	1.48×10^{12}	256
0	48	1874.33	6.61487	3.26×10^{-2}	6.22×10^{11}	105
0	58	1890.35	6.55879	3.17×10^{-2}	6.14×10^{11}	110
0	102	2038.31	6.08268	8.44×10^{-1}	1.90×10^{13}	422
0	109	2045.37	6.06169	2.22×10^{-1}	6.71×10^{12}	176
0	110	2046.83	6.05739	1.79×10^{-1}	8.13×10^{12}	92
0	124	2060.79	6.01635	1.77×10^{-1}	4.07×10^{12}	153
0	125	2064.34	6.00599	4.75×10^{-1}	1.46×10^{13}	270
0	128	2072.70	5.98177	3.13×10^{-1}	1.46×10^{13}	337
0	155	2131.08	5.81789	6.75×10^{-2}	2.22×10^{12}	77
0	160	2133.61	5.81099	4.94×10^{-2}	1.22×10^{12}	89
2	387	2133.66	5.81087	2.23×10^{-1}	2.20×10^{13}	77
2	388	2134.93	5.80741	5.41×10^{-1}	1.78×10^{13}	150
0	161	2135.59	5.80561	1.15×10^{-1}	5.70×10^{12}	78
2	389	2135.86	5.80488	5.21×10^{-1}	2.58×10^{13}	156
0	164	2137.72	5.79984	4.76×10^{-2}	1.18×10^{12}	162
0	170	2143.49	5.78421	1.35×10^{-1}	4.48×10^{12}	146
0	172	2145.12	5.77983	1.52	7.60×10^{13}	672
2	400	2149.73	5.76742	3.04×10^{-1}	1.01×10^{13}	69
0	174	2153.51	5.75732	2.58	8.65×10^{13}	1134
1	222	2153.99	5.75602	4.13×10^{-1}	2.08×10^{13}	144
2	406	2155.12	5.75301	1.98×10^{-1}	6.66×10^{12}	68
0	175	2155.44	5.75216	4.32	1.09×10^{14}	1891
0	178	2158.00	5.74533	9.14×10^{-1}	3.08×10^{13}	431
1	227	2158.19	5.74482	2.72	9.16×10^{13}	536
1	229	2161.68	5.73555	9.99×10^{-1}	3.38×10^{13}	328
1	230	2163.76	5.73003	2.74	1.39×10^{14}	298
0	179	2164.29	5.72863	7.59×10^{-1}	1.93×10^{13}	403
0	186	2192.77	5.65422	2.01×10^{-1}	6.99×10^{12}	115
0	187	2194.77	5.64908	2.15×10^{-1}	5.62×10^{12}	143
0	200	2205.23	5.62229	4.68×10^{-2}	1.23×10^{12}	66
0	205	2208.72	5.61341	2.22×10^{-1}	5.88×10^{12}	143
0	206	2209.11	5.61241	1.14×10^{-1}	4.03×10^{12}	62
0	207	2209.11	5.61240	2.93×10^{-1}	7.77×10^{12}	175

(continued on next page)

Table 16 (*continued*)

i	k	ΔE (eV)	λ (Å)	gf	A (s^{-1})	ϵ (γ/ion/s)
0	222	2220.76	5.58296	4.91	2.63×10^{14}	1818
0	227	2224.96	5.57242	2.87	1.03×10^{14}	602
0	228	2227.47	5.56616	1.57×10^{-1}	4.23×10^{14}	6121
0	229	2228.45	5.56370	7.77	2.79×10^{14}	2708
0	230	2230.53	5.55851	1.05	5.66×10^{13}	121
0	284	2404.66	5.15600	7.08×10^{-1}	2.96×10^{13}	181
0	286	2406.69	5.15165	8.92×10^{-1}	5.61×10^{13}	201
0	287	2407.23	5.15050	4.51×10^{-1}	1.89×10^{13}	111
0	291	2408.58	5.14761	4.64×10^{-1}	1.46×10^{13}	150
0	295	2415.31	5.13326	1.08	3.40×10^{13}	275
0	302	2422.26	5.11854	6.19×10^{-1}	3.94×10^{13}	133
0	306	2432.48	5.09704	1.20	5.12×10^{13}	265
0	307	2433.22	5.09548	1.36	4.36×10^{13}	331
0	309	2442.98	5.07512	2.72×10^{-1}	8.82×10^{12}	107
0	452	2690.03	4.60903	1.03	4.06×10^{13}	145
0	457	2699.76	4.59241	5.89×10^{-1}	4.65×10^{13}	85
0	467	2724.75	4.55030	4.72×10^{-1}	2.53×10^{13}	74
0	905	2880.94	4.30360	3.25×10^{-1}	2.92×10^{13}	78
0	907	2881.09	4.30338	3.13×10^{-1}	1.88×10^{13}	70
0	919	2886.98	4.29460	9.97×10^{-1}	6.01×10^{13}	276
0	920	2888.54	4.29228	1.67	7.54×10^{13}	478
0	980	2947.75	4.20606	4.40×10^{-1}	2.07×10^{13}	89
0	994	2954.00	4.19717	1.05	9.89×10^{13}	286
0	998	2955.28	4.19535	1.79	8.46×10^{13}	490
0	1000	2955.51	4.19502	1.34	8.48×10^{13}	368
0	1956	3286.18	3.77290	6.83×10^{-1}	4.00×10^{13}	159
0	2093	3353.76	3.69687	3.66×10^{-1}	4.46×10^{13}	81
0	2095	3354.44	3.69612	4.93×10^{-1}	3.01×10^{13}	102
0	2096	3354.47	3.69609	3.73×10^{-1}	3.03×10^{13}	77

Table 17
Radiative transitions in Fe-like tungsten, W^{48+}.

i	k	ΔE (eV)	λ (Å)	gf	A (s^{-1})	ϵ (γ/ion/s)
1	36	1650.93	7.50998	3.22×10^{-4}	4.23×10^{9}	88
2	40	1651.21	7.50869	1.99×10^{-4}	4.70×10^{9}	42
0	35	1656.20	7.48607	2.74×10^{-4}	2.96×10^{9}	638
6	49	1657.14	7.48182	9.74×10^{-5}	8.93×10^{8}	37
6	52	1659.05	7.47319	9.75×10^{-4}	1.06×10^{10}	127
0	36	1659.87	7.46949	9.50×10^{-4}	1.26×10^{10}	264
1	37	1661.41	7.46259	1.21×10^{-4}	2.91×10^{9}	58
11	285	1661.79	7.46088	2.07×10^{-2}	2.76×10^{11}	242
1	38	1662.81	7.45632	3.20×10^{-4}	1.28×10^{10}	102
0	37	1670.36	7.42261	1.89×10^{-4}	4.58×10^{9}	91
1	40	1670.63	7.42141	2.47×10^{-4}	5.98×10^{9}	54
0	39	1677.40	7.39146	3.27×10^{-4}	5.70×10^{9}	219
10	299	1687.70	7.34634	9.62×10^{-3}	2.38×10^{11}	69
9	285	1688.03	7.34491	1.04×10^{-2}	1.43×10^{11}	125
3	64	1707.06	7.26302	7.58×10^{-4}	1.37×10^{10}	36
0	41	1722.08	7.19968	1.68×10^{-4}	2.40×10^{9}	48
0	43	1729.06	7.17061	3.99×10^{-4}	4.70×10^{9}	133
0	49	1737.36	7.13636	6.06×10^{-4}	6.11×10^{9}	253
0	57	1750.51	7.08275	1.99×10^{-3}	2.94×10^{10}	93
0	58	1752.32	7.07544	7.75×10^{-4}	9.39×10^{9}	68
1	63	1762.29	7.03542	1.89×10^{-3}	5.09×10^{10}	47
1	75	1807.69	6.85871	4.11×10^{-2}	8.33×10^{11}	80
0	75	1816.64	6.82493	5.55×10^{-2}	1.13×10^{12}	109
0	76	1817.39	6.82211	4.54×10^{-2}	7.23×10^{11}	175
1	79	1818.18	6.81913	2.38×10^{-2}	6.84×10^{11}	50
1	81	1818.71	6.81715	1.84×10^{-2}	5.30×10^{11}	42
1	86	1823.83	6.79801	1.17×10^{-1}	5.65×10^{12}	101
0	77	1824.04	6.79725	3.67×10^{-2}	4.82×10^{11}	217
0	78	1824.72	6.79469	3.29×10^{-1}	5.28×10^{12}	520
1	90	1831.11	6.77097	1.55×10^{-1}	3.23×10^{12}	219
0	83	1831.66	6.76896	2.45×10^{-1}	5.09×10^{12}	349
0	87	1833.51	6.76213	5.91×10^{-1}	7.83×10^{12}	955
1	91	1835.60	6.75442	1.68×10^{-1}	3.52×10^{12}	200
1	92	1836.48	6.75118	2.01×10^{-1}	5.90×10^{12}	208
2	97	1836.72	6.75029	1.35×10^{-1}	6.57×10^{12}	130
0	89	1839.18	6.74129	6.77×10^{-2}	1.10×10^{12}	200
0	90	1840.06	6.73804	2.58×10^{-2}	5.41×10^{11}	37
11	605	1848.66	6.70669	3.35×10^{-1}	5.52×10^{12}	227
1	95	1853.07	6.69075	1.94×10^{-2}	5.78×10^{11}	64
1	96	1855.73	6.68114	2.31×10^{-1}	4.92×10^{12}	160
10	602	1857.54	6.67463	2.11×10^{-1}	6.33×10^{12}	35
9	584	1858.23	6.67216	4.32×10^{-1}	7.19×10^{12}	95
2	108	1859.44	6.66783	1.67×10^{-1}	8.33×10^{12}	100
9	590	1860.77	6.66307	2.62×10^{-1}	4.37×10^{12}	48
0	94	1860.87	6.66269	1.87×10^{-1}	2.55×10^{12}	520
6	137	1862.65	6.65635	4.94×10^{-1}	8.26×10^{12}	40
6	140	1863.54	6.65317	3.82×10^{-1}	5.23×10^{12}	82
3	123	1864.15	6.65098	3.33×10^{-1}	7.17×10^{12}	36
0	96	1864.68	6.64908	1.18×10^{-1}	2.55×10^{12}	83
0	98	1865.13	6.64747	6.91×10^{-1}	1.16×10^{13}	532
1	101	1865.86	6.64489	1.84×10^{-1}	5.55×10^{12}	138
4	136	1867.33	6.63964	1.33×10^{-1}	2.88×10^{12}	46
3	126	1868.67	6.63488	2.82×10^{-1}	4.74×10^{12}	45
6	144	1869.36	6.63245	3.75×10^{-1}	6.32×10^{12}	43
1	104	1869.70	6.63123	2.84×10^{-1}	1.44×10^{13}	129
6	146	1870.48	6.62848	4.14×10^{-2}	5.72×10^{11}	43
11	650	1872.80	6.62027	1.98×10^{-2}	3.34×10^{11}	103
1	106	1873.75	6.61691	6.53×10^{-2}	1.99×10^{12}	112
0	102	1874.92	6.61277	3.44×10^{-1}	7.50×10^{12}	343
1	107	1875.42	6.61102	5.12×10^{-2}	1.12×10^{12}	75
0	105	1881.85	6.58841	4.83×10^{-2}	8.24×10^{11}	210
0	107	1884.37	6.57963	1.43×10^{-1}	3.14×10^{12}	212
0	127	1934.49	6.40913	4.09×10^{-2}	6.04×10^{11}	41
0	131	1938.04	6.39739	2.56×10^{-2}	4.63×10^{11}	36
0	212	2069.92	5.98982	1.11	1.87×10^{13}	265
1	229	2071.81	5.98433	2.89×10^{-1}	1.08×10^{13}	42
1	234	2073.71	5.97886	5.73×10^{-1}	1.53×10^{13}	90
0	222	2078.57	5.96489	1.51×10^{-1}	4.05×10^{12}	55
0	224	2078.76	5.96435	1.13×10^{-1}	2.35×10^{12}	55

(continued on next page)

Table 17 (*continued*)

i	k	ΔE (eV)	λ (Å)	gf	A (s^{-1})	ϵ (γ/ion/s)
0	237	2086.11	5.94332	3.00×10^{-1}	5.14×10^{12}	100
0	242	2090.13	5.93188	6.11×10^{-1}	1.29×10^{13}	135
1	287	2106.66	5.88535	2.23×10^{-1}	6.13×10^{12}	46
0	279	2112.04	5.87035	3.31×10^{-1}	7.12×10^{12}	106
0	288	2116.21	5.85879	5.93×10^{-1}	1.65×10^{13}	202
1	390	2173.23	5.70508	2.12×10^{-1}	8.69×10^{12}	51
10	1133	2176.42	5.69670	5.71×10^{-1}	2.35×10^{13}	35
10	1135	2176.62	5.69619	4.89×10^{-1}	1.43×10^{13}	42
9	1109	2179.83	5.68779	1.33	3.92×10^{13}	39
9	1115	2180.76	5.68536	7.71×10^{-1}	1.45×10^{13}	107
0	387	2181.32	5.68390	1.22×10^{-1}	2.80×10^{12}	49
0	394	2183.92	5.67713	7.84×10^{-1}	2.32×10^{13}	176
0	396	2184.07	5.67675	5.58×10^{-1}	1.65×10^{13}	134
9	1129	2184.29	5.67619	8.36×10^{-1}	1.92×10^{13}	82
0	398	2185.24	5.67371	3.81×10^{-1}	7.17×10^{12}	177
1	415	2186.10	5.67149	8.59×10^{-1}	5.94×10^{13}	127
6	552	2188.84	5.66437	3.11×10^{-1}	9.23×10^{12}	41
1	424	2190.44	5.66025	6.23×10^{-1}	2.59×10^{13}	100
0	400	2190.65	5.65970	4.43×10^{-1}	1.02×10^{13}	112
11	1201	2191.25	5.65815	7.96×10^{-1}	1.84×10^{13}	62
2	442	2191.33	5.65795	1.59	1.10×10^{14}	173
0	403	2191.80	5.65674	1.54×10^{-1}	4.59×10^{12}	37
0	405	2192.20	5.65571	1.19	2.75×10^{13}	280
0	413	2193.84	5.65147	1.17×10^{-1}	2.23×10^{12}	72
1	426	2194.71	5.64922	1.06	4.41×10^{13}	145
1	427	2195.25	5.64784	1.22×10^{-1}	3.66×10^{12}	35
3	534	2197.49	5.64209	6.95×10^{-1}	2.08×10^{13}	66
0	420	2197.58	5.64186	1.38	3.21×10^{13}	295
0	422	2199.19	5.63773	2.80	5.35×10^{13}	596
3	541	2200.51	5.63435	7.23×10^{-1}	2.17×10^{13}	93
0	425	2201.09	5.63285	1.32	3.07×10^{13}	284
1	437	2201.14	5.63272	3.74	1.12×10^{14}	489
4	567	2201.32	5.63227	1.17	4.91×10^{13}	77
3	544	2201.54	5.63170	1.36	3.17×10^{13}	72
3	547	2203.00	5.62798	2.09	4.89×10^{13}	105
5	582	2203.77	5.62601	9.82×10^{-1}	6.90×10^{13}	48
3	552	2203.83	5.62586	9.76×10^{-1}	2.94×10^{13}	131
0	431	2206.09	5.62009	3.34	6.42×10^{13}	679
4	576	2206.39	5.61933	2.26	6.82×10^{13}	150
4	579	2207.71	5.61597	1.73	5.23×10^{13}	153
4	580	2208.05	5.61511	9.04×10^{-1}	3.82×10^{13}	35
3	563	2209.17	5.61224	2.03	4.79×10^{13}	237
3	576	2215.83	5.59539	8.47×10^{-1}	2.58×10^{13}	57
0	456	2239.15	5.53711	3.49×10^{-1}	6.90×10^{12}	100
0	478	2245.96	5.52032	9.87×10^{-2}	2.40×10^{12}	40
0	483	2247.49	5.51658	3.92×10^{-1}	7.81×10^{12}	117
0	489	2249.44	5.51179	1.30×10^{-1}	2.60×10^{12}	52
1	541	2256.79	5.49382	3.72×10^{-1}	1.17×10^{13}	51
1	552	2260.12	5.48575	4.84×10^{-1}	1.53×10^{13}	68
0	534	2262.72	5.47943	1.08	3.42×10^{13}	108
0	541	2265.74	5.47212	1.83	5.83×10^{13}	251
1	567	2267.04	5.46899	1.75	7.79×10^{13}	122
0	547	2268.23	5.46611	8.87×10^{-1}	2.20×10^{13}	47
0	548	2268.33	5.46588	1.53	3.11×10^{13}	290
0	552	2269.06	5.46411	5.11	1.63×10^{14}	726
1	573	2270.32	5.46109	3.02	2.25×10^{14}	335
0	553	2270.91	5.45967	8.99	2.23×10^{14}	1586
1	574	2271.20	5.45897	4.16	1.86×10^{14}	422
1	576	2272.11	5.45678	3.02	9.68×10^{13}	213
1	579	2273.43	5.45361	6.92	2.22×10^{14}	648
0	562	2274.11	5.45198	1.97×10	4.02×10^{14}	3503
0	563	2274.41	5.45127	4.16	1.04×10^{14}	513
2	606	2274.56	5.45092	4.27	3.19×10^{14}	403
1	582	2274.79	5.45037	9.73×10^{-1}	7.28×10^{13}	50
0	576	2281.06	5.43537	5.74×10^{-1}	1.85×10^{13}	41
1	597	2282.80	5.43123	1.72	5.57×10^{13}	197
0	792	2436.44	5.08875	6.17×10^{-1}	1.44×10^{13}	91
1	809	2437.53	5.08646	9.25	3.41×10^{13}	74
0	795	2438.61	5.08422	1.79	6.60×10^{13}	192
0	798	2441.03	5.07917	8.30×10^{-1}	2.39×10^{13}	96

(*continued on next page*)

Table 17 (*continued*)

i	k	ΔE (eV)	λ (Å)	gf	A (s^{-1})	ϵ (γ/ion/s)
0	807	2445.13	5.07067	4.26×10^{-1}	1.00×10^{13}	65
1	822	2446.20	5.06844	4.83×10^{-1}	2.51×10^{13}	38
0	820	2452.78	5.05484	1.04	3.02×10^{13}	109
1	837	2453.61	5.05314	6.39×10^{-1}	3.34×10^{13}	41
0	828	2457.15	5.04586	8.25×10^{-1}	2.40×10^{13}	82
0	830	2457.83	5.04446	1.08	2.57×10^{13}	117
0	831	2458.97	5.04213	4.55×10^{-1}	1.09×10^{13}	56
0	833	2460.06	5.03989	3.64×10^{-1}	1.36×10^{13}	38
1	849	2460.15	5.03969	6.36×10^{-1}	2.39×10^{13}	48
0	843	2465.70	5.02835	6.93×10^{-1}	2.61×10^{13}	65
1	871	2476.46	5.00650	8.72×10^{-1}	3.31×10^{13}	60
0	861	2480.62	4.99812	1.61	3.91×10^{13}	171
0	865	2481.66	4.99601	6.20×10^{-1}	1.84×10^{13}	60
0	869	2483.95	4.99141	2.33×10^{-1}	5.68×10^{12}	50
0	1427	2727.19	4.54623	1.27	3.72×10^{13}	84
0	1445	2742.89	4.52021	9.37×10^{-1}	4.37×10^{13}	62
0	1447	2745.40	4.51608	6.39×10^{-1}	2.32×10^{13}	39
0	1469	2758.97	4.49386	4.77×10^{-1}	1.43×10^{13}	38
0	1494	2770.22	4.47562	5.96×10^{-1}	2.21×10^{13}	42
0	1495	2770.66	4.47490	5.68×10^{-1}	1.72×10^{13}	38
2	2456	2951.61	4.20057	5.82×10^{-1}	7.34×10^{13}	42
0	2389	2954.75	4.19609	7.14×10^{-1}	2.46×10^{13}	77
0	2391	2955.73	4.19470	8.41×10^{-1}	3.54×10^{13}	98
0	2423	2964.98	4.18162	8.37×10^{-1}	2.90×10^{13}	89
1	2447	2965.76	4.18051	1.03	5.64×10^{13}	85
0	2444	2973.77	4.16926	1.19	4.15×10^{13}	138
0	2592	3029.75	4.09223	5.42×10^{-1}	2.40×10^{13}	40
0	2596	3030.65	4.09102	1.99	7.20×10^{13}	244
0	2597	3030.77	4.09085	1.00	4.44×10^{13}	110
0	2606	3031.91	4.08932	1.43	8.16×10^{13}	159
0	2611	3033.67	4.08694	7.04×10^{-1}	3.12×10^{13}	55
1	2633	3034.00	4.08649	9.78×10^{-1}	5.58×10^{13}	63
1	2634	3034.26	4.08614	8.42×10^{-1}	6.73×10^{13}	59
2	2696	3035.23	4.08484	7.89×10^{-1}	1.05×10^{14}	53
0	5368	3369.86	3.67921	4.91×10^{-1}	2.20×10^{13}	45
0	5369	3370.34	3.67868	5.51×10^{-1}	3.02×10^{13}	55
0	5426	3389.24	3.65817	4.93×10^{-1}	2.23×10^{13}	44
0	5654	3446.43	3.59747	5.03×10^{-1}	2.36×10^{13}	44
0	5659	3447.21	3.59665	5.84×10^{-1}	4.30×10^{13}	57

Table 18
Radiative transitions in Mn-like tungsten, W^{49+}.

i	k	ΔE (eV)	λ (Å)	gf	A (s^{-1})	ϵ (γ/ion/s)
236	5116	1045.64	11.8573	1.61	7.64×10^{12}	36
215	5237	1146.27	10.8163	6.80×10^{-1}	3.88×10^{12}	34
2	148	1696.91	7.30646	4.88×10^{-5}	6.09×10^{8}	29
2	149	1700.54	7.29087	4.11×10^{-4}	6.45×10^{9}	46
8	160	1707.36	7.26174	3.55×10^{-4}	3.21×10^{9}	63
8	161	1710.20	7.24971	1.15×10^{-3}	1.22×10^{10}	48
25	491	1710.47	7.24853	6.79×10^{-3}	8.62×10^{10}	36
25	494	1712.34	7.24064	1.40×10^{-2}	1.79×10^{11}	83
1	151	1714.83	7.23014	3.97×10^{-4}	1.27×10^{10}	43
4	159	1715.63	7.22676	3.13×10^{-4}	3.33×10^{9}	34
0	148	1716.44	7.22333	5.02×10^{-4}	6.41×10^{9}	307
0	149	1720.07	7.20809	7.85×10^{-4}	1.26×10^{10}	90
27	530	1722.99	7.19589	8.52×10^{-3}	1.83×10^{11}	41
2	152	1725.19	7.18668	2.15×10^{-4}	1.39×10^{10}	30
0	150	1725.21	7.18661	3.55×10^{-4}	7.64×10^{9}	81
26	530	1729.43	7.16906	9.75×10^{-3}	2.11×10^{11}	48
22	491	1735.72	7.14310	7.38×10^{-3}	9.65×10^{10}	41
22	494	1737.58	7.13544	1.24×10^{-2}	1.63×10^{11}	76
23	512	1738.18	7.13301	5.41×10^{-3}	1.77×10^{11}	25
20	512	1758.17	7.05187	6.81×10^{-3}	2.28×10^{11}	32
0	154	1780.54	6.96328	2.57×10^{-4}	3.53×10^{9}	31
0	159	1788.22	6.93338	3.10×10^{-4}	3.59×10^{9}	36
0	160	1788.41	6.93264	6.46×10^{-4}	6.41×10^{9}	127
2	179	1799.03	6.89172	8.44×10^{-4}	1.97×10^{10}	31
0	168	1809.32	6.85253	1.65×10^{-3}	2.93×10^{10}	53
0	169	1810.89	6.84659	2.23×10^{-3}	3.17×10^{10}	96
2	200	1852.74	6.69193	3.76×10^{-3}	7.00×10^{10}	33
2	205	1858.72	6.67040	2.47×10^{-2}	9.25×10^{11}	31
1	198	1858.86	6.66992	1.22×10^{-2}	3.05×10^{11}	23
1	204	1865.26	6.64703	2.60×10^{-2}	1.96×10^{12}	25
2	213	1869.51	6.63191	2.01×10^{-2}	5.09×10^{11}	38
0	202	1874.83	6.61311	6.93×10^{-2}	1.06×10^{12}	141
0	203	1876.13	6.60852	2.90×10^{-1}	5.53×10^{12}	235
1	216	1878.44	6.60037	1.30×10^{-1}	4.99×10^{12}	79
1	217	1879.45	6.59682	1.80×10^{-1}	4.61×10^{12}	125
0	206	1881.17	6.59080	5.70×10^{-2}	7.29×10^{11}	203
0	208	1883.03	6.58430	4.10×10^{-1}	6.31×10^{12}	374
25	1030	1883.96	6.58103	2.19×10^{-1}	3.37×10^{12}	81
0	210	1884.53	6.57904	6.34×10^{-1}	8.15×10^{12}	583
2	221	1885.86	6.57440	1.40×10^{-1}	2.71×10^{12}	135
1	218	1888.07	6.56671	2.52×10^{-2}	1.95×10^{12}	27
2	226	1888.79	6.56421	2.68×10^{-1}	5.19×10^{12}	268
2	227	1889.01	6.56345	1.46×10^{-1}	5.65×10^{12}	90
2	228	1889.78	6.56077	2.17×10^{-1}	5.60×10^{12}	152
0	215	1890.91	6.55686	6.89×10^{-2}	1.34×10^{12}	148
1	222	1893.23	6.54881	5.06×10^{-2}	3.94×10^{12}	38
1	223	1893.28	6.54865	6.47×10^{-2}	1.68×10^{12}	52
21	945	1895.99	6.53929	1.23×10^{-1}	1.92×10^{12}	27
1	227	1895.99	6.53927	5.60×10^{-2}	2.18×10^{12}	35
1	228	1896.77	6.53661	6.63×10^{-2}	1.73×10^{12}	47
19	926	1904.05	6.51160	2.10×10^{-1}	2.37×10^{12}	33
0	220	1904.52	6.51000	3.00×10^{-2}	4.72×10^{11}	115
10	287	1905.46	6.50678	1.83×10^{-1}	3.60×10^{12}	24
2	234	1906.74	6.50243	1.59×10^{-1}	3.14×10^{12}	72
2	235	1906.75	6.50238	6.33×10^{-2}	1.66×10^{12}	33
22	1028	1908.28	6.49717	1.50×10^{-1}	2.36×10^{12}	41
22	1030	1909.21	6.49401	2.66×10^{-1}	4.21×10^{12}	101
25	1099	1912.01	6.48448	1.44×10^{-1}	2.29×10^{12}	138
8	281	1912.50	6.48283	1.36×10^{-1}	1.54×10^{12}	51
26	1110	1912.61	6.48245	2.29×10^{-1}	6.07×10^{12}	49
1	235	1913.74	6.47864	1.66×10^{-1}	4.39×10^{12}	87
8	285	1914.86	6.47486	9.66×10^{-2}	1.10×10^{12}	39
2	238	1915.12	6.47398	2.43×10^{-1}	6.45×10^{12}	141
2	239	1916.23	6.47021	1.48×10^{-1}	5.90×10^{12}	55
9	294	1916.24	6.47019	1.81×10^{-1}	3.60×10^{12}	26
27	1162	1917.43	6.46616	1.11×10^{-1}	4.44×10^{12}	47
8	288	1918.29	6.46326	8.75×10^{-1}	1.16×10^{13}	66
19	986	1918.69	6.46192	4.05×10^{-1}	6.47×10^{12}	26
1	237	1918.85	6.46137	1.19×10^{-1}	9.47×10^{12}	47

(*continued on next page*)

Table 18 (*continued*)

i	k	ΔE (eV)	λ (Å)	gf	A (s^{-1})	ϵ (γ/ion/s)
4	282	1921.03	6.45405	1.58×10^{-1}	2.10×10^{12}	48
3	273	1921.54	6.45235	1.25×10^{-1}	2.00×10^{12}	24
4	284	1922.27	6.44989	5.09×10^{-1}	8.16×10^{12}	39
0	229	1922.48	6.44919	4.83×10^{-1}	7.74×10^{12}	382
0	230	1922.78	6.44819	4.93×10^{-2}	6.59×10^{11}	266
1	239	1923.22	6.44671	2.04×10^{-1}	8.17×10^{12}	76
8	297	1924.08	6.44381	2.17×10^{-1}	3.49×10^{12}	24
25	1159	1925.27	6.43983	3.03×10^{-1}	8.11×10^{12}	41
49	2418	1925.39	6.43944	2.00×10^{-1}	3.21×10^{12}	38
27	1201	1926.10	6.43705	1.39×10^{-2}	3.74×10^{11}	23
0	234	1926.27	6.43651	4.41×10^{-1}	8.88×10^{12}	203
4	292	1930.36	6.42286	4.09×10^{-1}	8.26×10^{12}	39
0	236	1931.06	6.42051	2.47×10^{-1}	5.00×10^{12}	277
2	252	1931.90	6.41774	1.29×10^{-1}	5.22×10^{12}	120
26	1201	1932.55	6.41557	1.72×10^{-2}	4.65×10^{11}	29
19	1044	1932.99	6.41413	2.55×10^{-1}	4.14×10^{12}	43
1	403	2107.57	5.88282	4.03×10^{-1}	1.29×10^{13}	40
0	391	2108.54	5.88009	1.06	1.71×10^{13}	168
2	426	2113.93	5.86511	7.59×10^{-1}	1.84×10^{13}	81
0	396	2115.30	5.86130	4.55×10^{-1}	7.37×10^{12}	113
0	397	2116.62	5.85764	1.88×10^{-1}	4.57×10^{12}	48
0	402	2119.84	5.84874	6.73×10^{-1}	1.31×10^{13}	105
1	425	2120.87	5.84591	2.61×10^{-1}	1.28×10^{13}	28
0	412	2128.23	5.82570	6.16×10^{-2}	1.21×10^{12}	25
2	469	2134.31	5.80910	3.78×10^{-1}	1.25×10^{13}	37
0	461	2151.00	5.76403	1.86×10^{-1}	4.66×10^{12}	33
0	462	2151.61	5.76239	4.56×10^{-1}	9.17×10^{12}	99
0	473	2154.78	5.75390	1.85×10^{-1}	4.65×10^{12}	26
2	511	2156.74	5.74868	2.01×10^{-1}	1.01×10^{13}	38
0	493	2162.92	5.73225	2.85×10^{-1}	7.24×10^{12}	74
25	2139	2183.76	5.67755	6.83×10^{-1}	2.36×10^{13}	58
22	2153	2211.99	5.60509	8.74×10^{-1}	1.55×10^{13}	58
22	2182	2217.06	5.59228	1.30	3.46×10^{13}	50
22	2184	2217.45	5.59131	1.85	3.94×10^{13}	88
0	616	2220.22	5.58432	3.42×10^{-2}	7.31×10^{11}	23
2	707	2222.93	5.57750	5.07×10^{-1}	2.72×10^{13}	61
0	625	2223.48	5.57613	1.99×10^{-1}	5.33×10^{12}	41
19	2112	2223.71	5.57557	2.32×10^{-2}	3.55×10^{11}	34
2	724	2227.18	5.56687	4.19×10^{-1}	1.50×10^{13}	25
2	725	2227.40	5.56633	8.38×10^{-1}	3.01×10^{13}	86
2	727	2229.02	5.56227	1.99×10^{-1}	7.14×10^{12}	23
1	708	2230.15	5.55946	5.84×10^{-1}	6.30×10^{13}	58
48	3744	2230.70	5.55808	3.31×10^{-1}	1.19×10^{13}	24
8	930	2230.99	5.55736	8.12×10^{-1}	1.75×10^{13}	48
2	731	2231.08	5.55714	3.97×10^{-1}	2.14×10^{13}	40
0	663	2231.86	5.55520	2.63×10^{-1}	5.69×10^{12}	64
0	671	2233.05	5.55225	2.86×10^{-1}	7.72×10^{12}	58
9	971	2233.39	5.55139	1.31	4.74×10^{13}	34
8	942	2234.11	5.54961	2.75×10^{-1}	5.95×10^{12}	31
9	975	2234.17	5.54946	9.08×10^{-1}	2.46×10^{13}	41
1	725	2234.38	5.54893	7.85×10^{-1}	2.83×10^{13}	81
2	743	2235.02	5.54733	1.75	4.74×10^{13}	198
0	677	2235.36	5.54649	2.20×10^{-1}	5.97×10^{12}	56
22	2270	2235.50	5.54614	7.82×10^{-1}	1.41×10^{13}	36
25	2408	2235.74	5.54557	1.40	3.03×10^{13}	49
1	727	2236.01	5.54489	5.38×10^{-1}	1.94×10^{13}	63
8	955	2236.84	5.54282	4.07×10^{-1}	8.84×10^{12}	43
1	731	2238.06	5.53980	1.15	6.25×10^{13}	117
0	693	2238.63	5.53839	2.73×10^{-1}	4.95×10^{12}	106
19	2189	2239.08	5.53730	1.33	2.40×10^{13}	36
0	696	2239.14	5.53713	2.25	4.89×10^{13}	355
2	756	2239.81	5.53548	7.80×10^{-1}	2.83×10^{13}	77
21	2258	2239.87	5.53533	3.13	6.80×10^{13}	32
0	706	2242.32	5.52927	8.23×10^{-1}	1.80×10^{13}	144
4	942	2242.56	5.52869	4.37×10^{-1}	9.53×10^{12}	50
8	984	2243.42	5.52658	6.04×10^{-1}	1.10×10^{13}	29
4	952	2244.28	5.52445	4.85×10^{-1}	1.32×10^{13}	39
10	1038	2244.93	5.52287	1.26	4.58×10^{13}	68
6	980	2245.46	5.52156	7.09×10^{-1}	2.58×10^{13}	25
2	761	2245.57	5.52128	2.26	6.18×10^{13}	235

(*continued on next page*)

Table 18 (*continued*)

i	k	ΔE (eV)	λ (Å)	gf	A (s^{-1})	ϵ (γ/ion/s)
4	958	2246.15	5.51985	4.03×10^{-1}	7.36×10^{12}	50
3	930	2246.44	5.51915	1.79	3.93×10^{13}	107
22	2333	2246.49	5.51901	4.72×10^{-1}	1.03×10^{13}	35
1	756	2246.79	5.51827	1.32	4.80×10^{13}	131
8	997	2247.00	5.51777	9.14×10^{-1}	1.67×10^{13}	84
4	964	2247.67	5.51613	1.13	2.48×10^{13}	46
10	1048	2247.69	5.51607	6.85×10^{-1}	2.50×10^{13}	44
10	1050	2248.12	5.51501	7.74×10^{-1}	2.12×10^{13}	59
0	728	2248.67	5.51367	6.35	1.16×10^{14}	954
9	1038	2249.69	5.51116	4.53×10^{-1}	1.66×10^{13}	25
4	976	2249.87	5.51073	1.79	3.94×10^{13}	64
10	1054	2250.09	5.51020	2.92	8.01×10^{13}	110
3	948	2250.25	5.50979	2.20	6.05×10^{13}	28
4	984	2251.87	5.50584	3.26	5.98×10^{13}	158
3	955	2252.29	5.50481	2.92×10^{-1}	6.42×10^{12}	31
9	1050	2252.89	5.50334	4.63×10^{-1}	1.27×10^{13}	35
7	1012	2253.14	5.50274	5.89×10^{-1}	3.24×10^{13}	40
6	1011	2254.32	5.49986	2.26	6.24×10^{13}	26
6	1017	2255.23	5.49763	3.22×10^{-1}	1.19×10^{13}	24
3	976	2256.86	5.49366	1.17	2.58×10^{13}	42
19	2292	2259.19	5.48800	3.77×10^{-1}	5.96×10^{12}	24
7	1045	2260.38	5.48511	3.30×10^{-1}	1.83×10^{13}	25
5	1045	2263.88	5.47663	3.08×10^{-1}	1.71×10^{13}	24
5	1048	2264.76	5.47451	5.94×10^{-1}	2.20×10^{13}	39
2	893	2284.54	5.42710	3.75×10^{-1}	1.06×10^{13}	37
0	812	2287.65	5.41973	8.06×10^{-2}	1.83×10^{12}	26
0	814	2287.86	5.41922	6.55×10^{-2}	1.24×10^{12}	29
0	821	2289.96	5.41425	3.28×10^{-1}	6.22×10^{12}	87
0	891	2303.12	5.38332	6.89×10^{-1}	1.32×10^{13}	104
1	950	2303.78	5.38177	7.03×10^{-1}	4.05×10^{13}	44
1	980	2310.70	5.36566	8.57×10^{-1}	3.31×10^{13}	31
0	930	2312.04	5.36255	2.03	4.71×10^{13}	129
1	985	2312.10	5.36242	6.76×10^{-1}	2.61×10^{13}	28
1	988	2312.66	5.36111	8.53×10^{-1}	9.90×10^{13}	53
0	938	2313.60	5.35893	3.49	1.01×10^{14}	462
0	940	2314.59	5.35664	3.67	1.07×10^{14}	471
0	942	2315.16	5.35533	6.45	1.50×10^{14}	794
2	1026	2315.20	5.35523	3.18×10^{-1}	1.23×10^{13}	25
0	952	2316.88	5.35135	1.13	3.28×10^{13}	97
0	955	2317.89	5.34900	3.56	8.30×10^{13}	407
2	1038	2317.95	5.34887	3.21	1.25×10^{14}	185
0	958	2318.75	5.34703	1.73×10	3.36×10^{14}	2279
1	1012	2319.59	5.34510	3.93	2.29×10^{14}	285
2	1045	2319.84	5.34451	3.85	2.25×10^{14}	309
1	1015	2320.13	5.34384	1.58	6.16×10^{13}	120
0	964	2320.26	5.34354	8.28×10^{-1}	1.93×10^{13}	36
1	1017	2320.47	5.34307	4.36	1.70×10^{14}	337
2	1048	2320.72	5.34250	3.80	1.48×10^{14}	259
1	1022	2321.05	5.34173	1.52	1.78×10^{14}	107
2	1050	2321.15	5.34150	9.33	2.73×10^{14}	752
0	975	2321.96	5.33964	4.67×10^{-1}	1.37×10^{13}	23
0	976	2322.47	5.33847	1.14	2.68×10^{13}	43
2	1054	2323.11	5.33699	2.72	7.96×10^{13}	109
0	984	2324.46	5.33388	2.21	4.33×10^{13}	114
8	1284	2324.83	5.33305	2.08×10	3.49×10^{14}	29
1	1045	2326.83	5.32847	5.15×10^{-1}	3.03×10^{13}	42
1	1048	2327.70	5.32646	1.11	4.37×10^{13}	76
0	997	2328.05	5.32567	2.21	4.33×10^{13}	217
0	1464	2464.55	5.03070	5.31×10^{-1}	1.75×10^{13}	32
0	1476	2471.52	5.01651	4.69×10^{-1}	1.24×10^{13}	40
0	1478	2471.86	5.01582	6.90×10^{-1}	1.52×10^{13}	47
0	1494	2477.03	5.00535	4.06×10^{-1}	1.08×10^{13}	38
0	1498	2478.60	5.00218	6.25×10^{-1}	1.39×10^{13}	60
0	1501	2479.12	5.00113	1.50	4.99×10^{13}	118
0	1515	2483.41	4.99251	1.48	3.29×10^{13}	146
2	1576	2483.81	4.99170	5.90×10^{-1}	2.63×10^{13}	32
0	1519	2483.97	4.99137	6.71×10^{-1}	2.24×10^{13}	55
2	1586	2486.40	4.98650	4.50×10^{-1}	1.51×10^{13}	23
2	1587	2486.83	4.98564	6.61×10^{-1}	4.43×10^{13}	34
1	1564	2487.66	4.98398	5.62×10^{-1}	2.52×10^{13}	31

(*continued on next page*)

Table 18 (*continued*)

i	k	ΔE (eV)	λ (Å)	gf	A (s^{-1})	ϵ (γ/ion/s)
0	1543	2490.99	4.97730	8.78×10^{-1}	2.36×10^{13}	75
2	1610	2495.07	4.96916	5.23×10^{-1}	1.76×10^{13}	30
0	1552	2495.17	4.96898	3.97×10^{-1}	1.34×10^{13}	32
0	1556	2495.85	4.96761	1.54	4.16×10^{13}	119
2	1638	2502.78	4.95386	5.38×10^{-1}	1.83×10^{13}	33
2	1644	2504.67	4.95013	4.75×10^{-1}	1.62×10^{13}	26
2	1651	2506.64	4.94623	6.74×10^{-1}	3.06×10^{13}	34
0	1623	2517.97	4.92397	1.48	3.39×10^{13}	118
1	1671	2518.46	4.92301	6.60×10^{-1}	3.03×10^{13}	31
0	1629	2519.40	4.92118	4.76×10^{-1}	1.09×10^{13}	47
0	1673	2531.33	4.89798	3.37×10^{-1}	7.81×10^{12}	31
0	2902	2766.38	4.48181	5.12×10^{-1}	1.70×10^{13}	23
0	2908	2766.88	4.48101	1.26	3.48×10^{13}	64
2	3041	2771.66	4.47328	8.52×10^{-1}	3.55×10^{13}	29
0	3011	2785.66	4.45080	9.91×10^{-1}	4.17×10^{13}	50
0	3024	2787.85	4.44731	7.09×10^{-1}	2.39×10^{13}	33
0	3113	2806.07	4.41843	5.54×10^{-1}	1.58×10^{13}	32
0	3161	2816.32	4.40234	7.50×10^{-1}	2.15×10^{13}	38
0	3162	2816.67	4.40181	7.81×10^{-1}	2.69×10^{13}	41
0	3171	2818.33	4.39920	6.58×10^{-1}	2.83×10^{13}	36
2	5262	3021.94	4.10280	5.20×10^{-1}	3.43×10^{13}	32
2	5289	3028.83	4.09347	7.95×10^{-1}	3.96×10^{13}	48
1	5281	3033.21	4.08756	4.42×10^{-1}	4.41×10^{13}	26
1	5291	3036.45	4.08320	7.52×10^{-1}	5.02×10^{13}	46
0	5236	3036.47	4.08318	5.23×10^{-1}	2.09×10^{13}	38
0	5250	3038.94	4.07985	6.79×10^{-1}	2.27×10^{13}	53
0	5251	3039.21	4.07948	5.13×10^{-1}	2.06×10^{13}	36
2	5333	3044.48	4.07243	6.39×10^{-1}	3.21×10^{13}	35
0	5280	3045.55	4.07100	2.00	6.72×10^{13}	190
0	5403	3095.88	4.00482	5.92×10^{-1}	2.05×10^{13}	39
0	5463	3105.73	3.99211	2.00	6.96×10^{13}	178
0	5477	3107.82	3.98943	1.57	6.59×10^{13}	136
0	5493	3108.95	3.98798	1.64	8.59×10^{13}	143
0	5503	3110.45	3.98606	5.22×10^{-1}	2.19×10^{13}	23
0	5511	3111.81	3.98431	9.66×10^{-1}	3.38×10^{13}	70
2	5604	3112.26	3.98374	9.79×10^{-1}	1.03×10^{14}	62
2	5607	3112.98	3.98281	5.62×10^{-1}	3.94×10^{13}	26
2	5609	3113.34	3.98236	1.42	7.47×10^{13}	81
0	6485	3356.50	3.69385	7.28×10^{-1}	4.45×10^{13}	35
0	6551	3368.96	3.68019	6.63×10^{-1}	3.27×10^{13}	30
0	12102	3469.60	3.57344	4.17×10^{-1}	2.18×10^{13}	27
0	12104	3470.95	3.57205	5.87×10^{-1}	2.56×10^{13}	41
0	12120	3477.45	3.56538	6.33×10^{-1}	2.77×10^{13}	45
0	12366	3530.65	3.51166	4.10×10^{-1}	1.85×10^{13}	24
0	12410	3538.70	3.50366	6.66×10^{-1}	3.02×10^{13}	46
0	12419	3539.98	3.50240	8.39×10^{-1}	4.56×10^{13}	63
0	12424	3540.56	3.50183	7.42×10^{-1}	5.05×10^{13}	57

Table 19
Radiative transitions in Cr-like tungsten, W^{50+}.

i	k	ΔE (eV)	λ (Å)	gf	A (s^{-1})	ϵ (γ/ion/s)
596	8412	1071.40	11.5722	1.28	7.06×10^{12}	36
595	8420	1074.06	11.5435	5.36×10^{-1}	5.36×10^{12}	13
585	8585	1176.91	10.5347	3.02×10^{-1}	3.63×10^{12}	18
577	8547	1177.30	10.5312	3.91×10^{-1}	2.61×10^{12}	29
576	8547	1177.31	10.5312	2.06×10^{-1}	1.37×10^{12}	15
43	759	1700.80	7.28977	1.91×10^{-3}	2.67×10^{10}	15
1	518	1763.57	7.03032	1.06×10^{-4}	2.05×10^{9}	21
1	519	1766.40	7.01903	4.44×10^{-4}	1.20×10^{10}	35
7	523	1769.25	7.00772	6.37×10^{-4}	6.66×10^{9}	41
45	897	1769.90	7.00516	3.82×10^{-3}	1.04×10^{11}	17
43	873	1770.72	7.00190	1.85×10^{-2}	2.80×10^{11}	120
7	526	1771.16	7.00017	4.94×10^{-4}	6.12×10^{9}	16
6	526	1771.18	7.00007	3.95×10^{-4}	4.89×10^{9}	13
0	518	1771.25	6.99983	5.93×10^{-4}	1.15×10^{10}	117
0	519	1774.08	6.98864	4.15×10^{-4}	1.13×10^{10}	33
7	528	1775.36	6.98360	5.15×10^{-4}	6.41×10^{9}	17
42	873	1782.81	6.95443	2.25×10^{-2}	3.45×10^{11}	148
7	533	1784.10	6.94941	5.10×10^{-4}	7.83×10^{9}	13
61	1070	1784.89	6.94632	2.04×10^{-2}	2.17×10^{11}	12
45	939	1788.21	6.93344	4.09×10^{-3}	5.68×10^{11}	18
41	897	1791.46	6.92086	4.19×10^{-3}	1.17×10^{11}	19
40	894	1797.43	6.89787	3.49×10^{-3}	9.78×10^{10}	14
40	897	1798.11	6.89525	5.72×10^{-3}	1.61×10^{11}	26
36	873	1816.89	6.82397	1.05×10^{-2}	1.68×10^{11}	72
0	523	1841.99	6.73099	5.94×10^{-4}	6.73×10^{9}	41
0	528	1848.10	6.70874	5.44×10^{-4}	7.33×10^{9}	20
34	937	1854.61	6.68519	5.07×10^{-3}	5.82×10^{10}	23
7	568	1860.94	6.66246	9.51×10^{-4}	1.10×10^{10}	17
0	537	1863.42	6.65358	3.00×10^{-3}	6.46×10^{10}	71
1	556	1911.87	6.48498	1.99×10^{-2}	6.31×10^{11}	36
107	3203	1917.98	6.46432	7.08×10^{-1}	8.69×10^{12}	20
0	558	1922.09	6.45048	1.03×10^{-1}	2.37×10^{12}	115
46	1533	1924.32	6.44302	1.98×10^{-1}	3.53×10^{12}	14
1	567	1925.33	6.43962	4.86×10^{-2}	1.12×10^{12}	41
1	572	1927.01	6.43402	3.21×10^{-2}	1.03×10^{12}	38
1	574	1927.42	6.43266	4.04×10^{-2}	2.17×10^{12}	35
59	1667	1927.54	6.43227	1.65×10^{-2}	2.96×10^{11}	17
58	1666	1929.00	6.42738	1.59×10^{-1}	2.85×10^{12}	16
58	1667	1929.23	6.42663	3.32×10^{-2}	5.96×10^{11}	35
7	616	1930.84	6.42124	2.05×10^{-1}	2.21×10^{12}	52
55	1667	1932.39	6.41610	1.50×10^{-2}	2.71×10^{11}	16
0	566	1932.97	6.41419	4.93×10^{-2}	8.89×10^{11}	81
0	567	1933.01	6.41403	1.39×10^{-1}	3.21×10^{12}	117
7	620	1933.56	6.41222	6.46×10^{-1}	8.06×10^{12}	30
6	620	1933.59	6.41214	3.82×10^{-1}	4.77×10^{12}	18
0	571	1934.55	6.40893	3.32×10^{-1}	4.90×10^{12}	373
43	1532	1936.30	6.40317	2.49×10^{-1}	4.50×10^{12}	62
1	581	1936.89	6.40119	1.81×10^{-1}	5.88×10^{12}	113
45	1564	1937.06	6.40065	1.53×10^{-1}	4.99×10^{12}	15
0	576	1940.51	6.38925	2.88×10^{-1}	4.28×10^{12}	276
0	577	1940.52	6.38924	3.49×10^{-1}	6.34×10^{12}	315
1	584	1941.05	6.38749	9.79×10^{-2}	5.33×10^{12}	61
1	585	1942.22	6.38364	3.31×10^{-1}	7.73×10^{12}	242
2	591	1942.86	6.38155	1.42×10^{-1}	7.76×10^{12}	94
0	579	1943.51	6.37940	4.42×10^{-2}	1.03×10^{12}	75
0	583	1947.87	6.36511	7.15×10^{-2}	1.31×10^{12}	103
41	1532	1948.56	6.36287	6.14×10^{-2}	1.12×10^{12}	16
0	585	1949.90	6.35849	3.74×10^{-2}	8.82×10^{11}	28
43	1598	1956.12	6.33826	2.90×10^{-2}	5.35×10^{11}	21
1	590	1957.21	6.33474	1.78×10^{-2}	5.92×10^{11}	38
44	1606	1957.64	6.33336	4.11×10^{-2}	1.37×10^{12}	12
38	1477	1957.66	6.33327	1.49×10^{-1}	2.76×10^{12}	18
2	598	1960.74	6.32333	8.13×10^{-2}	4.52×10^{12}	37
11	664	1960.99	6.32253	1.41×10^{-1}	2.14×10^{12}	11
40	1549	1961.15	6.32201	6.24×10^{-2}	2.08×10^{12}	11
7	642	1961.92	6.31955	1.25×10^{-1}	1.90×10^{12}	13
40	1552	1962.20	6.31862	6.22×10^{-2}	2.08×10^{12}	17
61	1939	1964.60	6.31090	5.51×10^{-1}	7.10×10^{12}	30
111	3780	1965.96	6.30656	7.37×10^{-2}	1.37×10^{12}	16

(continued on next page)

Table 19 (*continued*)

i	k	ΔE (eV)	λ (Å)	gf	A (s^{-1})	ϵ (γ/ion/s)
11	669	1966.16	6.30590	1.50×10^{-1}	2.79×10^{12}	21
44	1649	1967.72	6.30089	7.29×10^{-2}	1.22×10^{13}	15
42	1598	1968.21	6.29934	3.49×10^{-1}	6.51×10^{12}	250
36	1463	1968.36	6.29887	3.89×10^{-2}	5.04×10^{11}	18
41	1598	1968.39	6.29878	1.70×10^{-2}	3.17×10^{11}	12
45	1702	1968.87	6.29722	4.59×10^{-2}	1.54×10^{12}	50
34	1393	1969.32	6.29578	5.08×10^{-1}	6.58×10^{12}	24
69	2041	1969.33	6.29575	1.25×10^{-1}	1.62×10^{12}	11
9	655	1969.99	6.29366	1.99×10^{-1}	3.72×10^{12}	15
41	1606	1970.82	6.29100	2.23×10^{-1}	7.51×10^{12}	66
9	658	1970.97	6.29052	5.80×10^{-2}	1.40×10^{12}	14
1	595	1971.76	6.28800	2.28×10^{-1}	7.69×10^{12}	137
14	680	1971.78	6.28792	4.05×10^{-1}	9.77×10^{12}	27
11	676	1971.93	6.28745	1.95×10^{-1}	3.66×10^{12}	14
43	1667	1972.16	6.28672	4.43×10^{-2}	8.31×10^{11}	49
1	596	1972.71	6.28496	5.02×10^{-2}	1.21×10^{12}	25
20	719	1972.83	6.28459	2.16×10^{-1}	2.43×10^{12}	11
6	649	1975.77	6.27524	3.76×10^{-2}	5.78×10^{11}	13
7	650	1975.92	6.27475	6.22×10^{-2}	7.02×10^{11}	51
7	652	1977.07	6.27111	5.96×10^{-1}	7.78×10^{12}	56
6	655	1978.16	6.26764	1.72×10^{-1}	3.25×10^{12}	13
43	1702	1978.17	6.26762	1.83×10^{-2}	6.20×10^{11}	20
1	598	1978.42	6.26683	1.15×10^{-1}	6.49×10^{12}	54
0	594	1979.03	6.26491	1.68×10^{-1}	3.17×10^{12}	252
7	657	1979.10	6.26469	1.29×10^{-1}	1.99×10^{12}	13
6	657	1979.12	6.26461	4.44×10^{-1}	6.85×10^{12}	44
45	1776	1979.22	6.26429	2.42×10^{-2}	4.12×10^{12}	31
0	596	1980.39	6.26059	5.34×10^{-1}	1.30×10^{13}	264
36	1525	1980.51	6.26023	1.40×10^{-1}	2.64×10^{12}	48
111	3915	1981.49	6.25711	4.27×10^{-2}	1.46×10^{12}	11
36	1532	1982.46	6.25405	1.42×10^{-1}	2.70×10^{12}	37
4	648	1982.47	6.25403	2.74×10^{-1}	5.19×10^{12}	24
107	3778	1982.82	6.25292	3.54×10^{-1}	6.71×10^{12}	11
6	663	1982.91	6.25263	3.81×10^{-2}	5.00×10^{11}	22
7	664	1982.92	6.25262	5.07×10^{-1}	7.86×10^{12}	41
6	666	1985.15	6.24557	4.75×10^{-1}	9.02×10^{12}	17
4	653	1985.28	6.24517	2.98×10^{-1}	7.27×10^{12}	18
11	689	1987.90	6.23694	2.31×10^{-1}	5.65×10^{12}	15
7	673	1990.74	6.22806	2.42×10^{-1}	3.78×10^{12}	45
107	3873	1992.87	6.22139	2.54×10^{-2}	4.86×10^{11}	12
106	3873	2004.93	6.18396	3.09×10^{-2}	5.98×10^{11}	14
36	1667	2018.33	6.14291	1.26×10^{-2}	2.48×10^{11}	15
1	769	2147.80	5.77263	4.96×10^{-2}	1.42×10^{12}	11
1	773	2150.92	5.76425	2.81×10^{-1}	1.13×10^{13}	33
0	767	2151.30	5.76323	8.55×10^{-1}	1.56×10^{13}	126
17	1122	2153.94	5.75617	2.23×10^{-1}	4.08×10^{12}	13
0	769	2155.48	5.75206	1.64×10^{-1}	4.73×10^{12}	37
0	770	2156.06	5.75051	4.99×10^{-1}	9.14×10^{12}	109
7	914	2157.16	5.74757	1.48	2.00×10^{13}	22
1	779	2157.46	5.74676	7.01×10^{-1}	2.02×10^{13}	83
0	776	2161.14	5.73699	6.55×10^{-1}	1.47×10^{13}	97
1	786	2161.21	5.73680	1.73×10^{-1}	1.17×10^{13}	29
2	812	2164.03	5.72933	2.67×10^{-1}	1.81×10^{13}	28
0	803	2184.50	5.67563	4.27×10^{-1}	9.82×10^{12}	85
0	810	2187.01	5.66913	2.49×10^{-1}	7.37×10^{12}	36
1	852	2199.52	5.63686	1.60×10^{-1}	6.73×10^{12}	15
1	857	2200.26	5.63498	1.11×10^{-1}	7.76×10^{12}	13
0	846	2204.38	5.62445	3.21×10^{-1}	9.66×10^{12}	63
43	3222	2230.95	5.55747	5.01×10^{-1}	2.16×10^{13}	17
43	3294	2239.35	5.53661	3.30×10^{-1}	1.44×10^{13}	11
0	937	2239.45	5.53637	2.43×10^{-3}	4.07×10^{10}	16
42	3221	2242.73	5.52828	4.09×10^{-1}	8.11×10^{12}	15
42	3341	2255.80	5.49625	7.81×10^{-1}	1.92×10^{13}	36
41	3341	2255.97	5.49582	5.52×10^{-1}	1.36×10^{13}	25
38	3156	2256.08	5.49555	2.59×10^{-1}	6.37×10^{12}	15
40	3310	2259.89	5.48630	9.20×10^{-1}	2.91×10^{13}	29
38	3198	2261.29	5.48289	9.29×10^{-1}	2.94×10^{13}	23
39	3222	2263.40	5.47778	4.53×10^{-1}	2.02×10^{13}	16
42	3397	2264.02	5.47628	8.55×10^{-1}	1.73×10^{13}	48
40	3365	2265.41	5.47292	5.00×10^{-1}	1.59×10^{13}	12

(*continued on next page*)

Table 19 (*continued*)

i	k	ΔE (eV)	λ (Å)	gf	A (s^{-1})	ϵ (γ/ion/s)
7	1290	2265.68	5.47227	1.91×10^{-2}	3.28×10^{11}	13
6	1293	2265.90	5.47175	1.46×10^{-1}	3.61×10^{12}	16
40	3372	2266.58	5.47011	8.22×10^{-1}	3.66×10^{13}	31
1	1056	2267.56	5.46774	1.28×10^{-1}	9.49×10^{12}	22
44	3532	2267.85	5.46705	1.11	4.97×10^{13}	36
0	1017	2267.91	5.46690	1.50×10^{-1}	3.71×10^{12}	44
107	6028	2268.47	5.46555	1.10×10^{-1}	2.73×10^{12}	12
6	1309	2268.82	5.46470	1.70×10^{-2}	2.91×10^{11}	14
36	3156	2269.12	5.46397	5.38×10^{-1}	1.34×10^{13}	32
0	1021	2269.40	5.46331	1.44×10^{-1}	4.60×10^{12}	33
39	3276	2270.09	5.46165	6.01×10^{-1}	2.69×10^{13}	17
7	1315	2270.86	5.45979	2.06×10^{-1}	4.19×10^{12}	27
7	1319	2271.09	5.45923	4.57×10^{-2}	7.86×10^{11}	20
36	3176	2271.53	5.45819	8.36×10^{-1}	1.70×10^{13}	11
37	3188	2272.29	5.45636	6.99×10^{-1}	1.74×10^{13}	18
4	1284	2272.29	5.45635	1.67×10^{-1}	3.41×10^{12}	14
0	1038	2272.33	5.45626	8.18×10^{-2}	1.67×10^{12}	44
39	3300	2272.36	5.45620	7.12×10^{-1}	2.28×10^{13}	17
13	1482	2272.60	5.45561	2.92×10^{-1}	2.18×10^{13}	22
2	1150	2272.95	5.45477	8.98×10^{-1}	6.71×10^{13}	102
42	3464	2273.08	5.45447	1.34×10^{-1}	2.74×10^{12}	30
41	3467	2273.53	5.45337	2.01	5.01×10^{13}	34
183	7458	2273.97	5.45231	9.69×10^{-1}	2.41×10^{13}	11
37	3207	2274.67	5.45065	2.85×10^{-1}	9.15×10^{12}	12
11	1488	2274.77	5.45041	1.39×10^{-1}	2.83×10^{12}	14
11	1491	2275.14	5.44951	8.91×10^{-1}	2.22×10^{13}	43
41	3484	2275.48	5.44871	5.07×10^{-1}	1.26×10^{13}	13
14	1510	2276.01	5.44745	1.92×10^{-1}	6.16×10^{12}	19
106	5995	2276.41	5.44649	1.12×10^{-1}	2.28×10^{12}	12
11	1500	2276.54	5.44618	1.32	4.23×10^{13}	23
36	3221	2276.81	5.44553	2.02	4.13×10^{13}	75
14	1512	2276.86	5.44541	2.45×10^{-1}	1.10×10^{13}	25
6	1369	2277.76	5.44324	4.27×10^{-1}	1.07×10^{13}	18
183	7480	2278.06	5.44254	1.71	4.28×10^{13}	12
6	1376	2278.84	5.44067	2.68×10^{-1}	5.48×10^{12}	16
39	3365	2278.96	5.44040	6.94×10^{-1}	2.23×10^{13}	17
14	1523	2279.12	5.44001	3.99×10^{-1}	1.28×10^{13}	27
106	6017	2279.28	5.43961	7.08×10^{-1}	1.77×10^{13}	15
7	1382	2279.45	5.43922	7.23×10^{-2}	1.09×10^{12}	28
37	3243	2279.56	5.43895	1.54	4.96×10^{13}	14
34	3149	2279.64	5.43876	1.74	3.03×10^{13}	19
38	3367	2279.82	5.43834	6.16×10^{-1}	1.54×10^{13}	11
9	1439	2279.99	5.43794	2.62×10^{-1}	8.45×10^{12}	11
1	1103	2280.04	5.43781	1.33	6.00×10^{13}	181
9	1443	2280.27	5.43726	5.12×10^{-1}	1.65×10^{13}	37
13	1518	2280.32	5.43715	5.12×10^{-1}	3.85×10^{13}	13
12	1518	2280.51	5.43669	6.35×10^{-1}	4.78×10^{13}	16
10	1497	2280.54	5.43662	2.99×10^{-1}	2.25×10^{13}	23
7	1389	2280.90	5.43576	1.94×10^{-1}	3.99×10^{12}	13
37	3255	2281.14	5.43519	2.20	5.53×10^{13}	22
12	1523	2281.20	5.43504	5.62×10^{-1}	1.81×10^{13}	38
0	1080	2281.25	5.43492	1.49	3.75×10^{13}	271
179	7378	2281.61	5.43408	4.58×10^{-1}	9.39×10^{12}	11
11	1520	2281.74	5.43376	1.76	3.61×10^{13}	32
8	1443	2281.83	5.43353	2.53×10^{-1}	8.16×10^{12}	18
7	1397	2282.22	5.43262	9.97×10^{-1}	2.05×10^{13}	52
43	3662	2282.26	5.43253	2.64	6.63×10^{13}	13
7	1403	2282.52	5.43191	6.76×10^{-1}	1.18×10^{13}	26
14	1536	2282.78	5.43129	1.05	3.41×10^{13}	20
36	3265	2282.81	5.43120	5.08	8.84×10^{13}	74
9	1458	2283.24	5.43019	4.24×10^{-1}	1.37×10^{13}	53
106	6041	2283.51	5.42955	1.04×10^{-1}	3.37×10^{12}	14
1	1120	2283.79	5.42887	2.54	8.22×10^{13}	345
9	1462	2283.93	5.42855	1.21	5.46×10^{13}	20
9	1467	2284.19	5.42793	6.66×10^{-1}	1.68×10^{13}	60
34	3190	2284.61	5.42692	7.91×10^{-1}	1.38×10^{13}	33
8	1458	2284.80	5.42647	1.03×10^{-1}	3.32×10^{12}	13
12	1536	2284.86	5.42634	9.39×10^{-1}	3.04×10^{13}	18
183	7516	2284.96	5.42609	5.41	1.11×10^{14}	12
8	1465	2285.60	5.42459	9.96×10^{-1}	3.23×10^{13}	16

(*continued on next page*)

Table 19 (*continued*)

i	k	ΔE (eV)	λ (Å)	gf	A (s^{-1})	ϵ (γ/ion/s)
6	1426	2286.06	5.42348	1.15×10^{-1}	2.37×10^{12}	12
41	3587	2286.72	5.42193	8.71×10^{-1}	2.20×10^{13}	28
7	1431	2286.85	5.42162	1.22	2.12×10^{13}	26
10	1526	2286.91	5.42148	9.26×10^{-1}	7.00×10^{13}	27
38	3408	2286.94	5.42141	3.19	6.59×10^{13}	13
3	1369	2287.45	5.42019	2.57×10^{-1}	6.49×10^{12}	11
4	1383	2287.74	5.41951	1.24×10^{-1}	3.13×10^{12}	12
179	7416	2287.96	5.41899	1.83	3.20×10^{13}	26
8	1479	2288.12	5.41861	1.52	6.90×10^{13}	28
7	1442	2288.37	5.41802	2.09	3.65×10^{13}	33
6	1444	2288.55	5.41759	4.22×10^{-1}	1.06×10^{13}	41
7	1446	2288.73	5.41716	1.36	2.07×10^{13}	32
9	1491	2288.92	5.41671	2.27×10^{-1}	5.72×10^{12}	11
37	3341	2289.36	5.41567	2.98×10^{-1}	7.53×10^{12}	14
14	1556	2290.10	5.41392	1.54	5.02×10^{13}	12
9	1500	2290.31	5.41342	9.25×10^{-1}	3.01×10^{13}	17
1	1150	2290.63	5.41267	1.14×10^{-1}	8.68×10^{12}	13
106	6099	2291.17	5.41140	4.45×10^{-1}	1.13×10^{13}	12
0	1120	2291.47	5.41067	9.41×10^{-2}	3.06×10^{12}	13
8	1497	2291.59	5.41041	3.50×10^{-1}	2.66×10^{13}	27
3	1394	2291.64	5.41028	1.34×10^{-1}	4.37×10^{12}	11
0	1122	2291.81	5.40989	1.77×10^{-1}	3.67×10^{12}	11
6	1460	2291.86	5.40977	3.70×10^{-1}	7.67×10^{12}	24
0	1123	2291.93	5.40961	4.89	1.01×10^{14}	811
11	1558	2293.08	5.40688	3.80	7.88×10^{13}	13
8	1510	2294.07	5.40454	2.03×10^{-1}	6.63×10^{12}	21
4	1426	2294.20	5.40425	8.65×10^{-1}	1.80×10^{13}	89
3	1415	2294.50	5.40354	8.10×10^{-1}	2.64×10^{13}	18
3	1417	2294.66	5.40316	6.68×10^{-1}	2.18×10^{13}	16
7	1478	2294.68	5.40312	3.73×10^{-1}	7.74×10^{12}	29
6	1478	2294.70	5.40306	1.81	3.75×10^{13}	143
3	1420	2294.99	5.40238	1.70×10^{-1}	4.32×10^{12}	14
108	6208	2295.46	5.40127	6.02×10^{-1}	2.75×10^{13}	11
9	1523	2295.62	5.40090	2.89×10^{-1}	9.44×10^{12}	20
7	1485	2296.36	5.39916	6.98	1.06×10^{14}	106
4	1444	2296.68	5.39840	8.14×10^{-1}	2.07×10^{13}	80
7	1488	2296.69	5.39838	1.35×10^{-1}	2.82×10^{12}	14
6	1488	2296.72	5.39832	6.75×10^{-1}	1.40×10^{13}	71
6	1496	2298.15	5.39495	5.97	1.05×10^{14}	19
3	1444	2298.24	5.39476	1.25	3.18×10^{13}	123
36	3402	2299.00	5.39297	8.11×10^{-1}	1.43×10^{13}	70
4	1458	2299.55	5.39167	1.42×10^{-1}	4.67×10^{12}	18
8	1537	2300.89	5.38854	7.96×10^{-1}	3.66×10^{13}	13
4	1470	2301.35	5.38745	6.92×10^{-1}	1.77×10^{13}	35
3	1467	2302.06	5.38580	1.05	2.68×10^{13}	96
4	1478	2302.84	5.38397	1.65	3.46×10^{13}	132
3	1470	2302.91	5.38381	1.56	3.98×10^{13}	80
4	1488	2304.86	5.37926	2.30	4.82×10^{13}	243
36	3529	2314.74	5.35629	6.68×10^{-2}	1.19×10^{12}	34
1	1257	2321.66	5.34032	1.13×10^{-1}	5.30×10^{12}	12
0	1249	2327.32	5.32734	7.23×10^{-2}	1.89×10^{12}	14
1	1288	2329.94	5.32134	1.25×10^{-1}	4.22×10^{12}	13
0	1264	2331.52	5.31773	3.13×10^{-1}	6.71×10^{12}	59
1	1311	2334.30	5.31140	1.05×10^{-1}	3.54×10^{12}	19
0	1292	2338.58	5.30168	5.88×10^{-2}	1.27×10^{12}	13
0	1293	2338.61	5.30162	1.02×10^{-1}	2.68×10^{12}	12
1	1366	2342.19	5.29351	9.69×10^{-2}	3.29×10^{12}	17
7	1673	2342.77	5.29220	1.54	3.33×10^{13}	15
0	1315	2343.60	5.29033	2.16×10^{-1}	4.67×10^{12}	30
0	1332	2345.67	5.28567	4.87×10^{-2}	1.29×10^{12}	18
1	1394	2346.99	5.28269	2.56×10^{-1}	8.73×10^{12}	22
0	1366	2349.87	5.27621	9.08×10^{-2}	3.11×10^{12}	16
0	1383	2352.32	5.27072	1.54×10^{-1}	4.12×10^{12}	15
0	1397	2354.96	5.26482	3.45×10^{-1}	7.56×10^{12}	19
26	2291	2355.32	5.26402	8.62×10^{-1}	1.89×10^{13}	17
7	1767	2357.14	5.25994	3.07	5.69×10^{13}	33
0	1420	2358.02	5.25798	2.10×10^{-1}	5.62×10^{12}	18
7	1774	2358.27	5.25742	8.40	1.56×10^{14}	92
6	1774	2358.30	5.25736	1.89	3.51×10^{13}	21
0	1426	2358.78	5.25629	2.54	5.57×10^{13}	275

(*continued on next page*)

Table 19 (*continued*)

i	k	ΔE (eV)	λ (Å)	gf	A (s^{-1})	ϵ (γ/ion/s)
6	1780	2358.99	5.25581	4.75	1.04×10^{14}	18
1	1482	2360.42	5.25263	9.02×10^{-1}	7.27×10^{13}	73
0	1439	2360.88	5.25162	3.32×10^{-1}	1.15×10^{13}	15
0	1443	2361.16	5.25098	9.99×10^{-1}	3.45×10^{13}	78
0	1444	2361.26	5.25076	5.60	1.51×10^{14}	584
6	1804	2362.01	5.24909	3.33	6.21×10^{13}	15
4	1746	2362.23	5.24861	6.37	1.40×10^{14}	16
7	1812	2363.05	5.24679	1.54×10	2.49×10^{14}	211
1	1497	2363.23	5.24639	1.67	1.35×10^{14}	136
0	1458	2364.13	5.24439	5.84	2.02×10^{14}	776
0	1460	2364.57	5.24341	3.42×10^{-1}	7.55×10^{12}	24
0	1467	2365.08	5.24228	3.17	8.54×10^{13}	307
1	1510	2365.72	5.24087	6.63	2.30×10^{14}	715
0	1470	2365.93	5.24040	1.24	3.36×10^{13}	67
1	1512	2366.57	5.23898	5.43	2.64×10^{14}	597
0	1478	2367.42	5.23711	4.62	1.02×10^{14}	389
2	1578	2367.80	5.23627	3.73	3.02×10^{14}	347
1	1523	2368.83	5.23398	1.92	6.68×10^{13}	140
0	1488	2369.43	5.23265	9.78	2.17×10^{14}	1093
1	1526	2369.60	5.23229	3.68×10^{-1}	2.99×10^{13}	12
0	1491	2369.81	5.23182	5.80×10^{-1}	1.57×10^{13}	30
0	1510	2373.40	5.22391	2.90×10^{-1}	1.01×10^{13}	31
11	1986	2375.84	5.21853	6.36	1.42×10^{14}	13
7	1898	2375.92	5.21837	1.06×10	1.73×10^{14}	143
7	2203	2438.58	5.08427	1.39×10^{-2}	2.40×10^{11}	12
0	2055	2485.55	4.98820	1.32×10^{-1}	3.23×10^{12}	15
0	2204	2511.65	4.93636	4.67×10^{-1}	1.42×10^{13}	26
1	2255	2513.21	4.93331	3.07×10^{-1}	2.80×10^{13}	19
0	2219	2513.95	4.93184	7.87×10^{-1}	3.08×10^{13}	53
0	2221	2514.39	4.93098	2.24×10^{-1}	5.60×10^{12}	23
0	2232	2517.10	4.92567	8.11×10^{-1}	2.48×10^{13}	69
1	2285	2517.83	4.92425	8.96×10^{-1}	3.52×10^{13}	61
1	2301	2520.02	4.91996	2.26×10^{-1}	8.89×10^{12}	18
0	2251	2520.48	4.91908	3.51×10^{-1}	1.08×10^{13}	29
0	2254	2520.68	4.91868	1.02	2.57×10^{13}	71
0	2257	2521.19	4.91769	7.88×10^{-1}	3.10×10^{13}	71
0	2263	2522.24	4.91565	7.01×10^{-1}	2.15×10^{13}	66
0	2267	2522.99	4.91418	1.45×10^{-1}	3.65×10^{12}	21
7	2644	2523.18	4.91381	2.28	5.73×10^{13}	16
1	2321	2524.48	4.91128	7.15×10^{-1}	6.59×10^{13}	53
7	2658	2525.41	4.90946	2.53	4.66×10^{13}	22
0	2301	2527.70	4.90501	2.65×10^{-1}	1.05×10^{13}	21
0	2309	2528.77	4.90294	1.18	2.98×10^{13}	104
1	2337	2529.56	4.90141	6.25×10^{-1}	2.48×10^{13}	51
0	2313	2529.95	4.90066	5.98×10^{-1}	1.85×10^{13}	59
0	2315	2530.15	4.90027	1.01	4.01×10^{13}	89
2	2420	2530.23	4.90013	4.37×10^{-1}	4.05×10^{13}	25
1	2341	2531.81	4.89706	1.47	8.17×10^{13}	100
0	2323	2532.44	4.89584	5.50×10^{-1}	1.39×10^{13}	54
0	2335	2536.59	4.88783	1.71×10^{-1}	6.82×10^{12}	16
0	2337	2537.24	4.88657	1.95×10^{-1}	7.79×10^{12}	16
2	2467	2539.57	4.88209	4.75×10^{-1}	4.43×10^{13}	26
0	2344	2539.72	4.88182	1.11×10^{-1}	3.45×10^{12}	12
0	2386	2549.96	4.86220	2.49×10^{-1}	6.38×10^{12}	19
1	2435	2550.48	4.86121	4.75×10^{-1}	1.92×10^{13}	33
0	2391	2551.43	4.85940	9.16×10^{-1}	2.35×10^{13}	77
1	2446	2552.67	4.85703	2.54×10^{-1}	1.03×10^{13}	16
0	2396	2552.85	4.85671	3.62×10^{-1}	1.14×10^{13}	28
0	2400	2553.31	4.85581	3.31×10^{-1}	1.04×10^{13}	22
0	2410	2554.65	4.85328	6.23×10^{-1}	1.96×10^{13}	50
7	2934	2562.72	4.83800	2.14	4.06×10^{13}	17
1	2516	2565.68	4.83240	4.25×10^{-1}	1.74×10^{13}	27
1	2522	2566.57	4.83073	2.75×10^{-1}	1.57×10^{13}	16
0	2495	2569.37	4.82547	7.98×10^{-1}	2.08×10^{13}	72
0	4513	2808.60	4.41445	4.45×10^{-1}	1.69×10^{13}	21
0	4518	2809.12	4.41363	1.08	3.36×10^{13}	58
1	4639	2813.89	4.40615	7.31×10^{-1}	3.59×10^{13}	31
1	4755	2825.09	4.38869	3.40×10^{-1}	3.93×10^{13}	15
1	4766	2826.50	4.38649	2.94×10^{-1}	2.04×10^{13}	11
0	4701	2827.89	4.38433	7.73×10^{-1}	3.83×10^{13}	42

(*continued on next page*)

Table 19 (*continued*)

i	k	ΔE (eV)	λ (Å)	gf	A (s^{-1})	ϵ (γ/ion/s)
0	4721	2829.68	4.38156	6.09×10^{-1}	2.35×10^{13}	30
0	4966	2854.81	4.34300	3.56×10^{-1}	1.14×10^{13}	18
0	5024	2862.27	4.33168	9.39×10^{-1}	3.04×10^{13}	50
0	5025	2862.34	4.33156	6.24×10^{-1}	2.47×10^{13}	33
1	5097	2863.07	4.33046	3.13×10^{-1}	3.71×10^{13}	14
1	5104	2863.93	4.32917	5.41×10^{-1}	3.85×10^{13}	23
1	5110	2864.58	4.32818	4.27×10^{-1}	2.17×10^{13}	18
0	5058	2866.10	4.32588	5.59×10^{-1}	2.85×10^{13}	28
0	5638	2947.57	4.20632	3.24×10^{-1}	1.11×10^{13}	16
2	8566	3096.42	4.00412	2.87×10^{-1}	3.98×10^{13}	18
1	8543	3109.55	3.98721	3.72×10^{-1}	3.13×10^{13}	25
8	8802	3110.60	3.98586	1.65×10^{-1}	9.88×10^{12}	12
1	8555	3111.35	3.98490	8.83×10^{-1}	5.30×10^{13}	69
0	8533	3114.23	3.98122	4.81×10^{-1}	2.25×10^{13}	36
0	8556	3119.38	3.97464	1.91	7.32×10^{13}	194
4	8801	3125.26	3.96717	2.28×10^{-1}	8.80×10^{12}	16
7	8864	3127.15	3.96476	1.70	4.82×10^{13}	15
3	8807	3127.73	3.96403	6.17×10^{-1}	2.91×10^{13}	13
0	8677	3168.40	3.91315	3.12×10^{-1}	1.24×10^{13}	16
0	8722	3180.89	3.89778	3.79×10^{-1}	1.51×10^{13}	20
7	9145	3181.74	3.89675	2.48	7.28×10^{13}	22
0	8733	3182.39	3.89595	3.26×10^{-1}	1.59×10^{13}	19
1	8816	3184.27	3.89364	2.40×10^{-1}	1.51×10^{13}	12
0	8762	3186.47	3.89096	5.64×10^{-1}	2.26×10^{13}	27
0	8791	3189.12	3.88773	1.37	6.73×10^{13}	110
0	8801	3189.84	3.88685	1.05	4.20×10^{13}	75
0	8802	3189.92	3.88674	9.61×10^{-1}	6.06×10^{13}	71
1	8853	3190.20	3.88641	9.98×10^{-1}	6.30×10^{13}	64
1	8858	3190.85	3.88562	5.40×10^{-1}	7.95×10^{13}	37
1	8860	3191.35	3.88501	7.90×10^{-1}	6.99×10^{13}	51
2	8937	3192.48	3.88364	7.36×10^{-1}	1.08×10^{14}	47
0	8850	3197.03	3.87811	2.91×10^{-1}	1.17×10^{13}	12
0	10117	3425.46	3.61949	2.89×10^{-1}	1.63×10^{13}	12
0	10122	3426.02	3.61890	6.00×10^{-1}	4.37×10^{13}	31
1	10193	3429.85	3.61486	2.95×10^{-1}	5.01×10^{13}	12
1	10209	3432.98	3.61156	4.43×10^{-1}	4.53×10^{13}	18
0	10172	3434.29	3.61019	5.71×10^{-1}	2.66×10^{13}	26
0	10321	3459.83	3.58354	3.84×10^{-1}	1.82×10^{13}	15

Table 20
Radiative transitions in V-like tungsten, W^{51+}.

i	k	ΔE (eV)	λ (Å)	gf	A (s^{-1})	ϵ (γ/ion/s)
1488	10213	1001.68	12.3776	3.48	1.90×10^{13}	58
1445	10191	1024.86	12.0977	2.35	1.78×10^{13}	14
1512	10313	1024.98	12.0963	2.89	1.65×10^{13}	24
1357	10137	1095.48	11.3178	1.13	9.81×10^{12}	35
1352	10239	1204.40	10.2943	3.63×10^{-1}	3.81×10^{12}	54
1350	10239	1205.90	10.2814	1.56×10^{-1}	1.64×10^{12}	23
1503	11250	1226.67	10.1073	2.40×10^{-1}	2.61×10^{12}	18
45	1488	1761.99	7.03660	1.48×10^{-3}	3.32×10^{10}	21
9	1322	1810.61	6.84763	1.88×10^{-4}	1.34×10^{10}	16
0	1313	1824.16	6.79679	3.43×10^{-4}	2.48×10^{10}	73
3	1316	1826.96	6.78637	7.65×10^{-4}	1.11×10^{10}	38
76	1715	1834.05	6.76014	2.63×10^{-2}	3.20×10^{11}	22
45	1566	1834.60	6.75809	7.99×10^{-3}	1.94×10^{11}	81
45	1568	1834.98	6.75672	2.06×10^{-3}	5.01×10^{10}	15
44	1566	1836.87	6.74974	1.34×10^{-2}	3.28×10^{11}	136
44	1568	1837.24	6.74838	3.74×10^{-3}	9.12×10^{10}	27
4	1322	1840.89	6.73500	2.53×10^{-4}	1.86×10^{10}	22
42	1566	1854.41	6.68592	9.32×10^{-3}	2.32×10^{11}	96
40	1566	1877.33	6.60428	3.29×10^{-3}	8.39×10^{10}	35
0	1316	1898.95	6.52909	4.63×10^{-4}	7.25×10^{9}	25
0	1320	1905.72	6.50589	3.87×10^{-4}	7.61×10^{9}	14
37	1619	1911.23	6.48716	6.95×10^{-3}	1.10×10^{11}	37
3	1344	1916.13	6.47056	1.06×10^{-3}	1.69×10^{10}	18
39	1644	1916.24	6.47019	2.88×10^{-3}	5.74×10^{10}	14
2	1346	1921.08	6.45390	3.65×10^{-3}	9.74×10^{10}	17
156	3933	1972.25	6.28645	6.13×10^{-1}	8.63×10^{12}	31
0	1340	1977.65	6.26928	6.86×10^{-2}	2.91×10^{12}	115
5	1379	1979.55	6.26324	9.48×10^{-2}	1.34×10^{12}	20
5	1384	1985.68	6.24390	2.97×10^{-1}	4.24×10^{12}	24
3	1381	1988.11	6.23628	1.94×10^{-1}	2.37×10^{12}	65
0	1345	1989.76	6.23113	2.52×10^{-1}	5.42×10^{12}	333
3	1384	1991.25	6.22646	6.48×10^{-1}	9.29×10^{12}	54
0	1346	1991.56	6.22550	1.13×10^{-2}	3.23×10^{11}	56
0	1348	1992.41	6.22282	1.15×10^{-1}	4.97×10^{12}	150
0	1350	1995.69	6.21260	1.80×10^{-1}	3.89×10^{12}	240
0	1352	1997.20	6.20791	3.07×10^{-1}	8.86×10^{12}	387
43	2094	2006.42	6.17939	7.50×10^{-2}	2.18×10^{12}	22
45	2167	2006.88	6.17795	6.82×10^{-2}	1.99×10^{12}	101
76	2535	2007.64	6.17563	1.43×10^{-1}	2.09×10^{12}	15
44	2167	2009.15	6.17097	7.82×10^{-2}	2.28×10^{12}	116
5	1403	2010.46	6.16694	1.70×10^{-1}	2.98×10^{12}	23
3	1403	2016.03	6.14992	1.14×10^{-1}	2.01×10^{12}	16
8	1410	2021.70	6.13268	8.83×10^{-2}	1.96×10^{12}	25
76	2588	2022.76	6.12947	2.60×10^{-1}	3.84×10^{12}	28
43	2167	2024.82	6.12323	1.19×10^{-2}	3.53×10^{11}	18
81	2648	2024.83	6.12319	2.00×10^{-1}	3.56×10^{12}	16
2	1404	2024.91	6.12295	9.86×10^{-2}	2.92×10^{12}	16
42	2167	2026.69	6.11757	2.81×10^{-1}	8.35×10^{12}	424
39	2056	2027.20	6.11604	2.90×10^{-1}	6.46×10^{12}	23
8	1417	2029.15	6.11016	2.16×10^{-1}	4.83×10^{12}	25
6	1413	2029.64	6.10867	1.73×10^{-1}	5.15×10^{12}	17
6	1414	2029.78	6.10826	1.22×10^{-1}	5.46×10^{12}	26
157	4580	2029.83	6.10810	5.54×10^{-2}	1.65×10^{12}	51
44	2250	2030.78	6.10525	1.02×10^{-1}	3.04×10^{12}	168
40	2094	2031.21	6.10395	1.76×10^{-1}	5.26×10^{12}	52
37	2019	2031.71	6.10244	5.56×10^{-1}	9.96×10^{12}	24
8	1421	2032.98	6.09865	2.38×10^{-1}	7.10×10^{12}	21
0	1357	2033.61	6.09677	2.24×10^{-1}	1.00×10^{13}	299
147	3526	2033.64	6.09665	4.25×10^{-2}	1.27×10^{12}	19
147	3527	2033.66	6.09661	1.81×10^{-2}	5.41×10^{11}	22
5	1415	2034.40	6.09437	2.99×10^{-1}	6.71×10^{12}	43
3	1409	2035.14	6.09217	2.20×10^{-1}	3.29×10^{12}	90
14	1466	2035.49	6.09113	5.65×10^{-1}	7.26×10^{12}	15
4	1411	2035.63	6.09070	1.09×10^{-1}	3.25×10^{12}	21
2	1410	2037.02	6.08654	1.48×10^{-1}	3.33×10^{12}	43
5	1416	2037.03	6.08653	1.12×10^{-1}	2.01×10^{12}	26
2	1411	2037.29	6.08576	1.46×10^{-1}	4.38×10^{12}	28
5	1417	2037.40	6.08542	2.14×10^{-1}	4.82×10^{12}	25
3	1412	2037.50	6.08510	5.97×10^{-1}	1.08×10^{13}	50

(*continued on next page*)

Table 20 (*continued*)

i	k	ΔE (eV)	λ (Å)	gf	A (s^{-1})	ϵ (γ/ion/s)
1	1405	2038.01	6.08359	2.22×10^{-1}	1.00×10^{13}	19
146	3526	2038.38	6.08249	1.15×10^{-1}	3.44×10^{12}	52
146	3527	2038.39	6.08245	4.82×10^{-2}	1.45×10^{12}	59
2	1413	2040.31	6.07673	1.52×10^{-1}	4.56×10^{12}	15
3	1416	2042.59	6.06995	9.21×10^{-2}	1.67×10^{12}	22
154	4580	2045.89	6.06017	3.10×10^{-2}	9.38×10^{11}	29
42	2250	2048.32	6.05298	4.05×10^{-2}	1.23×10^{12}	68
40	2167	2049.61	6.04915	9.50×10^{-3}	2.89×10^{11}	15
154	4664	2053.70	6.03710	6.76×10^{-2}	2.06×10^{12}	22
0	1488	2191.53	5.65743	8.12×10^{-4}	2.82×10^{10}	18
0	1489	2197.93	5.64094	7.52×10^{-1}	1.97×10^{13}	221
0	1490	2200.07	5.63547	1.69×10^{-1}	5.93×10^{12}	62
3	1589	2200.83	5.63351	1.51	2.26×10^{13}	33
0	1495	2202.87	5.62831	1.87×10^{-1}	9.83×10^{12}	52
0	1499	2208.31	5.61444	2.08×10^{-1}	5.51×10^{12}	77
0	1503	2212.92	5.60274	5.52×10^{-1}	1.95×10^{13}	172
0	1531	2245.05	5.52256	2.24×10^{-1}	1.22×10^{13}	76
24	2089	2245.43	5.52162	2.43×10^{-1}	6.66×10^{12}	15
45	3844	2281.67	5.43393	2.76×10^{-1}	1.04×10^{13}	34
44	3844	2283.94	5.42853	6.44×10^{-1}	2.43×10^{13}	80
0	1619	2284.51	5.42717	1.99×10^{-3}	4.51×10^{10}	15
45	3908	2289.13	5.41623	6.58×10^{-1}	3.74×10^{13}	56
45	3920	2290.32	5.41341	4.11×10^{-1}	4.68×10^{13}	39
44	3908	2291.39	5.41086	2.38×10^{-1}	1.36×10^{13}	20
44	3917	2292.44	5.40839	4.56×10^{-1}	1.30×10^{13}	32
43	3844	2299.60	5.39155	2.28×10^{-1}	8.72×10^{12}	29
44	4036	2306.24	5.37602	5.21×10^{-1}	2.01×10^{13}	31
42	3917	2309.98	5.36733	1.46	4.23×10^{13}	104
37	3604	2310.54	5.36603	8.04×10^{-2}	1.33×10^{12}	17
43	3972	2313.75	5.35859	1.50	5.80×10^{13}	26
5	1949	2314.07	5.35785	7.84×10^{-2}	1.82×10^{12}	21
156	7225	2314.08	5.35781	1.05×10^{-1}	3.04×10^{12}	25
3	1928	2314.18	5.35759	1.34×10^{-1}	2.60×10^{12}	20
43	3975	2314.31	5.35729	1.19	6.92×10^{13}	16
42	3963	2314.49	5.35687	3.21	7.47×10^{13}	236
0	1676	2314.75	5.35626	1.92×10^{-1}	7.43×10^{12}	96
8	1999	2314.96	5.35577	1.80×10^{-1}	6.98×10^{12}	25
299	8855	2315.74	5.35398	6.99×10^{-1}	4.07×10^{13}	15
3	1934	2316.73	5.35168	1.86×10^{-1}	4.32×10^{12}	28
41	3842	2318.10	5.34853	7.83×10^{-1}	4.56×10^{13}	21
40	3783	2318.25	5.34819	1.59	4.64×10^{13}	60
290	8785	2318.85	5.34681	1.23	4.80×10^{13}	16
155	7261	2320.92	5.34202	8.08×10^{-2}	4.72×10^{12}	14
290	8806	2321.25	5.34126	1.50	4.38×10^{13}	25
9	2119	2321.35	5.34105	1.83	7.14×10^{13}	14
5	1986	2321.71	5.34021	1.76×10^{-1}	3.43×10^{12}	34
9	2124	2322.49	5.33841	1.57	9.19×10^{13}	14
40	3824	2322.69	5.33796	3.19	7.47×10^{13}	87
44	4195	2323.17	5.33686	2.54	7.43×10^{13}	44
38	3783	2323.53	5.33604	4.85×10^{-1}	1.42×10^{13}	18
154	7221	2323.96	5.33505	2.06×10^{-1}	4.82×10^{12}	46
8	2053	2324.25	5.33438	1.08×10^{-1}	4.22×10^{12}	23
40	3844	2324.40	5.33404	1.41×10^{-1}	5.52×10^{12}	18
41	3908	2325.61	5.33127	4.00×10^{-1}	2.34×10^{13}	35
2	1977	2326.57	5.32906	1.63×10^{-1}	3.84×10^{12}	22
8	2064	2326.68	5.32880	5.19×10^{-1}	1.52×10^{13}	57
154	7235	2326.74	5.32867	4.81×10^{-2}	1.88×10^{12}	14
8	2066	2326.75	5.32865	3.47×10^{-1}	1.36×10^{13}	54
6	2041	2326.77	5.32860	3.64×10^{-1}	2.13×10^{13}	23
41	3920	2326.80	5.32853	1.43×10^{-1}	1.68×10^{13}	14
5	2017	2326.90	5.32829	1.35	3.16×10^{13}	31
38	3816	2327.19	5.32763	2.12	6.23×10^{13}	20
295	8917	2327.87	5.32608	4.32	1.01×10^{14}	27
6	2053	2328.90	5.32371	4.93×10^{-1}	1.93×10^{13}	106
8	2075	2328.94	5.32364	1.09	3.19×10^{13}	231
5	2035	2329.35	5.32271	3.18×10^{-1}	9.37×10^{12}	19
3	2004	2329.71	5.32188	1.76	3.45×10^{13}	60
37	3774	2330.43	5.32023	4.53	7.62×10^{13}	16
8	2085	2331.17	5.31854	8.13×10^{-1}	2.40×10^{13}	83
6	2064	2331.34	5.31816	1.44	4.26×10^{13}	161

(*continued on next page*)

Table 20 (*continued*)

i	k	ΔE (eV)	λ (Å)	gf	A (s^{-1})	ϵ (γ/ion/s)
6	2066	2331.40	5.31801	1.12	4.38×10^{13}	173
6	2067	2331.44	5.31792	1.14×10^{-1}	6.74×10^{12}	28
0	1724	2331.68	5.31739	2.38	7.02×10^{13}	768
7	2083	2331.97	5.31672	1.57	9.25×10^{13}	75
282	8798	2333.08	5.31420	4.45	8.76×10^{13}	36
6	2075	2333.59	5.31301	6.90×10^{-2}	2.04×10^{12}	15
8	2102	2334.04	5.31199	2.83	6.70×10^{13}	18
3	2033	2334.84	5.31017	5.55×10^{-1}	9.38×10^{12}	26
1	1958	2334.93	5.30997	7.22×10^{-1}	2.14×10^{13}	45
3	2039	2335.30	5.30914	5.18×10^{-1}	1.02×10^{13}	31
4	2041	2335.78	5.30804	8.17×10^{-1}	4.83×10^{13}	52
6	2085	2335.83	5.30794	1.48	4.37×10^{13}	152
6	2089	2336.17	5.30715	2.79×10^{-1}	8.25×10^{12}	19
1	1968	2336.29	5.30689	7.94×10^{-1}	3.13×10^{13}	18
2	2035	2336.42	5.30658	1.45	4.29×10^{13}	87
1	1973	2337.32	5.30455	5.94×10^{-1}	1.76×10^{13}	39
154	7306	2338.02	5.30296	2.55	6.04×10^{13}	27
42	4168	2338.19	5.30257	1.06	2.53×10^{13}	78
14	2413	2338.87	5.30103	1.48	2.51×10^{13}	26
12	2366	2339.07	5.30059	2.25	4.46×10^{13}	25
3	2060	2339.53	5.29953	6.10	1.04×10^{14}	154
2	2053	2339.57	5.29944	2.49×10^{-1}	9.84×10^{12}	54
282	8852	2340.11	5.29823	5.96×10^{-1}	1.18×10^{13}	23
5	2092	2340.36	5.29766	5.68	1.13×10^{14}	101
4	2066	2340.42	5.29752	4.18×10^{-1}	1.66×10^{13}	66
4	2067	2340.46	5.29743	7.42×10^{-2}	4.41×10^{12}	18
39	3963	2340.56	5.29721	2.17×10^{-1}	5.17×10^{12}	16
12	2386	2341.26	5.29562	1.49	2.95×10^{13}	25
2	2063	2341.63	5.29477	2.92	5.46×10^{13}	14
14	2458	2345.59	5.28583	2.15	3.66×10^{13}	21
18	2523	2346.76	5.28322	3.21	6.40×10^{13}	18
1	2035	2348.35	5.27963	2.35	7.04×10^{13}	143
13	2466	2349.89	5.27617	6.86	1.37×10^{14}	30
12	2458	2350.83	5.27405	5.61	9.61×10^{13}	55
1	2053	2351.50	5.27256	1.47×10^{-1}	5.86×10^{12}	32
1	2067	2354.04	5.26687	1.15×10^{-1}	6.93×10^{12}	29
13	2505	2356.16	5.26213	1.32	2.65×10^{13}	15
1	2075	2356.19	5.26206	2.04×10^{-1}	6.14×10^{12}	44
12	2500	2357.39	5.25938	1.13	1.95×10^{13}	16
1	2085	2358.42	5.25708	7.83×10^{-1}	2.36×10^{13}	82
0	1895	2376.53	5.21703	9.64×10^{-2}	3.94×10^{12}	18
0	1908	2379.80	5.20987	1.18×10^{-1}	3.61×10^{12}	14
0	1958	2393.48	5.18007	2.11×10^{-1}	6.55×10^{12}	14
0	1999	2400.77	5.16435	1.68×10^{-1}	7.01×10^{12}	25
5	2383	2400.91	5.16406	1.75	4.38×10^{13}	23
5	2399	2402.31	5.16105	1.91	4.00×10^{13}	30
5	2407	2403.17	5.15919	3.36	7.01×10^{13}	51
3	2366	2404.43	5.15650	2.86	5.98×10^{13}	34
3	2383	2406.47	5.15212	1.70	4.27×10^{13}	23
3	2386	2406.62	5.15180	7.07	1.48×10^{14}	123
0	2035	2406.90	5.15119	1.07	3.35×10^{13}	68
0	2041	2407.92	5.14902	3.50×10^{-1}	2.20×10^{13}	24
3	2413	2409.47	5.14570	9.68	1.74×10^{14}	179
0	2053	2410.05	5.14446	4.03	1.69×10^{14}	926
5	2455	2410.25	5.14404	2.66	6.71×10^{13}	17
8	2518	2412.08	5.14015	4.90	1.24×10^{14}	21
0	2064	2412.49	5.13927	1.33	4.20×10^{13}	159
0	2066	2412.55	5.13913	2.48	1.04×10^{14}	412
0	2067	2412.59	5.13905	3.81	2.41×10^{14}	1001
0	2073	2414.41	5.13517	1.63×10^{-1}	5.17×10^{12}	16
0	2075	2414.74	5.13447	5.96	1.89×10^{14}	1363
3	2458	2416.19	5.13139	6.47	1.17×10^{14}	67
0	2083	2416.59	5.13055	3.22×10^{-1}	2.04×10^{13}	16
0	2085	2416.97	5.12973	1.89	5.98×10^{13}	207
0	2089	2417.32	5.12899	2.72×10^{-1}	8.64×10^{12}	19
2	2455	2417.33	5.12898	3.82	9.68×10^{13}	25
5	2505	2417.89	5.12779	8.68	1.84×10^{14}	104
3	2500	2422.75	5.11750	2.66	4.84×10^{13}	40
3	2519	2426.02	5.11060	3.64	6.64×10^{13}	80
0	2634	2529.85	4.90084	1.07×10^{-1}	3.72×10^{12}	23

(*continued on next page*)

Table 20 (*continued*)

i	k	ΔE (eV)	λ (Å)	gf	A (s^{-1})	ϵ (γ/ion/s)
0	2833	2561.27	4.84073	9.89×10^{-2}	3.52×10^{12}	21
0	2838	2562.05	4.83926	1.62	7.68×10^{13}	241
0	2852	2564.31	4.83500	4.21×10^{-1}	3.00×10^{13}	68
3	3278	2566.38	4.83110	1.39	2.83×10^{13}	19
3	3279	2566.38	4.83109	1.05	2.51×10^{13}	14
0	2868	2566.67	4.83055	6.79×10^{-1}	4.85×10^{13}	92
0	2881	2568.70	4.82674	2.27	8.13×10^{13}	343
3	3303	2569.67	4.82491	1.61	4.63×10^{13}	16
0	2909	2573.04	4.81860	8.66×10^{-1}	6.22×10^{13}	148
5	3385	2574.36	4.81612	1.64	3.93×10^{13}	15
3	3358	2576.59	4.81194	2.18	4.49×10^{13}	29
0	2940	2578.27	4.80881	7.51×10^{-1}	3.61×10^{13}	137
0	2963	2582.23	4.80144	1.15	4.18×10^{13}	202
0	2965	2582.39	4.80115	2.54×10^{-1}	1.23×10^{13}	36
0	3101	2610.10	4.75017	4.34×10^{-1}	1.60×10^{13}	57
0	3109	2611.22	4.74813	1.96×10^{-1}	9.69×10^{12}	28
44	7225	2635.36	4.70465	4.39×10^{-2}	1.65×10^{12}	14
1	6012	2850.61	4.34939	3.22×10^{-1}	1.42×10^{13}	21
1	6037	2852.91	4.34588	4.62×10^{-1}	2.04×10^{13}	17
0	5379	2853.86	4.34444	2.77×10^{-1}	1.63×10^{13}	25
0	5384	2854.18	4.34395	7.66×10^{-1}	3.38×10^{13}	78
0	5552	2869.27	4.32110	4.08×10^{-1}	3.65×10^{13}	43
0	5570	2870.50	4.31926	3.83×10^{-1}	2.28×10^{13}	36
0	6012	2909.16	4.26185	6.46×10^{-1}	2.97×10^{13}	44
0	6038	2911.94	4.25779	5.03×10^{-1}	3.09×10^{13}	49
0	6062	2914.80	4.25361	4.48×10^{-1}	4.13×10^{13}	47
0	6779	2992.83	4.14271	2.34×10^{-1}	1.14×10^{13}	20
42	11250	3029.86	4.09207	3.39×10^{-2}	2.25×10^{12}	16
42	12163	3169.57	3.91171	1.04	4.51×10^{13}	17
6	10398	3189.09	3.88776	1.91×10^{-1}	1.40×10^{13}	22
6	10414	3190.66	3.88585	2.42×10^{-1}	1.78×10^{13}	26
0	10213	3193.21	3.88275	7.95×10^{-1}	4.39×10^{13}	135
4	10388	3196.42	3.87885	1.98×10^{-1}	2.19×10^{13}	14
3	10392	3197.32	3.87775	1.14	3.60×10^{13}	15
5	10433	3198.42	3.87642	1.95	7.20×10^{13}	21
3	10423	3201.44	3.87276	1.29	4.09×10^{13}	18
1	10411	3212.56	3.85936	9.65×10^{-2}	5.40×10^{12}	16
0	10313	3249.54	3.81544	2.00×10^{-1}	1.15×10^{13}	17
0	10353	3263.70	3.79888	1.96×10^{-1}	1.13×10^{13}	16
3	10639	3263.95	3.79859	1.59	5.24×10^{13}	17
3	10655	3265.70	3.79656	1.17	4.51×10^{13}	14
0	10369	3265.93	3.79629	3.84×10^{-1}	2.96×10^{13}	47
0	10377	3266.90	3.79517	1.94×10^{-1}	2.25×10^{13}	24
0	10388	3268.55	3.79325	2.28×10^{-1}	2.64×10^{13}	17
0	10398	3270.24	3.79129	5.09×10^{-1}	3.94×10^{13}	61
0	10405	3270.83	3.79060	5.51×10^{-1}	6.40×10^{13}	83
0	10411	3271.11	3.79028	1.48	8.56×10^{13}	251
0	10414	3271.81	3.78947	5.54×10^{-1}	4.29×10^{13}	62
0	11578	3497.91	3.54452	3.13×10^{-1}	2.77×10^{13}	28
0	11597	3500.52	3.54188	2.09×10^{-1}	2.78×10^{13}	19
0	11610	3503.60	3.53877	4.89×10^{-1}	3.25×10^{13}	44
0	11616	3504.19	3.53817	2.49×10^{-1}	3.32×10^{13}	22
0	11663	3512.41	3.52989	2.94×10^{-1}	2.62×10^{13}	25
0	11681	3514.64	3.52765	3.51×10^{-1}	2.35×10^{13}	29