Energy Levels of Zinc, Zn I through Zn XXX

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Jack Sugar, and Arlene Musgrove

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Jack Sugar and Arlene Musgrove

Atomic Physics Division, Physics Laboratory, National Institute of Standards and Technology, Gaithersburg, MD 20899–0001

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Atomic energy levels of zinc have been compiled for all stages of ionization for which experimental data are available. No data have yet been published for Zn IX, Zn X, Zn XXVI, and Zn XXVIII, and only several resonance lines of Zn XXIX and Zn XXX. Very accurate calculated values are compiled for Zn XXIX and Zn XXX. Experimental g-factors and leading percentages from calculated eigenvectors are given. A value for the ionization energy, either experimental when available or theoretical, is included for the neutral atom and each ion. A review of the published literature is given. ©*1995 American Institute of Physics and American Chemical Society.*

Key words: atomic; energy levels; ions; spectra; zinc.

Contents

1. Introduction

In 1952 C. E. Moore published a compilation of energy levels of zinc containing the results of extensive analyses of Zn I through Zn III. We now have experimental energy levels for most stages of ionization of Zn, and very accurate calculated levels for Zn XXIX (He-like) and Zn XXX (H-like). Only for the ions Zn IX, Zn X, Zn XXVI, and Zn XXVIII are there no experimental or theoretical data. New results have been published on Zn I, Zn II, and Zn III, the only spectra of Zn included in the 1952 compilation.

The present critical compilation of the atomic energy levels of zinc in all stages of ionization is part of an ongoing program of the National Institute of Standards and Technology (formerly the National Bureau of Standards) Atomic Energy Levels Data Center to compile similar data for all the elements. These publications include helium by Martin [1973, 1987], O II by Martin *et al.* [1993], sodium, magnesium, aluminum, and silicon by Martin and Zalubas [1981, 1980, 1979, 1983], and phosphorus and sulfur by Martin, Zalubas, and Musgrove [1985, 1990], potassium through nickel by Sugar and Corliss [1985], copper, germanium, krypton, and molybdenum by Sugar and Musgrove [1990, 1993, 1991, 1988], and lanthanum through lutetium by Martin, Zalubas, and Hagan [1978].

Companion works containing wavelengths for the higher stages of ionization have been prepared in collaboration with the Japanese Atomic Energy Research Institute in Tokai-Mura, Japan. These include titanium by Mori *et al.* [1986] and vanadium, chromium, manganese, iron, cobalt, nickel, copper, and molybdenum by Shirai *et al.* [1992a, 1993, 1994, 1990, 1992b, 1987a, 1991, 1987b]. In addition, wavelength compilations including data for all stages of ionization have been published for Sc by Kaufman and Sugar [1988] and for Mg, Al, and S by Kaufman and Martin [1991a, 1991b, 1993] and O II by Martin *et al.* [1993].

The strong lines of Zn I through Zn V are contained in "Line Spectra of the Elements" edited by Reader and Corliss [1993], which appears in the *CRC Handbook of Chemistry and Physics*. These data also appear in the NIST Standard Reference Database 38 [1992]. A compilation published by Kelly [1987] gives wavelengths of zinc spectra below 2000 Å and their energy level classifications.

All energy levels are given in units of cm^{-1}. A review of the spectroscopic literature for each ion is given, including wavelength and energy level uncertainty estimates. Ionization energies are given in cm^{-1} and in eV, with the conversion factor 8065.5410(24) cm^{-1}/eV published by Cohen and Taylor [1987].

Generally, uncertainties are not given for each energy level by the authors quoted. Instead they are given for a range of measured wavelengths. From these one may roughly deduce an uncertainty for a range of energy levels. These are one standard deviation estimates.

We use without comment notations for various coupling schemes as appropriate. Martin, Zalubas, and Hagan [1978] give a complete summary of the coupling notations used here and tables of the allowed terms for equivalent electrons.

We have included under the heading "Leading percentages" the results of calculations that express the eigenvector percentage composition of levels (rounded to the nearest percent) in terms of the basis states of a single configuration, or more than one configuration where configuration interaction has been included. We give first the percentage of the basis state corresponding to the level's name; next the second largest percentage together with the related basis state. Generally, when the leading percentage is less than 40%, no name is given. However, when two different parent states give rise to the same final term type and the sum of their percentages is ⩾40%, the level is designated by the higher percentage term. For an unnamed level, the term symbol for the leading percentage follows the percentage. The user should of course bear in mind that the percentages are model dependent, so that the results of different calculations may yield notably different percentages.

For configurations of equivalent *d*-electrons, several terms of the same *LS* type may occur. These are theoretically distinguished by their seniority number. In our compilations they are designated in the notation of Nielson and Koster [1963]. For example, in the $3d^5$ configuration there are three ^{2}D terms with seniorities of 1, 3, and 5. These terms are denoted as ^{2}D1, ^{2}D2, and ^{2}D3 respectively, by Nielson and Koster.

In cases where the ionization energies cannot be determined from the experimetnal data, we have calculated the binding energy of the outermost electron with Cowan's [1981] Hartree Fock code (HFR) with relativistic and correlation corrections included. The uncertainty in these determinations varies from ±0.1% to 1.0%. It is given in some cases for comparison with the experimental values.

The text for each spectrum does not include a complete review of the literature but is intended to credit the major past contributions as well as those whose results are compiled. In assembling the data for each spectrum, we referred to the following bibliographies:

i. Papers cited by Moore (1952)
ii. C. E. Moore (1969)
iii. L. Hagan and W. C. Martin (1972)
iv. L. Hagan (1977)
v. R. Zalubas and A. Albright (1980)
vi. A. Musgrove and R. Zalubas (1985)
vii. Bibliographic file of publications since December 1983 maintained by the NIST Atomic Energy Levels Data Center

2. Acknowledgments

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3. Tables of Energy Levels

Zn I

$Z=30$

Ground state $1s^22s^22p^63s^23p^63d^{10}4s^2\ ^1S_0$

Ionization energy 75 769.33 ± 0.18 cm^{-1} (9.394 203 ± 0.000 02 eV)

Early work on the 4*snl* series was published by Paschen and Götze [1922] and by Fowler [1922]. More accurate wavelengths in the range of 2178−7799 Å were measured by Hetzler *et al.* [1935] using prism, grating and interferometric observations. They gave energy levels with two or three place decimal values.

With a specially designed hollow cathode discharge Muntenbruch [1960] was able to observe forbidden $4s4p-4snl$ transitions with nl=$5p-11p$, $5f-8f$, $5g-8g$, $6h-9h$, and $7i-8i$. These lines were in the range of 2394−2839 Å.

New measurements of 45 lines in the range of 3000−25 000 Å with a hollow cathode source were made by Johansson and Contreras [1967]. The wavenumber accuracy was estimated to be ±0.02 cm^{-1} in the range of 13 000−25 000 Å and ±0.01 cm^{-1} for the shorter wavelengths. Agreement with the wavelengths of Hetzler *et al.* was found to be very good, and their values were used for lines not observed by Johansson and Contreras. They redetermined all the energy level values for the terms of 4*snl* with nl=$5s-9s$, $4p-9p$, $4d-6d$, and $4f-5f$. The estimated uncertainties for these levels is ±0.02 cm^{-1} except for those given to three decimal places. The uncertainty of the latter is ±0.002 cm^{-1}.

High-dispersion absorption spectra were obtained by Brown *et al.* [1975] in the range of 1300−1750 Å with an uncertainty of ±0.003 Å (except for broad, blended, or diffuse features). Both electric dipole and electric quadrupole series were observed as well as intersystem series. They include $4snp\ ^1P^\circ_1$ through n=66, $4snp\ ^3P^\circ_1$ through n=12, and $4snd\ ^1D_2$ through n=20. The $^1P^\circ$ series was used to determine the quoted value for the ionization energy. We give their level values for $^1P^\circ_1$ (n>7), $^1D_2$ (n>7), and $^3P^\circ_1$ (n>10) with an estimated uncertainty of ±0.10 cm^{-1}.

The $4p^2$ configuration lies above the first ionization limit. The ^1S and ^1D terms mix with the $\epsilon s\ ^1S$ and $\epsilon d\ ^1D_2$ continua and are too broad to observe. Although there is no even parity $\epsilon p\ ^3P$ continuum the $^3P_2$ level is broadened by its mixture with $^1D_2$ due to the spin-orbit interaction. This was recognized by Majorana [1931]. The four sharp lines $4s4p\ ^3P^\circ_{0,1,2}-4p^2\ ^3P_{0,1}$ were identified by Sawyer [1926]. The two diffuse lines at 2070 and 2087 Å were incorrectly classified by Sawyer as the $4s4p\ ^3P^\circ_{1,2}-4p^2\ ^1D_2$ lines. New measurements of the $4s4p\ ^3P^\circ-4p^2\ ^3P$ multiplet were made by Martin and Kaufman [1970] with an uncertainty of ±0.001 Å for the four sharp lines and ±0.03 Å for the two diffuse lines which arise from the $4p^2\ ^3P_2$ level.

Inner shell transitions $3d^{10}4s^2-3d^94s^2np$, *nf* have been observed in absorption by Beutler and Guggenheimer [1933] through 12*p* and 5*f* with a wavelength uncertainty of ±0.03Å. Garton and Connerade [1969] reduced the measurement uncertainty to ±0.007 and extended the number of series members. They proposed the *jl*-coupling scheme for these series. This was confirmed by Martin *et al.* [1972] who calculated the percentage composition of the $3d^94s^24p$ and 5*p* configurations. The coupling for $3d^94p$ is much purer in *LS* whereas the $3d^95p$ levels are close to 100% pure in *jl*-coupling. They conclude that *jl*-coupling will prevail for the higher $3d^9np$ levels.

More accurate and more extensive observations of these series were carried out by Sommer *et al.* [1987] using synchrotron radiation as the background source. Their observations were in the range of 700−760 Å with a wavelength uncertainty for sharp lines of ±0.004 Å. This provides a level uncertainty of ±1 cm^{-1}. The two series $3d^9(^2D_{3/2})4s^2np\ ^2[^3/_2]^\circ_1$ and $^2[^1/_2]^\circ_1$ are unresolved from n=13 upward. We give their results for the *np* and *nf* series. They do not report values for 4*p* and 5*p*. We obtained the 4*p* levels from Martin *et al.* and the 5*p* from Garton and Connerade. Sommer *et al.* have calculated these series using multi-channel quantum defect theory. Their results agree with observations to within ±1 cm^{-1} for high series members. The $^2D_{3/2,5/2}$ limits were derived from the Zn II $3d^94s^2\ ^2D$ levels and the ionization energy of Zn I from Brown *et al.*

Using synchrotron radiation for their background continuum source Mansfield and Connerade [1978] observed 120 two-electron absorption resonances. They occur in two groups: one at 900−990 Å due to excitation of two valence electrons, and the other at 420−610 Å due to excitation of one 3*d* electron and one valence electron. Their wavelength uncertainty varies from ±0.03 Å above 700 Å to ±0.06 Å below 500 Å giving level uncertainties of ±6 cm^{-1} and ±25 cm^{-1}, respectively. The detection of double excitation series is attributed by these authors to their mixing with configurations due to one-electron inner-shell excitations, in this case with the $3d^94s^2np$ series. Mansfield and Connerade include many tentative assignments to Rydberg series which we have not quoted.

The *g*-values for three levels are taken from the compilation of this spectrum by C. E. Moore [1971].

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Zn I

Configuration	Term	J	Level (cm^{-1})	g	Leading percentages
$4s^2$	^1S	0	0.000		
$4s4p$	$^3P^\circ$	0	*32 311.350*		
		1	*32 501.421*	1.496	
		2	*32 890.352*	1.505	
$4s4p$	$^1P^\circ$	1	*46 745.413*		
$4s5s$	^3S	1	53 672.280	2.001	
$4s5s$	^1S	0	55 789.228		
$4s5p$	$^3P^\circ$	0	*61 247.904*		
		1	*61 274.455*		
		2	*61 330.891*		
$4s4d$	^1D	2	62 458.56		
$4s4d$	^3D	1	62 768.756		
		2	62 772.029		
		3	62 776.993		
$4s5p$	$^1P^\circ$	1	*62 910.45*		
$4s6s$	^3S	1	65 432.333		
$4s6s$	^1S	0	66 037.68		
$4s6p$	$^3P^\circ$	0	*68 070.89*		
		1	*68 080.70*		
		2	*68 101.81*		
$4s5d$	^1D	2	68 338.51		
$4s5d$	^3D	1	68 579.19		
		2	68 580.73		
		3	68 583.12		
$4s6p$	$^1P^\circ$	1	*68 607.26*		
$4s4f$	$^3F^\circ$	2	*68 833.79*		
		3	*68 833.93*		
		4	*68 834.03*		
$4s4f$	$^1F^\circ$	3	*68 834.25*		
$4s7s$	^3S	1	69 745.96		

Zn I — Continued

Configuration	Term	J	Level (cm^{-1})	g	Leading percentages
4s7s	^{1}S	0	70 003.73		
4s7p	^{3}P°	0	*70 977.17*		
		1	*70 982.00*		
		2	*70 992.19*		
4s6d	^{1}D	2	71 050.47		
4s6d	^{3}D	1	71 212.18		
		2	71 213.02		
		3	71 214.29		
4s7p	^{1}P°	1	*71 219.02*		
4s5f	^{3}F°	2−4	*71 335.6*		
4s6f	^{3}F°	2−4	*72 690.8*		
4s7f	^{3}F°	2−4	*73 499.5*		
4s5f	^{1}F°	3	*71 336.15*		
4s5g	^{3}G	3−5	71 373.8		
4s6g	^{3}G	3−5	72 710.2		
4s7g	^{3}G	3−5	73 517.0		
4s8g	^{3}G	3−5	74 041		
4s8s	^{1}S	0	71 956.21		
4s8p	^{3}P°	0	*72 495.82*		
		1	*72 498.58*		
		2	*72 504.23*		
4s7d	^{1}D	2	72 516.98		
4s8d	^{1}D	2	73 395.42		
4s9d	^{1}D	2	73 961.89		
4s10d	^{1}D	2	74 348.18		
4s11d	^{1}D	2	74 622.77		
4s12d	^{1}D	2	74 825.05		
4s13d	^{1}D	2	74 978.20		
4s14d	^{1}D	2	75 097.09		
4s15d	^{1}D	2	75 191.06		
4s16d	^{1}D	2	75 266.61		
4s17d	^{1}D	2	75 328.42		
4s18d	^{1}D	2	75 379.33		
4s19d	^{1}D	2	75 422.01		
4s20d	^{1}D	2	75 458.13		
4s8p	^{1}P°	1	*72 626.32*		
4s9p	^{1}P°	1	*73 469.37*		
4s10p	^{1}P°	1	*74 013.87*		
4s11p	^{1}P°	1	*74 385.80*		
4s12p	^{1}P°	1	*74 650.87*		
4s13p	^{1}P°	1	*74 846.54*		
4s14p	^{1}P°	1	*74 994.99*		
4s15p	^{1}P°	1	*75 110.31*		
4s16p	^{1}P°	1	*75 201.67*		
4s17p	^{1}P°	1	*75 275.31*		
4s18p	^{1}P°	1	*75 335.50*		
4s19p	^{1}P°	1	*75 385.25*		
4s20p	^{1}P°	1	*75 427.00*		
4s21p	^{1}P°	1	*75 462.27*		
4s22p	^{1}P°	1	*75 492.28*		
4s23p	^{1}P°	1	*75 518.21*		
4s24p	^{1}P°	1	*75 540.59*		
4s25p	^{1}P°	1	*75 560.17*		

Zn I — Continued

Configuration	Term	*J*	Level (cm⁻¹)	*g*	Leading percentages
4s26p	$^1P°$	1	*75 577.27*		
4s27p	$^1P°$	1	*75 592.42*		
4s28p	$^1P°$	1	*75 605.81*		
4s29p	$^1P°$	1	*75 617.67*		
4s30p	$^1P°$	1	*75 628.40*		
4s31p	$^1P°$	1	*75 637.92*		
4s32p	$^1P°$	1	*75 646.59*		
4s33p	$^1P°$	1	*75 654.41*		
4s34p	$^1P°$	1	*75 661.50*		
4s35p	$^1P°$	1	*75 667.95*		
4s36p	$^1P°$	1	*75 673.84*		
4s37p	$^1P°$	1	*75 679.22*		
4s38p	$^1P°$	1	*75 684.19*		
4s39p	$^1P°$	1	*75 688.76*		
4s40p	$^1P°$	1	*75 692.90*		
4s41p	$^1P°$	1	*75 696.79*		
4s42p	$^1P°$	1	*75 700.40*		
4s43p	$^1P°$	1	*75 703.73*		
4s44p	$^1P°$	1	*75 706.85*		
4s45p	$^1P°$	1	*75 709.68*		
4s46p	$^1P°$	1	*75 712.36*		
4s47p	$^1P°$	1	*75 714.88*		
4s48p	$^1P°$	1	*75 717.25*		
4s49p	$^1P°$	1	*75 719.45*		
4s50p	$^1P°$	1	*75 721.52*		
4s51p	$^1P°$	1	*75 723.43*		
4s52p	$^1P°$	1	*75 725.27*		
4s53p	$^1P°$	1	*75 726.99*		
4s54p	$^1P°$	1	*75 728.58*		
4s55p	$^1P°$	1	*75 730.15*		
4s56p	$^1P°$	1	*75 731.53*		
4s57p	$^1P°$	1	*75 732.91*		
4s58p	$^1P°$	1	*75 734.24*		
4s59p	$^1P°$	1	*75 735.44*		
4s60p	$^1P°$	1	*75 736.54*		
4s61p	$^1P°$	1	*75 737.71*		
4s62p	$^1P°$	1	*75 738.84*		
4s63p	$^1P°$	1	*75 739.80*		
4s64p	$^1P°$	1	*75 740.79*		
4s65p	$^1P°$	1	*75 741.58*		
4s66p	$^1P°$	1	*75 742.38*		
4s6h	^3H	4–6	72 731.2		
4s7h	^3H	4–6	73 534.9		
4s8h	^3H	4–6	74 053.7		
4s9h	^3H	4–6	74 409.3		
4s9s	^1S	0	73 060.65		
4s9p	$^3P°$	1	*73 392.30*		
		2	*73 395.88*		
4s7i	^3I	5–7	73 554.8		
4s8i	^3I	5–7	74 066.3		
4s10p	$^3P°$	1	*73 964.33*		
4s11p	$^3P°$	1	*74 351.85*		
4s12p	$^3P°$	1	*74 626.80*		

Zn I — Continued

Configuration	Term	J	Level (cm^{-1})	g	Leading percentages
Zn II ($^2S_{1/2}$)	***Limit***		**75 769.33**		
$4p^2$	^3P	0	80 175.04		
		1	80 394.20		
		2	80 792.1		
$3d^94s^24p$	$^3P^\circ$	1	*90 227*		96
$3d^94s^24p$	$^3D^\circ$	1	*95 209*		79
$3d^94s^24p$	$^1P^\circ$	1	*95 792*		76
$3d^{10}4p(^2P^\circ_{1/2})5s$	$^2[^1/_2]^\circ$	1	*101 945*		or $3d^{10}4p5s$ $^3P^\circ$
$3d^{10}4p(^2P^\circ_{1/2})6s$	$^2[^1/_2]^\circ$	1	*113 949*		or $3d^{10}4p6s$ $^3P^\circ$
$3d^{10}4p(^2P^\circ_{1/2})7s$	$^2[^1/_2]^\circ$	1	*118 151*		
$3d^{10}4p(^2P^\circ_{1/2})8s$	$^2[^1/_2]^\circ$	1	*120 301*		
$3d^{10}4p(^2P^\circ_{1/2})9s$	$^2[^1/_2]^\circ$	1	*121 480*		
$3d^{10}4p(^2P^\circ_{1/2})10s$	$^2[^1/_2]^\circ$	1	*122 192*		
$3d^{10}4p(^2P^\circ_{1/2})11s$	$^2[^1/_2]^\circ$	1	*122 648*		
$3d^{10}4p(^2P^\circ_{1/2})12s$	$^2[^1/_2]^\circ$	1	*122 985*		
$3d^{10}4p(^2P^\circ_{1/2})16s$	$^2[^1/_2]^\circ$	1	*123 636*		
$3d^{10}4p(^2P^\circ_{1/2})17s$	$^2[^1/_2]^\circ$	1	*123 712*		
$3d^{10}4p(^2P^\circ_{3/2})5s$	$^2[^3/_2]^\circ$	1	*103 001*		or $3d^{10}4p5s$ $^1P^\circ$
$3d^{10}4p(^2P^\circ_{3/2})6s$	$^2[^3/_2]^\circ$	1	*114 978*		or $3d^{10}4p6s$ $^1P^\circ$
$3d^{10}4p(^2P^\circ_{3/2})7s$	$^2[^3/_2]^\circ$	1	*119 188*		
$3d^{10}4p(^2P^\circ_{3/2})8s$	$^2[^3/_2]^\circ$	1	*121 275*		
$3d^{10}4p(^2P^\circ_{3/2})9s$	$^2[^3/_2]^\circ$	1	*122 374*		
$3d^{10}4p(^2P^\circ_{3/2})10s$	$^2[^3/_2]^\circ$	1	*123 063*		
$3d^{10}4p(^2P^\circ_{3/2})11s$	$^2[^3/_2]^\circ$	1	*123 533*		
$3d^{10}4p(^2P^\circ_{3/2})12s$	$^2[^3/_2]^\circ$	1	*123 843*		
$3d^{10}4p(^2P^\circ_{3/2})13s$	$^2[^3/_2]^\circ$	1	*124 083*		
$3d^{10}4p(^2P^\circ_{3/2})14s$	$^2[^3/_2]^\circ$	1	*124 265*		
$3d^{10}4p(^2P^\circ_{3/2})15s$	$^2[^3/_2]^\circ$	1	*124 388*		
$3d^{10}4p(^2P^\circ_{3/2})16s$	$^2[^3/_2]^\circ$	1	*124 515*		
$3d^{10}4p(^2P^\circ_{3/2})17s$	$^2[^3/_2]^\circ$	1	*124 595*		
$3d^{10}4p(^2P^\circ_{3/2})18s$	$^2[^3/_2]^\circ$	1	*124 662*		
$3d^{10}4p(^2P^\circ_{3/2})19s$	$^2[^3/_2]^\circ$	1	*124 717*		
$3d^{10}4p(^2P^\circ_{3/2})20s$	$^2[^3/_2]^\circ$	1	*124 761*		
$3d^{10}4p(^2P^\circ_{3/2})4d$	$^2[^3/_2]^\circ$	1	*113 167*		or $3d^{10}4p4d$ $^1P^\circ$
$3d^{10}4p(^2P^\circ_{3/2})5d$	$^2[^3/_2]^\circ$	1	*118 437*		or $3d^{10}4p5d$ $^1P^\circ$
$3d^{10}4p(^2P^\circ_{3/2})6d$	$^2[^3/_2]^\circ$	1	*120 745*		or $3d^{10}4p6d$ $^1P^\circ$
$3d^{10}4p(^2P^\circ_{1/2})5d$	$^2[^3/_2]^\circ$	1	*117 130*		or $3d^{10}4p5d$ $^3D^\circ$
$3d^{10}4p(^2P^\circ_{1/2})6d$	$^2[^3/_2]^\circ$	1	*119 777*		or $3d^{10}4p6d$ $^3D^\circ$
$3d^{10}4p(^2P^\circ_{1/2})7d$	$^2[^3/_2]^\circ$	1	*121 112*		or $3d^{10}4p7d$ $^3D^\circ$
$3d^{10}4p(^2P^\circ_{1/2})8d$	$^2[^3/_2]^\circ$	1	*122 530*		or $3d^{10}4p8d$ $^3D^\circ$
$3d^9(^2D_{5/2})4s^25p$	$^2[^3/_2]^\circ$	1	*123 470*		98
$3d^9(^2D_{5/2})4s^26p$	$^2[^3/_2]^\circ$	1	*130 632*		
$3d^9(^2D_{5/2})4s^27p$	$^2[^3/_2]^\circ$	1	*133 624.4*		
$3d^9(^2D_{5/2})4s^28p$	$^2[^3/_2]^\circ$	1	*135 167.5*		
$3d^9(^2D_{5/2})4s^29p$	$^2[^3/_2]^\circ$	1	*136 076.8*		
$3d^9(^2D_{5/2})4s^210p$	$^2[^3/_2]^\circ$	1	*136 666.6*		
$3d^9(^2D_{5/2})4s^211p$	$^2[^3/_2]^\circ$	1	*137 059.6*		
$3d^9(^2D_{5/2})4s^212p$	$^2[^3/_2]^\circ$	1	*137 338.9*		
$3d^9(^2D_{5/2})4s^213p$	$^2[^3/_2]^\circ$	1	*137 543.2*		
$3d^9(^2D_{5/2})4s^214p$	$^2[^3/_2]^\circ$	1	*137 698.0*		
$3d^9(^2D_{5/2})4s^215p$	$^2[^3/_2]^\circ$	1	*137 816.3*		
$3d^9(^2D_{5/2})4s^216p$	$^2[^3/_2]^\circ$	1	*137 914.5*		
$3d^9(^2D_{5/2})4s^217p$	$^2[^3/_2]^\circ$	1	*137 990.2*		
$3d^9(^2D_{5/2})4s^218p$	$^2[^3/_2]^\circ$	1	*138 051.2*		
$3d^9(^2D_{5/2})4s^219p$	$^2[^3/_2]^\circ$	1	*138 102.4*		

Zn I — Continued

Configuration	Term	J	Level (cm^{-1})	g	Leading percentages
$3d^9(^2D_{5/2})4s^2 20p$	$^2[^3/_2]^\circ$	1	138 146.0		
$3d^9(^2D_{5/2})4s^2 21p$	$^2[^3/_2]^\circ$	1	138 182.4		
$3d^9(^2D_{5/2})4s^2 22p$	$^2[^3/_2]^\circ$	1	138 214.6		
$3d^9(^2D_{5/2})4s^2 23p$	$^2[^3/_2]^\circ$	1	138 238.0		
$3d^9(^2D_{5/2})4s^2 24p$	$^2[^3/_2]^\circ$	1	138 260.9		
$3d^9(^2D_{5/2})4s^2 25p$	$^2[^3/_2]^\circ$	1	138 282.2		
$3d^9(^2D_{5/2})4s^2 26p$	$^2[^3/_2]^\circ$	1	138 300.3		
$3d^9(^2D_{5/2})4s^2 27p$	$^2[^3/_2]^\circ$	1	138 314.4		
$3d^9(^2D_{5/2})4s^2 28p$	$^2[^3/_2]^\circ$	1	138 328.8		
$3d^9(^2D_{5/2})4s^2 29p$	$^2[^3/_2]^\circ$	1	138 341.3		
$3d^9(^2D_{5/2})4s^2 30p$	$^2[^3/_2]^\circ$	1	138 352.1		
$3d^9(^2D_{5/2})4s^2 31p$	$^2[^3/_2]^\circ$	1	138 360.6		
$3d^9(^2D_{5/2})4s^2 32p$	$^2[^3/_2]^\circ$	1	138 369.6		
$3d^9(^2D_{5/2})4s^2 33p$	$^2[^3/_2]^\circ$	1	138 377.2		
Zn II ($^2P^\circ_{1/2}$)	*Limit*		124 250.3		
Zn II ($^2P^\circ_{3/2}$)	*Limit*		125 124.4		
$3d^9(^2D_{3/2})4s^2 5p$	$^2[^1/_2]^\circ$	1	125 934		
$3d^9(^2D_{3/2})4s^2 6p$	$^2[^1/_2]^\circ$	1	133 209.8		
$3d^9(^2D_{3/2})4s^2 7p$	$^2[^1/_2]^\circ$	1	136 274.6		
$3d^9(^2D_{3/2})4s^2 8p$	$^2[^1/_2]^\circ$	1	137 860.2		
$3d^9(^2D_{3/2})4s^2 9p$	$^2[^1/_2]^\circ$	1	138 787.2		
$3d^9(^2D_{3/2})4s^2 10p$	$^2[^1/_2]^\circ$	1	139 375.3		
$3d^9(^2D_{3/2})4s^2 11p$	$^2[^1/_2]^\circ$	1	139 774.4		
$3d^9(^2D_{3/2})4s^2 12p$	$^2[^1/_2]^\circ$	1	140 057.5		
$3d^9(^2D_{3/2})4s^2 13p$	$^2[^1/_2]^\circ$	1	140 264.4		
$3d^9(^2D_{3/2})4s^2 14p$	$^2[^1/_2]^\circ$	1	140 420.3		
$3d^9(^2D_{3/2})4s^2 15p$	$^2[^1/_2]^\circ$	1	140 541.8		
$3d^9(^2D_{3/2})4s^2 16p$	$^2[^1/_2]^\circ$	1	140 636.2		
$3d^9(^2D_{3/2})4s^2 17p$	$^2[^1/_2]^\circ$	1	140 712.3		
$3d^9(^2D_{3/2})4s^2 18p$	$^2[^1/_2]^\circ$	1	140 776.1		
$3d^9(^2D_{3/2})4s^2 19p$	$^2[^1/_2]^\circ$	1	140 826.8		
$3d^9(^2D_{3/2})4s^2 20p$	$^2[^1/_2]^\circ$	1	140 870.3		
$3d^9(^2D_{3/2})4s^2 21p$	$^2[^1/_2]^\circ$	1	140 906.0		
$3d^9(^2D_{3/2})4s^2 22p$	$^2[^1/_2]^\circ$	1	140 938.0		
$3d^9(^2D_{3/2})4s^2 23p$	$^2[^1/_2]^\circ$	1	140 963.3		
$3d^9(^2D_{3/2})4s^2 24p$	$^2[^1/_2]^\circ$	1	140 986.6		
$3d^9(^2D_{3/2})4s^2 25p$	$^2[^1/_2]^\circ$	1	141 007.0		
$3d^9(^2D_{3/2})4s^2 26p$	$^2[^1/_2]^\circ$	1	141 025.2		
$3d^9(^2D_{3/2})4s^2 27p$	$^2[^1/_2]^\circ$	1	141 040.3		
$3d^9(^2D_{3/2})4s^2 28p$	$^2[^1/_2]^\circ$	1	141 052.3		
$3d^9(^2D_{3/2})4s^2 5p$	$^2[^3/_2]^\circ$	1	126 263		
$3d^9(^2D_{3/2})4s^2 6p$	$^2[^3/_2]^\circ$	1	133 336.7		
$3d^9(^2D_{3/2})4s^2 7p$	$^2[^3/_2]^\circ$	1	136 333.7		
$3d^9(^2D_{3/2})4s^2 8p$	$^2[^3/_2]^\circ$	1	137 891.0		
$3d^9(^2D_{3/2})4s^2 9p$	$^2[^3/_2]^\circ$	1	138 806.1		
$3d^9(^2D_{3/2})4s^2 10p$	$^2[^3/_2]^\circ$	1	139 388.7		
$3d^9(^2D_{3/2})4s^2 11p$	$^2[^3/_2]^\circ$	1	139 782.4		
$3d^9(^2D_{3/2})4s^2 12p$	$^2[^3/_2]^\circ$	1	140 062.1		
$3d^9(^2D_{3/2})4s^2 13p$	$^2[^3/_2]^\circ$	1	140 264.4		
$3d^9(^2D_{3/2})4s^2 14p$	$^2[^3/_2]^\circ$	1	140 420.3		
$3d^9(^2D_{3/2})4s^2 15p$	$^2[^3/_2]^\circ$	1	140 541.8		
$3d^9(^2D_{3/2})4s^2 16p$	$^2[^3/_2]^\circ$	1	140 636.2		
$3d^9(^2D_{3/2})4s^2 17p$	$^2[^3/_2]^\circ$	1	140 712.3		
$3d^9(^2D_{3/2})4s^2 18p$	$^2[^3/_2]^\circ$	1	140 776.1		
$3d^9(^2D_{3/2})4s^2 19p$	$^2[^3/_2]^\circ$	1	140 826.8		

Zn I — Continued

Configuration	Term	J	Level (cm^{-1})	g	Leading percentages
$3d^9(^2D_{3/2})4s^2 20p$	$^2[^3/_2]^\circ$	1	*140 870.3*		
$3d^9(^2D_{3/2})4s^2 21p$	$^2[^3/_2]^\circ$	1	*140 906.0*		
$3d^9(^2D_{3/2})4s^2 22p$	$^2[^3/_2]^\circ$	1	*140 938.0*		
$3d^9(^2D_{3/2})4s^2 23p$	$^2[^3/_2]^\circ$	1	*140 963.3*		
$3d^9(^2D_{3/2})4s^2 24p$	$^2[^3/_2]^\circ$	1	*140 986.6*		
$3d^9(^2D_{3/2})4s^2 25p$	$^2[^3/_2]^\circ$	1	*141 007.0*		
$3d^9(^2D_{3/2})4s^2 26p$	$^2[^3/_2]^\circ$	1	*141 025.2*		
$3d^9(^2D_{3/2})4s^2 27p$	$^2[^3/_2]^\circ$	1	*141 040.3*		
$3d^9(^2D_{3/2})4s^2 28p$	$^2[^3/_2]^\circ$	1	*141 052.3*		
$3d^9(^2D_{5/2})4s^2 4f$	$^2[^1/_2]^\circ$	1	*131 540.5*		
$3d^9(^2D_{5/2})4s^2 4f$	$^2[^3/_2]^\circ$	1	*131 546.2*		
$3d^9(^2D_{5/2})4s^2 5f$	$^2[^1/_2]^\circ$,$^2[^3/_2]^\circ$	1	*134 050.7*		
$3d^9(^2D_{3/2})4s^2 4f$	$^2[^3/_2]^\circ$	1	*134 263.0*		
$3d^9(^2D_{3/2})4s^2 5f$	$^2[^3/_2]^\circ$	1	*136 763.7*		
$3d^9(^2D_{3/2})4s^2 6f$	$^2[^3/_2]^\circ$	1	*138 132.8*		
$3d^9(^2D_{3/2})4s^2 7f$	$^2[^3/_2]^\circ$	1	*138 955.7*		
$3d^9(^2D_{3/2})4s^2 8f$	$^2[^3/_2]^\circ$	1	*139 486.1*		
$3d^9(^2D_{3/2})4s^2 9f$	$^2[^3/_2]^\circ$	1	*139 850.1*		
$3d^9(^2D_{3/2})4s^2 10f$	$^2[^3/_2]^\circ$	1	*140 111.0*		
$3d^9(^2D_{3/2})4s^2 11f$	$^2[^3/_2]^\circ$	1	*140 305.6*		
$3d^9(^2D_{3/2})4s^2 12f$	$^2[^3/_2]^\circ$	1	*140 449.8*		
$3d^9(^2D_{3/2})4s^2 13f$	$^2[^3/_2]^\circ$	1	*140 564.1*		
$3d^9(^2D_{3/2})4s^2 14f$	$^2[^3/_2]^\circ$	1	*140 654.6*		
$3d^9(^2D_{3/2})4s^2 15f$	$^2[^3/_2]^\circ$	1	*140 728.2*		
$3d^9(^2D_{3/2})4s^2 16f$	$^2[^3/_2]^\circ$	1	*140 787.1*		
$3d^9(^2D_{5/2})4s^2 6f$	$^2[^1/_2]^\circ$	1	*135 409.2*		
$3d^9(^2D_{5/2})4s^2 6f$	$^2[^3/_2]^\circ$	1	*135 413.0*		
$3d^9(^2D_{5/2})4s^2 7f$	$^2[^3/_2]^\circ$	1	*136 231.6*		
$3d^9(^2D_{5/2})4s^2 8f$	$^2[^3/_2]^\circ$	1	*136 771.1*		
$3d^9(^2D_{5/2})4s^2 9f$	$^2[^3/_2]^\circ$	1	*137 128.2*		
$3d^9(^2D_{5/2})4s^2 10f$	$^2[^3/_2]^\circ$	1	*137 388.2*		
$3d^9(^2D_{5/2})4s^2 11f$	$^2[^3/_2]^\circ$	1	*137 580.5*		
$3d^9(^2D_{5/2})4s^2 12f$	$^2[^3/_2]^\circ$	1	*137 726.0*		
Zn II ($^2D_{5/2}$)	*Limit*		138 491.7		
Zn II ($^2D_{3/2}$)	*Limit*		141 210.9		
$3d^{10}5s\,7p$	$^1P^\circ$	1	*159 512*		
$3d^{10}5s\,8p$	$^1P^\circ$	1	*160 767*		
$3d^{10}5s\,9p$	$^1P^\circ$	1	*161 657*		
$3d^{10}5s\,10p$	$^1P^\circ$	1	*162 269*		
$3d^{10}5s\,11p$	$^1P^\circ$	1	*162 687*		
$3d^{10}5s\,12p$	$^1P^\circ$	1	*162 974*		
Zn II ($^2S_{1/2}$)	*Limit*		164 206.5		
$3d^9(^2D)4s\,4p\,(^3P^\circ)5s$	$^1P^\circ$	1	*166 418*		
$3d^9(^2D)4s\,4p\,(^3P^\circ)6s$	$^1P^\circ$	1	*178 466*		
$3d^9(^2D)4s\,4p\,(^3P^\circ)7s$	$^1P^\circ$	1	*183 025*		
$3d^9(^2D)4s\,4p\,(^3P^\circ)8s$	$^1P^\circ$	1	*185 211*		
$3d^9(^2D)4s\,4p\,(^3P^\circ)9s$	$^1P^\circ$	1	*186 313*		
$3d^9(^2D)4s\,4p\,(^3P^\circ)10s$	$^1P^\circ$	1	*187 135*		
$3d^9(^2D)4s\,4p\,(^3P^\circ)11s$	$^1P^\circ$	1	*187 613*		

Zn I — Continued

Configuration	Term	J	Level (cm^{-1})	g	Leading percentages
$3d^9(^2D)4s4p(^3P^\circ)4d$	$^1P^\circ$	1	*177 050*		
$3d^9(^2D)4s4p(^3P^\circ)5d$	$^1P^\circ$	1	*182 250*		
$3d^9(^2D)4s4p(^3P^\circ)6d$	$^1P^\circ$	1	*184 649*		
$3d^9(^2D)4s4p(^3P^\circ)7d$	$^1P^\circ$	1	*186 098*		
$3d^9(^2D)4s4p(^3P^\circ)8d$	$^1P^\circ$	1	*186 929*		
$3d^9(^2D)4s4p(^3P^\circ)9d$	$^1P^\circ$	1	*187 501*		
$3d^9(^2D)4s4p(^3P^\circ)10d$	$^1P^\circ$	1	*187 860*		
$3d^9(^2D)4s4p(^3P^\circ)11d$	$^1P^\circ$	1	*188 129*		
$3d^9(^2D)4s4p(^3P^\circ)12d$	$^1P^\circ$	1	*188 323*		
$3d^9(^2D)4s4p(^3P^\circ)13d$	$^1P^\circ$	1	*188 478*		
$3d^9(^2D)4s4p(^3P^\circ)14d$	$^1P^\circ$	1	*188 579*		

Zn II

Z=30

Cu I isoelectronic sequence

Ground state $1s^22s^22p^63s^23p^63d^{10}4s\ ^2S_{1/2}$

Ionization energy 144 892.6 ± 2 cm^{-1} (17.964 40 ± 0.0002 eV)

The first extensive description of this spectrum was given by von Salis [1925] who classified 63 lines in the range of 2025–7758 Å. He established all the known $3d^{10}nl$ terms, except for $5g$, $9f$ and $10f$, and located the $3d^94s^2\ ^2D$ term. With the nd series he determined a value for the ionization energy within the uncertainty of the present value.

Crooker and Dick [1968] extended the range of observations to 742–9950 Å and gave 363 classified lines. They added six levels to the $3d^94s4p$ configuration which already had eight levels found by Takahashi [1929] and seven by Mazumber [1935]. Crooker and Dick also found the $3d^{10}9f$ and $10f$ terms, 6 levels of $3d^94s5s$, 3 of $3d^94s6s$, and 17 levels attributed to the $3d^94s4d$ configuration.

The $5g$ term was reported by Paschen and Ritschl [1935].

The spectrum was reobserved by Martin and Kaufman [1970] who measured 130 lines in the range of 1400–2100 Å with a hollow-cathode source and a spark discharge. They determined new values for most of the energy levels and calculated wavelengths from them for 267 lines with an uncertainty of ±0.002 Å to ±0.01 Å depending on the level uncertainties. These vary from ±0.1 to ±0.5 cm^{-1}.

Martin and Sugar [1969] calculated the energy levels and eigenvectors of the $3d^94s4p$ configuration. They found a strong perturbation of the $3d^9(^2D)4s4p(^1P^\circ)\ ^2D^\circ$ term by the $3d^84s^24p$ configuration even though the latter lies entirely above the ionization limit and its largest component in $3d^94s4p$ is 1.1%. The $(^1P^\circ)\ ^2P^\circ$ term mixes with the $3d^{10}np$ series and was omitted from the fit of Slater parameters to the levels. Eigenvectors from the fitted calculation are quoted here.

Martin and Sugar [1970] carried out fitted calculations of the $3d^94s5s$ configuration. These indicated that several levels from Crooker and Dick were incorrect and some J-values clearly needed to be changed. A search of Dick's [1966] line list led to the discovery of a new level for the $3d^94s4p(^3P^\circ)\ ^4F^\circ_{9/2}$, two new levels of $3d^94s5s$, and one of $3d^94s6s$. The J-values of two levels of $3d^94s4d$ were changed. The percentage composition for the levels of $3d^94s5s$ were also given.

The energy levels are quoted from Martin and Kaufman [1970] as well as the ionization energy, which was determined from the three-member ng series.

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Zn II

Configuration	Term	J	Level (cm^{-1})	Leading percentages
$3d^{10}4s$	^2S	1/2	0.00	
$3d^{10}4p$	$^2P^\circ$	1/2	*48 481.00*	
		3/2	*49 355.04*	
$3d^94s^2$	^2D	5/2	62 722.45	
		3/2	65 441.64	
$3d^{10}5s$	^2S	1/2	88 437.15	
$3d^{10}4d$	^2D	3/2	96 909.74	
		5/2	96 960.40	
$3d^{10}5p$	$^2P^\circ$	1/2	*101 365.9*	
		3/2	*101 611.4*	

Zn II — Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages		
$3d^9(^2D)4s4p(^3P^\circ)$	$^4P^\circ$	$5/2$	*103 701.6*	98		
		$3/2$	*105 322.7*	96		
		$1/2$	*106 528.8*	98		
$3d^9(^2D)4s4p(^3P^\circ)$	$^4F^\circ$	$9/2$	*106 779.9*	100		
		$7/2$	*106 852.4*	89	8	$3d^9(^2D)4s4p(^3P^\circ)$ $^2F^\circ$
		$5/2$	*107 268.6*	82	16	"
		$3/2$	*108 227.9*	97		
$3d^9(^2D)4s4p(^3P^\circ)$	$^2F^\circ$	$5/2$	*110 672.3*	73	16	$3d^9(^2D)4s4p(^3P^\circ)$ $^4D^\circ$
		$7/2$	*112 409.7*	75	13	"
$3d^9(^2D)4s4p(^3P^\circ)$	$^4D^\circ$	$7/2$	*110 867.2*	84	16	$3d^9(^2D)4s4p(^3P^\circ)$ $^2F^\circ$
		$5/2$	*111 743.0*	63	15	$3d^9(^2D)4s4p(^3P^\circ)$ $^2D^\circ$
		$3/2$	*111 994.3*	59	32	"
		$1/2$	*112 534.9*	53	44	$3d^9(^2D)4s4p(^3P^\circ)$ $^2P^\circ$
$3d^9(^2D)4s4p(^3P^\circ)$	$^2P^\circ$	$1/2$	*113 492.9*	54	46	$3d^9(^2D)4s4p(^3P^\circ)$ $^4D^\circ$
		$3/2$	*113 499.2*	93		
$3d^9(^2D)4s4p(^3P^\circ)$	$^2D^\circ$	$3/2$	*114 045.03*	64	35	$3d^9(^2D)4s4p(^3P^\circ)$ $^4D^\circ$
		$5/2$	*114 833.95*	81	17	"
$3d^{10}6s$	^2S	$1/2$	114 498.02			
$3d^{10}4f$	$^2F^\circ$	$7/2$	*117 263.4*			
		$5/2$	*117 264.0*			
$3d^{10}5d$	^2D	$3/2$	117 969.32			
		$5/2$	117 993.61			
$3d^{10}6p$	$^2P^\circ$	$1/2$	*119 888.51*			
		$3/2$	*119 959.34*			
$3d^{10}7s$	^2S	$1/2$	125 880.0			
$3d^{10}5f$	$^2F^\circ$	$7/2$	*127 199.6*			
		$5/2$	*127 209.4*			
$3d^{10}5g$	^2G	$9/2$	127 310.8			
		$7/2$	127 310.9			
$3d^{10}6d$	^2D	$3/2$	127 630.6			
		$5/2$	127 643.7			
$3d^{10}7p$	$^2P^\circ$	$3/2$	*128 343.44*			
		$1/2$	*128 518.5*			
$3d^9(^2D)4s4p(^1P^\circ)$	$^2F^\circ$	$7/2$	*130 014.26*	97	1	$3d^8(^1G)4s^24p$ $^2F^\circ$
		$5/2$	*133 145.76*	56	40	$3d^9(^2D)4s4p(^1P^\circ)$ $^2D^\circ$
$3d^9(^2D)4s4p(^1P^\circ)$	$^2P^\circ$	$3/2$	*130 371.57*	95	2	$3d^8(^3P)4s^24p$ $^2P^\circ$
		$1/2$	*133 806.3*	97	2	"
$3d^9(^2D)4s4p(^1P^\circ)$	$^2D^\circ$	$5/2$	*131 650.93*	55	41	$3d^9(^2D)4s4p(^1P^\circ)$ $^2F^\circ$
		$3/2$	*134 643.8*	93	3	$3d^8(^3F)4s^24p$ $^2D^\circ$
$3d^{10}8s$	^2S	$1/2$	131 876.9			

Zn II — Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages
$3d^{10}8p$	$^2P^o$	1/2	*132 414.9*	
		3/2	*133 622.1*	
$3d^{10}6f$	$^2F^o$	5/2	*132 604.09*	
		7/2	*132 639.4*	
$3d^{10}6g$	^2G	7/2,9/2	132 683.9	
$3d^{10}7d$	^2D	3/2	132 880.6	
		5/2	132 888.4	
$3d^{10}9s$	^2S	1/2	135 423.3	
$3d^{10}7f$	$^2F^o$	7/2	*135 889.9*	
		5/2	*135 892.6*	
$3d^{10}7g$	^2G	7/2,9/2	135 923.8	
$3d^{10}8d$	^2D	3/2	136 051.9	
		5/2	136 056.8	
$3d^{10}9p$	$^2P^o$	3/2	*136 505.3*?	
$3d^{10}8f$	$^2F^o$	7/2	*138 002.1*	
		5/2	*138 003.3*	
$3d^{8}9d$	^2D	3/2	138 114.0	
		5/2	138 117.5	
Zn III $3d^{10}(^1S_0)$	***Limit***		**144 892.6**	
$3d^94s(^3D)5s$	^4D	7/2	161 318.4	100
		5/2	162 070.3	85
		3/2	162 897.0	74
		1/2	164 070.1	100
$3d^94s(^3D)5s$	^2D	5/2	164 998.9	88
		3/2	165 277.1	46
$3d^94s(^1D)5s$	^2D	5/2	167 624.4	92
$3d^94s4d$	1	7/2	169 150.5	
$3d^94s4d$	3	5/2	169 447.7	
$3d^94s4d$	4	5/2	169 986.3	
$3d^94s4d$	5	1/2	171 110.5	
$3d^94s4d$	6	5/2	171 171.6	
$3d^94s4d$	7	7/2	171 643.0	
$3d^94s4d$	8	3/2	171 827.6	
$3d^94s4d$	9	5/2	172 165.7	
$3d^94s4d$	11	5/2	172 341.5	

Zn II — Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages
$3d^9 4s 4d$	12	$^7/_2$	173 003.1	
$3d^9 4s 4d$	13	$^5/_2$	173 035.3	
$3d^9 4s 4d$	14	$^5/_2$	173 339.8	
$3d^9 4s 4d$	20	$^5/_2$?	173 560.7?	
$3d^9 4s 4d$	21	$^9/_2$	173 561.9	
$3d^9 4s(^3D)6s$	^4D	$^7/_2$	191 198.0	
$3d^9 4s(^3D)6s$	^2D	$^5/_2$	192 598?	

Zn III

Z=30

Ni I isoelectronic sequence

Ground state $1s^22s^22p^63s^23p^63d^{10}$ $^1S_0$

Ionization energy 320 390 ± 1 cm^{-1} (39.7233 ± 0.0001 eV)

Laporte and Lang [1927] reported the first observations of this spectrum obtained with a vacuum spark. They classified 38 lines measured with an estimated uncertainty of ±0.05 Å, and determined 17 levels of the $3d^94s$ and $3d^94p$ configurations that were later confirmed. Mazumder [1936] extended the observations to the range of 497−3133 Å and classified 219 more lines, establishing 4 levels of the $3d^95s$, 18 levels of the $3d^94d$, and 31 levels of the $3d^84s4p$ configurations.

New observations were made by Dick [1968] in the range of 383−6270 Å. He retained 37 of the levels reported by Mazumder and established 233 additional levels, classifying 1279 lines. No wavelengths were given in the paper, but an address for obtaining photocopies of the line list was included. Also, no estimate of the wavelength uncertainty was reported. Levels of $3d^9ns$ (n=4−11), $3d^9np$ (n=4 and 5), $3d^9nd$ (n=4−7), $3d^9nf$ (n=4,7), $3d^9ng$ (n=5−8) and $3d^84s^2$ configurations were given. Thiry-two levels were tentatively identified with $3d^84s4p$ designations. All level designations were given in LS-coupling notation. We have compiled these energy levels but have changed coupling scheme designations where obvious grouping of levels indicate more suitable designations. All $3d^9ns$ terms are given in jj-coupling. The jl-scheme was adopted for the $3d^9nd$ configurations for n>4, the $3d^94f$ and $3d^97f$, and all the $3d^9ng$ configurations.

The spectrum was reobserved by Gayasov and Ryabtsev [1992] in the range of 345−1951 Å with a vacuum spark discharge. Their measurement uncertainty was reported as ±0.005 Å. With calculations of the mixed configurations $3d^84s4p$, $3d^94f$, $3d^96p$, and $3d^84p4d$ as a guide they established 61 levels of the $3d^84s4p$ configuration. Of the 32 levels given by Dick for this group, 22 were confirmed. In addition, Gayasov and Ryabtsev found 18 levels of the configurations $3d^96p$, $7p$, and $5f$. Percentage compositions in LS-coupling are given for all of these configurations. We quote their results for energy level values and the percentages. Their energy level uncertainty is ±5 cm^{-1}. The level uncertainty of Dick's data is estimated to be ±0.5 cm^{-1}. The remaining levels are taken from Dick. The percentages for the $3d^94p$ configuration are taken from the work of Roth [1968].

The value for the ionization energy was derived by Dick from the $3d^9ng$ series by the core polarization method.

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Zn III

Configuration	Term	J	Level (cm^{-1})	Leading percentages		
$3d^{10}$	^{1}S	0	0			
$3d^94s$	^{3}D	3	78 096.3			
		2	79 273.6			
		1	80 850.2			
$3d^94s$	^{1}D	2	83 500.3			
$3d^94p$	^{3}P°	2	*137 866.4*	98		
		1	*140 071.0*	97		
		0	*141 392.5*	100		
$3d^94p$	^{3}F°	3	*140 654.8*	71	26	$3d^94p$ ^{1}F°
		4	*141 327.0*	100		
		2	*142 483.3*	96		
$3d^94p$	^{1}F°	3	*144 501.2*	67	18	$3d^94p$ ^{3}F°
$3d^94p$	^{1}D°	2	*145 243.9*	62	34	$3d^94p$ ^{3}D°

Zn III — Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages		
$3d^94p$	$^3D°$	3	*145 966.6*	82	11	$3d^94p$ $^3F°$
		1	*147 571.2*	97		
		2	*147 921.5*	61	37	$3d^94p$ $^1D°$
$3d^94p$	$^1P°$	1	*147 498.6*	98		
$3d^84s^2$	^3F	4	190 341.3			
		3	192 763.7			
		2	194 303.3			
$3d^84s^2$	^1D	2	208 041.3			
$3d^84s^2$	^3P	2	211 725.5			
		1	211 920.7			
		0	212 340.3			
$3d^94d$	^3S	1	214 357.0			
$3d^9(^2D_{5/2})5s$	$(^5/_2,^1/_2)$	3	214 878.0			
		2	215 340.5			
$3d^9(^2D_{3/2})5s$	$(^3/_2,^1/_2)$	1	217 663.7			
		2	217 846.8			
$3d^94d$	^3G	4	216 464.5			
		5	216 607.4			
		3	219 684.9			
$3d^94d$	^3P	1	216 895.3			
		2	217 073.8			
		0	218 428.0			
$3d^94d$	^3D	3	217 655.8			
		2	218 540.3			
		1	220 006.6			
$3d^94d$	^3F	3	218 040.5			
		4	218 041.5			
		2	221 343.6			
$3d^94d$	^1P	1	218 909.4			
$3d^94d$	^1G	4	219 360.0			
$3d^94d$	^1D	2	220 668.3			
$3d^84s^2$	^1G	4	221 052.2			
$3d^94d$	^1F	3	221 143.7			
$3d^94d$	^1S	0	230 606.0			
$3d^84s^2$	^1S	0	233 204.4			
$3d^95p$	$^3P°$	2	*233 610.4*			
		1	*234 866.9*			
		0	*236 560.0*			

Zn III — Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages
$3d^95p$	$^3F^\circ$	3	*234 384.0*	
		4	*234 576.0*	
		2	*237 047.8*	
$3d^95p$	$^3D^\circ$	2	*235 452.5*	
		3	*235 623.9*	
		1	*238 205.5*	
$3d^95p$	$^1P^\circ$	1	*237 506.8*	
$3d^95p$	$^1F^\circ$	3	*237 642.7*	
$3d^84s(^4F)4p$	$^5D^\circ$	4	*240 911*	92
		3	*242 741*	89
		2	*244 248*	89
		1	*245 303*	91
$3d^84s(^4F)4p$	$^5G^\circ$	4	*245 136*	81 11 $3d^84s(^4F)4p$ $^5F^\circ$
		3	*245 991*	88
		2	*246 697*	94
$3d^84s(^4F)4p$	$^5F^\circ$	4	*248 149*	81 10 $3d^84s(^4F)4p$ $^5G^\circ$
		3	*249 010*	83
		2	*249 576*	90
		1	*249 859*	95
$3d^84s(^2F)4p$	$^3G^\circ$	4	*250 318*	43 23 $3d^84s(^2F)4p$ $^1G^\circ$
		3	*252 017*	54 28 $3d^84s(^4F)4p$ $^3G^\circ$
$3d^84s(^2F)4p$	$^3D^\circ$	3	*251 396*	49 17 $3d^84s(^4F)4p$ $^3D^\circ$
		2	*252 405*	53 21 "
		1	*253 690*	60 25 "
$3d^84s(^2F)4p$	$^3F^\circ$	4	*253 537*	57 33 $3d^84s(^4F)4p$ $^3F^\circ$
		3	*254 121*	38 22 "
		2	*255 299*	52 29 "
$3d^94f$	$^3P^\circ$	0	*257 491.1*	99
		1	*257 566.1*	84
		2	*260 418.1*	52 28 $3d^94f$ $^3D^\circ$
$3d^94f$		2	*257 678.7*	43 $^3P^\circ$ 27 $3d^94f$ $^3D^\circ$
$3d^84s(^2F)4p$	$^1F^\circ$	3	*257 705*	55 14 $3d^94f$ $^1F^\circ$
$3d^94f$	$^1H^\circ$	5	*257 796.0*	55 45 $3d^94f$ $^3H^\circ$
$3d^94f$	$^3H^\circ$	6	*257 799.0*	99
		5	260 613.1	46 38 $3d^94f$ $^1H^\circ$
		4	*260 623.1*	83
$3d^94f$	$^3D^\circ$	1	*257 908.2*	50 49 $3d^94f$ $^1P^\circ$
$3d^94f$		2	*257 962.5*	33 $^1D^\circ$ 33 $3d^94f$ $^3F^\circ$
$3d^84s(^2F)4p$	$^1D^\circ$	2	*258 086*	80 6 $3d^94f$ $^1D^\circ$
$3d^94f$	$^3G^\circ$	5	*258 171.2*	83
		3	*260 981.9*	67 20 $3d^94f$ $^1F^\circ$
		4	*260 988.4*	40 36 $3d^94f$ $^1G^\circ$

Zn III — Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages			
$3d^94f$	$^3F^\circ$	4	*258 178.3*	54		39	$3d^94f\ ^3G^\circ$
		3	*258 075.7*	42		40	$3d^94f\ ^3D^\circ$
		2	*260 805.9*	51		19	$3d^94f\ ^1D^\circ$
$3d^94f$	$^1G^\circ$	4	*258 239.6*	54		15	$3d^94f\ ^3G^\circ$
$3d^94f$	$^1F^\circ$	3	*258 277.7*	44		15	$3d^94f\ ^3F^\circ$
$3d^94f$	$^1P^\circ$	1	*260 584.1*	43		41	$3d^94f\ ^3D^\circ$
$3d^84s(^4P)4p$	$^5P^\circ$	2	*260 710*	70		12	$3d^94f\ ^3F^\circ$
		3	*260 879*	66		10	"
		1	*261 090*	94			
$3d^94f$		3	*260 783*	32	$^3F^\circ$	29	$3d^94f\ ^3D^\circ$
$3d^9(^2D_{5/2})6s$	$(^5/_2,^1/_2)$	3	260 796.6				
		2	261 007.3				
$3d^9(^2D_{5/2})5d$	$^2[^1/_2]$	1	261 286.8				
$3d^9(^2D_{5/2})5d$	$^2[^9/_2]$	5	261 829.8				
		4	261 909.7				
$3d^9(^2D_{5/2})5d$	$^2[^3/_2]$	2	261 921.6				
		1	261 936.4				
$3d^9(^2D_{5/2})5d$	$^2[^5/_2]$	3	262 235.8				
		2	262 520.2				
$3d^9(^2D_{5/2})5d$	$^2[^7/_2]$	3	262 446.1				
		4	262 495.9				
$3d^9(^2D_{3/2})5d$	$^2[^1/_2]$	0	263 111.7				
		1	264 237.4				
$3d^9(^2D_{3/2})6s$	$(^3/_2,^1/_2)$	1	263 559.5				
		2	263 742.1				
$3d^84s(^2D)4p$	$^3F^\circ$	2	*264 606*	76			
		3	*264 998*	70			
		4	*265 531*	64		26	$3d^84s(^4P)4p\ ^5D^\circ$
$3d^9(^2D_{3/2})5d$	$^2[^7/_2]$	3	264 632.4				
		4	264 783.9				
$3d^9(^2D_{3/2})5d$	$^2[^3/_2]$	1	264 826.3				
		2	265 005.3				
$3d^84s(^2D)4p$	$^3D^\circ$	1	*265 088*	57		13	$3d^84s(^2D)4p\ ^3P^\circ$
		2	*265 485*	60		11	$3d^84s(^2D)4p\ ^3F^\circ$
		3	*265 955*	69			
$3d^9(^2D_{3/2})5d$	$^2[^5/_2]$	3	265 256.1				
		2	265 313.4				
$3d^84s(^2D)4p$	$^3P^\circ$	1	*266 737*	50		26	$3d^84s(^2D)4p\ ^3D^\circ$
		2	*267 514*	71		11	

Zn III — Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages
$3d^84s(^4P)4p$	$^5D^\circ$	1	*268 148*	89
		2	*268 211*	87
		3	*268 422*	80
		4	*268 819*	66 20 $3d^84s(^2D)4p$ $^3F^\circ$
$3d^96p$	$^3P^\circ$	2	*269 027*	88
		1	*269 698*	46 43 $3d^96p$ $^1P^\circ$
		0	*271 830*	95
$3d^96p$	$^3F^\circ$	3	*269 417*	50 37 $3d^96p$ $^1F^\circ$
		4	*269 499*	96
		2	*272 093*	89
$3d^96p$	$^3D^\circ$	3	*269 713*	74 18 $3d^96p$ $^1F^\circ$
		2	*272 406*	40 34 $3d^96p$ $^1D^\circ$
		1	*272 536*	46 15 $3d^96p$ $^1P^\circ$
$3d^96p$	$^1D^\circ$	2	*269 863*	51 34 $3d^96p$ $^3D^\circ$
$3d^84s(^2P)4p$	$^3P^\circ$	2	*271 579*	44 16 $3d^84s(^2P)4p$ $^3D^\circ$
		0	*273 701*	49 33 $3d^84s(^2D)4p$ $^3P^\circ$
$3d^96p$		1	*272 093*	39 $^1P^\circ$ 28 $3d^96p$ $^3P^\circ$
$3d^96p$		1	*272 287*	33 $^3D^\circ$ 22 $3d^9(^2P)6p$ $^3D^\circ$
$3d^96p$		3	*272 317*	47 $^3F^\circ$ 43 $3d^96p$ $^1F^\circ$
$3d^84s(^2P)4p$	$^3D^\circ$	3	*272 818*	44 23 $3d^84s(^4P)4p$ $^3D^\circ$
$3d^84s(^2P)4p$		2	*273 096*	29 $^3D^\circ$ 17 $3d^84s(^4P)4p$ $^3D^\circ$
$3d^84s(^2P)4p$		1	*273 350*	26 $^3D^\circ$ 21 $3d^84s(^2P)4p$ $^3D^\circ$
$3d^84s(^2G)4p$	$^3F^\circ$	4	*274 149*	39 22 $3d^84s(^2F)4p$ $^3F^\circ$
		3	*275 256*	48 14 "
		2	*275 901*	58 16 $3d^84s(^2P)4p$ $^1D^\circ$
$3d^84s(^4P)4p$	$^5S^\circ$	2	*274 751*	94
$3d^84s(^2P)4p$	$^1P^\circ$	1	*275 771*	83
$3d^84s(^4F)4p$	$^3D^\circ$	3	*276 116*	47 15 $3d^84s(^2F)4p$ $^3D^\circ$
		2	*278 225*	52 19 "
		1	*279 495*	58 22 "
$3d^84s(^4F)4p$	$^3G^\circ$	4	*276 138*	54 33 $3d^84s(^2F)4p$ $^3G^\circ$
		3	*277 594*	59 32 "
$3d^84s(^2P)4p$	$^1D^\circ$	2	*276 376*	70
$3d^84s(^4F)4p$	$^3F^\circ$	4	*277 588*	38 36 $3d^84s(^2G)4p$ $^3F^\circ$
		3	*279 307*	49 21 "
		2	*280 713*	54 22 $3d^84s(^2F)4p$ $^3F^\circ$
$3d^95f$	$^1P^\circ$	1	*280 501*	50 46 $3d^95f$ $^3D^\circ$
$3d^9(^2D_{5/2})5g$	$^2[^3/_2]$	1,2	280 726.9	
$3d^9(^2D_{5/2})5g$	$^2[^{13}/_2]$	6,7	280 772.2	

Zn III — Continued

Configuration	Term	J	Level (cm⁻¹)	Leading percentages		
$3d^9(^2D_{5/2})5g$	$^2[^5/_2]$	2,3	280 782.8			
$3d^9(^2D_{5/2})5g$	$^2[^7/_2]$	3,4	280 837.2			
$3d^9(^2D_{5/2})5g$	$^2[^{11}/_2]$	5,6	280 861.1			
$3d^9(^2D_{5/2})5g$	$^2[^9/_2]$	4	280 870.5			
$3d^9(^2D_{5/2})7s$	$(^5/_2,^1/_2)$	3	282 057.6			
		2	282 169.0			
$3d^9(^2D_{5/2})6d$	$^2[^1/_2]$	1	282 254.9			
$3d^9(^2D_{5/2})6d$	$^2[^3/_2]$	2	282 628.6			
		1	282 651.8			
$3d^9(^2D_{5/2})6d$	$^2[^9/_2]$	5	282 640.2			
		4	282 680.4			
$3d^9(^2D_{5/2})6d$	$^2[^5/_2]$	3	282 839.5			
		2	282 950.7			
$3d^9(^2D_{5/2})6d$	$^2[^7/_2]$	3	282 970.6			
		4	282 977.6			
$3d^95f$		1	*283 185*	43 $^1P°$	40	$3d^95f\ ^3D°$
$3d^9(^2D_{3/2})5g$	$^2[^5/_2]$	2,3	283 515.2			
$3d^9(^2D_{3/2})5g$	$^2[^{11}/_2]$	5,6	283 545.6			
$3d^9(^2D_{3/2})5g$	$^2[^7/_2]$	3,4	283 601.8			
$3d^9(^2D_{3/2})5g$	$^2[^9/_2]$	4,5	283 632.2			
$3d^9(^2D_{3/2})6d$	$^2[^1/_2]$	0	283 968.8			
		1	284 689.0			
$3d^9(^2D_{3/2})7s$	$(^3/_2,^1/_2)$	1	284 816.8			
		2	284 901.5			
$3d^9(^2D_{3/2})6d$	$^2[^7/_2]$	3	285 411.7			
$3d^9(^2D_{3/2})6d$	$^2[^3/_2]$	1	285 503.7			
		2	285 592.1			
$3d^9(^2D_{3/2})6d$	$^2[^5/_2]$	3	285 723.5			
		2	285 753.5			
$3d^97p$	$^1F°$	3	*286 661*	54	43	$3d^97p\ ^3F°$
$3d^97p$	$^3F°$	4	*286 748*	99		
$3d^97p$	$^1P°$	1	*286 811*	51	40	$3d^97p\ ^3P°$
$3d^97p$	$^3P°$	1	*289 338*	55	42	$3d^97p\ ^1P°$
$3d^84s(^2D)4p$	$^1D°$	2	*291 945*	54	29	$3d^84s(^4P)4p\ ^3P°$
$3d^9(^2D_{5/2})6g$	$^2[^3/_2]$	1,2	292 861.7			
$3d^9(^2D_{5/2})6g$	$^2[^{13}/_2]$	6,7	292 886.1			
$3d^9(^2D_{5/2})6g$	$^2[^5/_2]$	2,3	292 892.5			

Zn III — Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages		
$3d^9(^2D_{5/2})6g$	$^2[^7/_2]$	3,4	292 923.4			
$3d^9(^2D_{5/2})6g$	$^2[^{11}/_2]$	5,6	292 937.4			
$3d^9(^2D_{5/2})6g$	$^2[^9/_2]$	4,5	292 942.6			
$3d^9(^2D_{3/2})8s$	$(^5/_2,^1/_2)$	3	293 658.4			
		2	293 724.3			
$3d^84s(^4P)4p$	$^3P^\circ$	1	*293 747*	49	27	$3d^84s(^2D)4p$ $^1P^\circ$
		2	*294 910*	42	38	$3d^84s(^2D)4p$ $^1D^\circ$
$3d^9(^2D_{5/2})7d$	$^2[^1/_2]$	1	293 768.6			
$3d^9(^2D_{5/2})7d$	$^2[^9/_2]$	5	294 005.8			
		4	294 034.3			
$3d^9(^2D_{5/2})7d$	$^2[^3/_2]$	2	294 035.1			
		1	294 044.5			
$3d^9(^2D_{5/2})7d$	$^2[^5/_2]$	3	294 123.7			
		2	294 188.3			
$3d^9(^2D_{5/2})7d$	$^2[^7/_2]$	3	294 275.0			
		4	294 302.8			
$3d^9(^2D_{3/2})6g$	$^2[^5/_2]$	2,3	295 635.8			
$3d^9(^2D_{3/2})6g$	$^2[^{11}/_2]$	5,6	295 653.3			
$3d^9(^2D_{3/2})6g$	$^2[^7/_2]$	3,4	295 685.6			
$3d^9(^2D_{3/2})6g$	$^2[^9/_2]$	4,5	295 702.6			
$3d^84s(^2D)4p$	$^1P^\circ$	1	*296 361*	61	23	$3d^84s(^4P)4p$ $^3P^\circ$
$3d^9(^2D_{3/2})8s$	$(^3/_2,^1/_2)$	1	296 417.9			
		2	296 464.3			
$3d^9(^2D_{3/2})7d$	$^2[^7/_2]$	3	296 720.9			
$3d^9(^2D_{3/2})7d$	$^2[^3/_2]$	1	296 852.7			
		2	296 875.6			
$3d^9(^2D_{3/2})7d$	$^2[^5/_2]$	3	296 921.3			
		2	296 953.0			
$3d^9(^2D_{5/2})7f$	$^2[^1/_2]^\circ$	1	*300 008.7*			
$3d^9(^2D_{5/2})7f$	$^2[^{11}/_2]^\circ$	6	*300 047.0*			
		5	*300 048.8*			
$3d^9(^2D_{5/2})7f$	$^2[^3/_2]^\circ$	2	*300 053.2*			
$3d^9(^2D_{5/2})7f$	$^2[^5/_2]^\circ$	2	*300 076.1*			
		3	*300 083.0*			
$3d^9(^2D_{5/2})7f$	$^2[^7/_2]^\circ$	4	*300 098.1*			
		3	*300 108.1*			

Zn III — Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages
$3d^9(^2D_{5/2})7f$	$^2[^9/_2]°$	5 4	*300 123.4* *300 126.0*	
$3d^9(^2D_{5/2})7g$	$^2[^3/_2]$	1,2	300 173.4	
$3d^9(^2D_{5/2})7g$	$^2[^{13}/_2]$	6,7	300 188.4	
$3d^9(^2D_{5/2})7g$	$^2[^5/_2]$	2,3	300 193.1	
$3d^9(^2D_{5/2})7g$	$^2[^7/_2]$	3,4	300 212.3	
$3d^9(^2D_{5/2})7g$	$^2[^{11}/_2]$	5,6	300 221.1	
$3d^9(^2D_{5/2})7g$	$^2[^9/_2]$	4,5	300 224.2	
$3d^9(^2D_{5/2})9s$	$(^5/_2,^1/_2)$	3 2	300 686.1 300 701.4	
$3d^9(^2D_{3/2})8s$	$(^3/_2,^1/_2)$	1	300 737.8	
$3d^9(^2D_{3/2})7f$	$^2[^9/_2]°$	5 4	*302 804.3* *302 808.4*	
$3d^9(^2D_{3/2})7f$	$^2[^5/_2]°$	2 3	*302 827.0* *302 856.9*	
$3d^9(^2D_{3/2})7f$	$^2[^7/_2]°$	3 4	*302 869.8* *302 908.5*	
$3d^9(^2D_{3/2})7g$	$^2[^5/_2]$	2,3	302 941.9	
$3d^9(^2D_{3/2})7g$	$^2[^{11}/_2]$	5,6	302 952.8	
$3d^9(^2D_{3/2})7g$	$^2[^7/_2]$	3,4	302 972.7	
$3d^9(^2D_{3/2})7g$	$^2[^9/_2]$	4,5	302 983.9	
$3d^9(^2D_{3/2})9s$	$(^3/_2,^1/_2)$	2	303 501.3	
$3d^84s(^2G)4p$	$^1F°$	3	*303 834*	90
$3d^9(^2D_{5/2})8g$	$^2[^{13}/_2]$	6,7	304 927.6	
$3d^9(^2D_{5/2})8g$	$^2[^5/_2]$	2,3	304 930.7	
$3d^9(^2D_{5/2})8g$	$^2[^7/_2]$	3,4	304 942.7	
$3d^9(^2D_{5/2})8g$	$^2[^{11}/_2]$	5,6	304 948.6	
$3d^9(^2D_{5/2})8g$	$^2[^9/_2]$	4,5	304 950.1	
$3d^9(^2D_{5/2})10s$	$(^5/_2,^1/_2)$	3 2	305 250.6 305 263.5	
$3d^9(^2D_{3/2})8g$	$^2[^{11}/_2]$	5,6	307 689.1	
$3d^9(^2D_{3/2})10s$	$(^3/_2,^1/_2)$	2	308 021.0	

Zn III — Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages
$3d^9(^2D_{5/2})11s$	$(^5/_2,^1/_2)$	3	308 396.5	
		2	308 404.8	
$3d^9(^2D_{3/2})11s$	$(^3/_2,^1/_2)$	1	311 149.8	
		2	311 159.5	
....	....	....	....	
Zn IV ($^2D_{5/2}$)	***Limit***		**320 390**	

Zn IV

Z=30

Co I isoelectronic sequence

Ground state $1s^2 2s^2 2p^6 3s^2 3p^6 3d^9$ $^2D_{5/2}$

Ionization energy 480 490 ± 150 cm^{-1} (59.57 ± 0.02 eV)

The spectrum was measured by Crooker and Dick [1964] in the range of 412−2473 Å. Excitation was by means of a spark discharge in an atmosphere of helium. Wavelengths to three decimal places are given but no wavelength uncertainty was estimated. The arrays $3d^9-3d^84p$ and $3d^84s-3d^84p$ were classified. The ground state $3d^9$ ^{2}D interval and all levels of the $3d^84s$ and $3d^84p$ configurations were determined, except for those based on the ^{1}S term of the $3d^8$ parent configuration.

The spectrum was measured by van Kleef *et al.* [1984] in the range of 227−497 Å from a vacuum spark discharge with an estimated uncertainty of ±0.005 Å. Differences of ±0.01−0.03Å are found between these and the earlier set of measurements. These authors give revised values for the $3d^9$ ^{2}D term and the levels of the $3d^84p$ configuration and give the missing $3d^8(^1S)4p$ $^2P^o$ term. They also determined many levels of the $3d^85p$, $6p$, $4f$, and $5f$ configurations from transitions to the ground term. The levels with $J=^9/_2$ and $J=^{11}/_2$ were determined from transitions to the $3d^84s$ configuration. They give the percentage composition for all the levels of odd parity.

New observations of this spectrum were reported by Joshi and Van Kleef [1987] in the range of 820−2000 Å. The wavelength uncertainty was estimated to be ±0.005 Å and the energy level uncertainty ±0.3 cm^{-1}. The earlier analysis of the $3d^84s-3d^84p$ array was confirmed and the missing $3d^8(^1S)4s$ $^2S_{1/2}$ level was found. Sixteen additional lines of this array were identified and improved values for the energy levels were determined. The $3d^84p-3d^84d$ array was identified and 59 of the 67 levels of the $3d^84d$ configuration were established.

Energy level values and percentage compositions for the $3d^9$ and $3d^84p$, $5p$, $6p$, $4f$, and $5f$ configurations are from van Kleef *et al.*, and those of $3d^84s$ and $3d^84d$ are from Joshi and van Kleef.

The value for the ionization energy was determined by van Kleef *et al.* [1984] from the $4d^8np$ and the $3d^84f$ and $5f$ series.

References

Crooker. A. M.. and Dick. K. A. [1964]. Can. J. Phys. **42**. 766.

Joshi, Y. N., and van Kleef, T. A. M. [1987], Phys. Scr. **36**, 282.

van Kleef, T. A. M., Joshi, Y. N., and Barakat, M. M. [1984], Phys. Scr. **29**, 216.

Zn IV

Configuration	Term	J	Level (cm^{-1})	Leading percentages		
$3d^9$	^{2}D	5/2	0.0	100		
		3/2	2 759.1	100		
$3d^8(^3F)4s$	^{4}F	9/2	128 729.8	100		
		7/2	130 366.1	96	4	$3d^8(^3F)4s$ ^{2}F
		5/2	131 804.5	98	1	"
		3/2	132 777.3	99		
$3d^8(^3F)4s$	^{2}F	7/2	135 951.2	96	4	$3d^8(^3F)4s$ ^{4}F
		5/2	138 479.4	97	2	$3d^8(^1D)4s$ ^{2}D
$3d^8(^1D)4s$	^{2}D	5/2	148 179.7	51	48	$3d^8(^3P)4s$ ^{4}P
		3/2	149 190.8	80	15	"
$3d^8(^3P)4s$	^{4}P	3/2	151 249.5	85	15	$3d^8(^1D)4s$ ^{2}D
		1/2	151 392.4	100		
		5/2	151 574.3	52	47	"
$3d^8(^3P)4s$	^{2}P	3/2	157 074.8	96	4	$3d^8(^1D)4s$ ^{2}D
		1/2	157 929.5	100		
$3d^8(^1G)4s$	^{2}G	9/2	160 886.0	100		
		7/2	160 919.0	100		

Zn IV — Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages		
$3d^8(^1S)4s$	^2S	1/2	199 369.0	100		
$3d^8(^3F)4p$	$^4D^\circ$	7/2	201 319.0	91	4	$3d^8(^3P)4p$ $^4D^\circ$
		5/2	203 684.6	90	5	"
		3/2	205 453.0	91	6	"
		1/2	206 513.0	92	7	"
$3d^8(^3F)4p$	$^4G^\circ$	9/2	204 447.0	60	24	$3d^8(^3F)4p$ $^2G^\circ$
		11/2	205 261.0	100		
		7/2	205 991.0	78	12	$3d^8(^3F)4p$ $^4F^\circ$
		5/2	207 175.3	91	7	"
$3d^8(^3F)4p$	$^4F^\circ$	9/2	207 737.0	81	15	$3d^8(^3F)4p$ $^2G^\circ$
		7/2	208 921.3	67	17	$3d^8(^3F)4p$ $^2F^\circ$
		5/2	209 899.0	78	7	$3d^8(^3F)4p$ $^4G^\circ$
		3/2	210 187.1	82	11	$3d^8(^3F)4p$ $^2D^\circ$
$3d^8(^3F)4p$	$^2G^\circ$	9/2	208 970.0	61	35	$3d^8(^3F)4p$ $^4G^\circ$
		7/2	211 189.5	71	20	$3d^8(^3F)4p$ $^2F^\circ$
$3d^8(^3F)4p$	$^2D^\circ$	5/2	211 569.7	73	14	$3d^8(^3F)4p$ $^2F^\circ$
		3/2	213 479.8	72	15	$3d^8(^3F)4p$ $^4F^\circ$
$3d^8(^3F)4p$	$^2F^\circ$	7/2	211 823.7	61	18	$3d^8(^3F)4p$ $^2G^\circ$
		5/2	214 167.3	77	13	$3d^8(^3F)4p$ $^2D^\circ$
$3d^8(^3P)4p$	$^4P^\circ$	3/2	221 426.2	76	10	$3d^8(^1D)4p$ $^2P^\circ$
		5/2	221 737.4	75	13	$3d^8(^1D)4p$ $^2D^\circ$
		1/2	222 120.0	91	6	$3d^8(^1D)4p$ $^2P^\circ$
$3d^8(^1D)4p$	$^2F^\circ$	5/2	223 609.4	77	11	$3d^8(^3P)4p$ $^4P^\circ$
		7/2	225 032.5	79	10	$3d^8(^3P)4p$ $^4D^\circ$
$3d^8(^1D)4p$	$^2D^\circ$	3/2	224 997.6	46	19	$3d^8(^3P)4p$ $^4P^\circ$
		5/2	226 050.2	77	11	"
$3d^8(^1D)4p$	$^2P^\circ$	1/2	225 414.0	61	27	$3d^8(^3P)4p$ $^2P^\circ$
		3/2	226 684.9	50	33	$3d^8(^1D)4p$ $^2D^\circ$
$3d^8(^3P)4p$	$^4D^\circ$	5/2	229 162.8	70	18	$3d^8(^3P)4p$ $^2D^\circ$
		3/2	229 230.9	83	5	$3d^8(^3F)4p$ $^4D^\circ$
		1/2	229 252.8	91	6	"
		7/2	229 877.9	84	6	$3d^8(^1D)4p$ $^2F^\circ$
$3d^8(^3P)4p$	$^2D^\circ$	5/2	231 693.0	75	21	$3d^8(^3P)4p$ $^4D^\circ$
		3/2	232 938.1	74	13	$3d^8(^3P)4p$ $^2P^\circ$
$3d^8(^3P)4p$	$^2P^\circ$	3/2	232 245.7	65	19	$3d^8(^3P)4p$ $^2D^\circ$
		1/2	234 493.9	64	25	$3d^8(^1D)4p$ $^2P^\circ$
$3d^8(^1G)4p$	$^2H^\circ$	9/2	232 981.0	99	1	$3d^8(^1G)4p$ $^2G^\circ$
		11/2	234 623.0	100		
$3d^8(^1G)4p$	$^2F^\circ$	7/2	234 802.2	82	13	$3d^8(^1D)4p$ $^2F^\circ$
		5/2	236 109.3	89	7	"
$3d^8(^3P)4p$	$^2S^\circ$	1/2	235 975.5	90	6	$3d^8(^1D)4p$ $^2P^\circ$
$3d^8(^3P)4p$	$^4S^\circ$	3/2	236 175.1	98	1	$3d^8(^1D)4p$ $^2P^\circ$

Zn IV — Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages			
$3d^8(^1G)4p$	$^2G^\circ$	7/2	*242 320.0*	98		1	$3d^8(^1G)4p\ ^2F^\circ$
		9/2	*242 640.0*	99		1	$3d^8(^1G)4p\ ^2H^\circ$
$3d^8(^1S)4p$	$^2P^\circ$	1/2	*274 746.3*	98		1	$3d^8(^1D)4p\ ^2P^\circ$
		3/2	*276 884.6*	98		1	"
$3d^8(^3F)4d$	^4D	7/2	304 097.1	92		6	$3d^8(^3F)4d\ ^4F$
		5/2	306 370.0	43		47	$3d^8(^3F)4d\ ^4P$
		1/2	307 159.6	80		12	"
		3/2	307 599.4	44		27	"
$3d^8(^3F)4d$	^4P	5/2	304 679.4	52		45	$3d^8(^3F)4d\ ^4D$
		3/2	308 162.0	69		22	$3d^8(^3F)4d\ ^2P$
		1/2	308 898.5	80		16	$3d^8(^3F)4d\ ^4D$
$3d^8(^3F)4d$	^4H	13/2	305 066.8	100			
		9/2	307 966.8	42		22	$3d^8(^3F)4d\ ^4G$
		11/2	308 078.0	53		32	$3d^8(^3F)4d\ ^2H$
		7/2	309 693.8	41		35	$3d^8(^3F)4d\ ^4G$
$3d^8(^3F)4d$	^2H	11/2	305 411.5	48		46	$3d^8(^3F)4d\ ^4H$
		9/2	310 043.0	44		23	$3d^8(^3F)4d\ ^2G$
$3d^8(^3F)4d$	^4G	11/2	305 928.3	78		20	$3d^8(^3F)4d\ ^2H$
		9/2	306 023.6	41		43	$3d^8(^3F)4d\ ^4F$
		5/2	309 885.1	53		43	$3d^8(^3F)4d\ ^2F$
$3d^8(^3F)4d$	^2F	7/2	306 411.1	51		24	$3d^8(^3F)4d\ ^4F$
$3d^8(^3F)4d$		9/2	306 736.5	39	^4F	26	$3d^8(^3F)4d\ ^2G$
$3d^8(^3F)4d$	^2P	3/2	307 502.7	50		43	$3d^8(^3F)4d\ ^4D$
$3d^8(^3F)4d$		5/2	308 293.0	33	^4F	32	$3d^8(^3F)4d\ ^2F$
$3d^8(^3F)4d$		7/2	308 414.1	38	^4G	32	$3d^8(^3F)4d\ ^4H$
$3d^8(^3F)4d$	^4F	7/2	308 849.6	48		24	$3d^8(^3F)4d\ ^4H$
		3/2	309 954.2	93		4	$3d^8(^3F)4d\ ^4D$
		5/2	310 015.2	55		19	$3d^8(^3F)4d\ ^4G$
$3d^8(^3F)4d$		9/2	308 900.6	32	^2G	26	$3d^8(^3F)4d\ ^2H$
$3d^8(^3F)4d$	^2G	7/2	311 238.4	78		9	$3d^8(^3F)4d\ ^4G$
$3d^8(^3F)4d$	^2D	5/2	315 493.7	69		14	$3d^8(^1D)4d\ ^2D$
		3/2	315 620.0	65		23	"
$3d^8(^1D)4d$	^2F	7/2	323 254.0	64		30	$3d^8(^3P)4d\ ^4D$
		5/2	323 391.6	61		16	"
$3d^8(^1D)4d$	^2G	7/2	324 494.4	82		10	$3d^8(^3P)4d\ ^2F$
		9/2	324 573.0	80		18	$3d^8(^3P)4d\ ^4F$
$3d^8(^3P)4d$	^2D	3/2	324 602.8	38		30	$3d^8(^1D)4d\ ^2D$
		5/2	327 127.1	36		30	"
$3d^8(^1D)4d$	^2P	3/2	324 863.9	53		36	$3d^8(^3P)4d\ ^4D$

Zn IV — Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages			
$3d^8(^3\mathrm{P})4d$	$^4\mathrm{D}$	5/2	325 725.4	50		28	$3d^8(^1\mathrm{D})4d\ ^2\mathrm{F}$
		7/2	326 645.9	68		31	"
$3d^8(^3\mathrm{P})4d$	$^4\mathrm{F}$	9/2	329 046.4	81		18	$3d^8(^1\mathrm{D})4d\ ^2\mathrm{G}$
		7/2	329 074.0	85		8	"
		5/2	329 395.4	91		3	$3d^8(^3\mathrm{P})4d\ ^2\mathrm{F}$
		3/2	329 509.3	95		2	$3d^8(^3\mathrm{P})4d\ ^2\mathrm{D}$
$3d^8(^3\mathrm{P})4d$	$^2\mathrm{F}$	7/2	329 571.0	84		7	$3d^8(^3\mathrm{P})4d\ ^4\mathrm{F}$
		5/2	330 440.4	75		16	$3d^8(^3\mathrm{P})4d\ ^4\mathrm{P}$
$3d^8(^1\mathrm{G})4d$	$^2\mathrm{D}$	5/2	329 640.0	31		18	$3d^8(^3\mathrm{P})4d\ ^2\mathrm{D}$
		3/2	330 870.4	44		19	"
$3d^8(^3\mathrm{P})4d$	$^2\mathrm{P}$	3/2	331 911.0	89		5	$3d^8(^1\mathrm{D})4d\ ^2\mathrm{D}$
		1/2	332 029.7	87		9	$3d^8(^1\mathrm{D})4d\ ^2\mathrm{P}$
$3d^8(^1\mathrm{G})4d$	$^2\mathrm{I}$	11/2	334 378.7	100			
		13/2	334 554.1	100			
$3d^8(^1\mathrm{G})4d$	$^2\mathrm{F}$	7/2	336 479.6	98		1	$3d^8(^3\mathrm{P})4p\ ^2\mathrm{F}^\circ$
		5/2	336 796.6	98			
$3d^8(^1\mathrm{G})4d$	$^2\mathrm{H}$	9/2	338 145.2	95		5	$3d^8(^1\mathrm{G})4d\ ^2\mathrm{G}$
		11/2	338 464.9	100			
$3d^8(^1\mathrm{G})4d$	$^2\mathrm{G}$	9/2	338 519.2	94		5	$3d^8(^1\mathrm{G})4d\ ^2\mathrm{H}$
		7/2	338 535.0	99			
$3d^8(^3\mathrm{F})5p$	$^4\mathrm{G}^\circ$	9/2	*342 528*	44		35	$3d^8(^3\mathrm{F})5p\ ^2\mathrm{G}^\circ$
		11/2	*342 778*	100			
		7/2	*345 069*	53		31	$3d^8(^3\mathrm{F})5p\ ^2\mathrm{F}^\circ$
		5/2	*346 549*	41		38	$3d^8(^3\mathrm{F})5p\ ^4\mathrm{F}^\circ$
$3d^8(^3\mathrm{F})5p$	$^4\mathrm{D}^\circ$	5/2	*343 440*	73		16	$3d^8(^3\mathrm{F})5p\ ^2\mathrm{D}^\circ$
		3/2	*345 223*	88		7	$3d^8(^3\mathrm{F})5p\ ^4\mathrm{F}^\circ$
$3d^8(^3\mathrm{F})5p$	$^4\mathrm{F}^\circ$	9/2	*343 533*	71		27	$3d^8(^3\mathrm{F})5p\ ^2\mathrm{G}^\circ$
		7/2	*346 180*	49		32	$3d^8(^3\mathrm{F})5p\ ^2\mathrm{F}^\circ$
		3/2	*347 059*	82		12	$3d^8(^3\mathrm{F})5p\ ^2\mathrm{D}^\circ$
$3d^8(^3\mathrm{F})5p$		7/2	*343 849*	32	$^4\mathrm{F}^\circ$	30	$3d^8(^3\mathrm{F})5p\ ^2\mathrm{F}^\circ$
$3d^8(^3\mathrm{F})5p$	$^2\mathrm{D}^\circ$	5/2	*345 534*	43		28	$3d^8(^3\mathrm{F})5p\ ^4\mathrm{G}^\circ$
		3/2	*347 881*	81		10	$3d^8(^3\mathrm{F})5p\ ^4\mathrm{F}^\circ$
$3d^8(^3\mathrm{F})5p$		5/2	*345 745*	36	$^2\mathrm{D}^\circ$	28	$3d^8(^3\mathrm{F})5p\ ^4\mathrm{G}^\circ$
$3d^8(^3\mathrm{F})5p$	$^2\mathrm{G}^\circ$	7/2	*347 447*	66		21	$3d^8(^3\mathrm{F})5p\ ^4\mathrm{G}^\circ$
$3d^8(^3\mathrm{F})5p$	$^2\mathrm{F}^\circ$	5/2	*348 150*	74		18	$3d^8(^3\mathrm{F})5p\ ^4\mathrm{F}^\circ$
$3d^8(^1\mathrm{G})4d$	$^2\mathrm{D}$	5/2	353 124.1	43		25	$3d^8(^3\mathrm{P})4d\ ^2\mathrm{D}$
		3/2	354 624.3	39		23	"
$3d^8(^1\mathrm{D})5p$	$^2\mathrm{D}^\circ$	5/2	*360 607*	44		27	$3d^8(^1\mathrm{D})5p\ ^2\mathrm{F}^\circ$
		3/2	*360 666*	49		19	$3d^8(^1\mathrm{D})5p\ ^2\mathrm{P}^\circ$
$3d^8(^1\mathrm{D})5p$	$^2\mathrm{F}^\circ$	5/2	*361 447*	56		22	$3d^8(^1\mathrm{D})5p\ ^2\mathrm{D}^\circ$
		7/2	*361 708*	78		20	$3d^8(^3\mathrm{P})5p\ ^4\mathrm{D}^\circ$

Zn IV — Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages			
$3d^8(^1D)5p$	$^2P°$	$^3/_2$	*362 192*	46		35	$3d^8(^1D)5p$ $^2D°$
$3d^8(^3P)5p$	$^4P°$	$^5/_2$	*364 267*	66		30	$3d^8(^1D)5p$ $^2D°$
		$^3/_2$	*364 401*	66		29	$3d^8(^1D)5p$ $^2P°$
$3d^8(^3P)5p$	$^4D°$	$^5/_2$	*365 687*	66		17	$3d^8(^3P)5p$ $^2D°$
		$^3/_2$	*365 768*	82		7	$3d^8(^3P)5p$ $^2P°$
$3d^8(^3P)5p$	$^2P°$	$^3/_2$	*366 242*	81		10	$3d^8(^1D)5p$ $^2D°$
		$^1/_2$	*367 344*	82		13	$3d^8(^1D)5p$ $^2P°$
$3d^8(^3P)5p$	$^2D°$	$^5/_2$	*366 621*	71		24	$3d^8(^3P)5p$ $^4D°$
		$^3/_2$	*367 310*	86		9	"
$3d^8(^3F)4f$	$^4D°$	$^7/_2$	*369 151*	59		35	$3d^8(^3F)4f$ $^4F°$
$3d^8(^3F)4f$	$^2S°$	$^1/_2$	*369 187*	44		27	$3d^8(^3F)4f$ $^2P°$
$3d^8(^3F)4f$	$^2P°$	$^3/_2$	*369 511*	45		20	$3d^8(^3F)4f$ $^2D°$
		$^1/_2$	*373 263*	41		24	$3d^8(^3F)4f$ $^2S°$
$3d^8(^3F)4f$	$^2F°$	$^7/_2$	*369 700*	48		17	$3d^8(^3F)4f$ $^4G°$
$3d^8(^3F)4f$	$^2D°$	$^5/_2$	*369 726*	44		19	$3d^8(^3F)4f$ $^4F°$
$3d^8(^3F)4f$	$^4P°$	$^1/_2$	*371 675*	56		32	$3d^8(^3F)4f$ $^2P°$
$3d^8(^3F)4f$		$^3/_2$	*371 736*	33	$^4D°$	27	$3d^8(^3F)4f$ $^2P°$
$3d^8(^3F)4f$		$^5/_2$	*371 803*	37	$^4P°$	27	$3d^8(^3F)4f$ $^2F°$
$3d^8(^3F)4f$		$^7/_2$	*371 803*	32	$^4F°$	32	$3d^8(^3F)4f$ $^2G°$
$3d^8(^3F)4f$		$^3/_2$	*371 893*	36	$^4F°$	23	$3d^8(^3F)4f$ $^2D°$
$3d^8(^3F)4f$		$^7/_2$	*372 012*	33	$^4G°$	31	$3d^8(^3F)4f$ $^2F°$
$3d^8(^3F)4f$		$^5/_2$	*372 064*	34	$^4G°$	27	$3d^8(^3F)4f$ $^2D°$
$3d^8(^1G)5p$	$^2H°$	$^9/_2$	*372 486*	99		1	$3d^8(^1G)4p$ $^2G°$
		$^{11}/_2$	*373 044*	100			
$3d^8(^1G)5p$	$^2F°$	$^7/_2$	*372 610*	97		2	$3d^8(^1G)5p$ $^2G°$
		$^5/_2$	*373 265*	99		1	$3d^8(^1D)4p$ $^2F°$
$3d^8(^3F)4f$		$^3/_2$	*373 145*	32	$^4P°$	31	$3d^8(^3F)4f$ $^4D°$
$3d^8(^3F)4f$		$^5/_2$	*373 391*	34	$^4F°$	33	$3d^8(^3F)4f$ $^4G°$
$3d^8(^3F)4f$	$^2D°$	$^3/_2$	*373 603*	49		21	$3d^8(^3F)4f$ $^2P°$
$3d^8(^3F)4f$	$^2G°$	$^7/_2$	*373 649*	49		16	$3d^8(^3F)4f$ $^2F°$
$3d^8(^3F)4f$	$^2F°$	$^5/_2$	*373 859*	46		27	$3d^8(^3F)4f$ $^4G°$
$3d^8(^1G)5p$	$^2G°$	$^7/_2$	*375 498*	98		2	$3d^8(^1G)5p$ $^2F°$
		$^9/_2$	*375 615*	99			
$3d^8(^1S)4d$	^2D	$^5/_2$	377 071.1	98		1	$3d^8(^1G)4p$ $^2D°$
		$^3/_2$	377 382.0	96		2	$3d^8(^3P)4d$ ^2D
$3d^8(^1D)4f$	$^2F°$	$^5/_2$	*387 509*	74		9	$3d^8(^3F)4f$ $^2F°$
		$^7/_2$	*387 734*	61		18	$3d^8(^1D)4f$ $^2G°$

Zn IV — Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages			
$3d^8(^1D)4f$	$^2D^\circ$	$3/2$	*387 896*	73		12	$3d^8(^3P)4f\ ^4F^\circ$
		$5/2$	*387 954*	77		9	$3d^8(^3P)4f\ ^4D^\circ$
$3d^8(^1D)4f$	$^2P^\circ$	$1/2$	*388 204*	79		19	$3d^8(^3P)4f\ ^4D^\circ$
		$3/2$	*388 208*	79		12	"
$3d^8(^3P)4f$	$^4F^\circ$	$7/2$	*391 506*	74		18	$3d^8(^1D)4f\ ^2F^\circ$
		$5/2$	*391 541*	80		9	"
		$3/2$	*391 611*	87		13	$3d^8(^1D)4f\ ^2D^\circ$
$3d^8(^3P)4f$	$^2F^\circ$	$7/2$	*391 759*	75		16	$3d^8(^1D)4f\ ^2G^\circ$
		$5/2$	*392 204*	74		13	$3d^8(^1D)4f\ ^2F^\circ$
$3d^8(^3P)4f$	$^4D^\circ$	$1/2$	*392 561*	81		19	$3d^8(^1D)4f\ ^2P^\circ$
		$5/2$	*392 702*	76		10	$3d^8(^3P)4f\ ^2D^\circ$
		$7/2$	*393 120*	64		18	$3d^8(^3P)4f\ ^2G^\circ$
$3d^8(^3P)4f$	$^4G^\circ$	$7/2$	*392 604*	68		22	$3d^8(^3P)4f\ ^2G^\circ$
		$5/2$	*392 702*	87		10	$3d^8(^3P)4f\ ^2D^\circ$
$3d^8(^3P)4f$	$^2D^\circ$	$3/2$	*392 798*	76		11	$3d^8(^3P)4f\ ^4D^\circ$
		$5/2$	*393 120*	71		12	"
$3d^8(^3F)6p$	$^2D^\circ$	$5/2$	*397 708*	49		42	$3d^8(^3F)6p\ ^4D^\circ$
		$3/2$	*401 555*	80		18	"
$3d^8(^3F)6p$	$^2F^\circ$	$7/2$	*397 708*	59		26	$3d^8(^3F)6p\ ^4F^\circ$
		$5/2$	*401 722*	66		25	"
$3d^8(^1G)4f$	$^2P^\circ$	$3/2$	*398 841*	100			
		$1/2$	*398 878*	100			
$3d^8(^1G)4f$	$^2D^\circ$	$5/2$	*399 227*	100			
		$3/2$	*399 290*	100			
$3d^8(^3F)6p$	$^4D^\circ$	$5/2$	*399 698*	48		44	$3d^8(^3F)6p\ ^2D^\circ$
$3d^8(^1G)4f$	$^2F^\circ$	$7/2$	*399 867*	100			
		$5/2$	*399 919*	100			
$3d^8(^3F)6p$	$^4F^\circ$	$5/2$	*399 948*	52		21	$3d^8(^3F)6p\ ^2F^\circ$
		$7/2$	*399 948*	59		23	"
$3d^8(^3F)5f$	$^2P^\circ$	$3/2$	*409 559*	45		21	$3d^8(^3F)5f\ ^2D^\circ$
		$1/2$	*413 433*	39		24	$3d^8(^3F)5f\ ^4D^\circ$
$3d^8(^3F)5f$	$^2F^\circ$	$7/2$	*409 667*	50		17	$3d^8(^3F)5f\ ^2G^\circ$
		$5/2$	*413 704*	47		21	$3d^8(^3F)5f\ ^4G^\circ$
$3d^8(^3F)5f$	$^2D^\circ$	$5/2$	*409 700*	45		19	$3d^8(^3F)5f\ ^2F^\circ$
		$3/2$	*413 684*	47		22	$3d^8(^3F)5f\ ^2P^\circ$
$3d^8(^3F)5f$	$^4P^\circ$	$1/2$	*411 772*	58		32	$3d^8(^3F)5f\ ^2P^\circ$
$3d^8(^3F)5f$		$3/2$	*411 805*	30	$^4D^\circ$	29	$3d^8(^3F)5f\ ^2P^\circ$
$3d^8(^3F)5f$		$3/2$	*411 954*	30	$^4F^\circ$	26	$3d^8(^3F)5f\ ^2D^\circ$
$3d^85f$		$5/2,7/2$	*411 965*				

Zn IV — Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages		
$3d^8(^1S)5p$	$^2P°$	1/2	*411 966*	99		
		3/2	*412 733*	99		
$3d^8(^3F)5f$		5/2	*413 433*	36 $^4F°$	34	$3d^8(^3F)5f\ ^4G°$
$3d^8(^3F)5f$	$^2G°$	7/2	*413 666*	46	16	$3d^8(^3F)5f\ ^2F°$
$3d^8(^1D)6p$	$^2D°$	5/2	*415 343*	61	17	$3d^8(^3P)6p\ ^4P°$
		3/2	*415 492*	62	14	$3d^8(^1D)6p\ ^2P°$
$3d^8(^1D)6p$	$^2F°$	5/2	*415 778*	67	14	$3d^8(^3P)6p\ ^2D°$
$3d^8(^1D)6p$	$^2P°$	3/2	*416 127*	63	18	$3d^8(^1D)6p\ ^2D°$
$3d^8(^3P)6p$	$^4D°$	3/2	*420 188*	48	47	$3d^8(^3P)6p\ ^2P°$
$3d^8(^3P)6p$	$^2P°$	1/2	*420 796*	83	13	$3d^8(^1D)6p\ ^2P°$
$3d^8(^1D)5f$	$^2F°$	5/2	*427 723*	75	8	$3d^8(^3P)5f\ ^2F°$
		7/2	*427 933*	62	18	$3d^8(^1D)5f\ ^2G°$
$3d^8(^1D)5f$	$^2D°$	3/2	*427 880*	71	11	$3d^8(^3P)5f\ ^2D°$
		5/2	*427 885*	78	10	$3d^8(^3P)5f\ ^4D°$
$3d^8(^1G)6p$	$^2F°$	7/2	*427 901*	99		
		5/2	*427 938*	100		
$3d^8(^3P)5f$	$^2F°$	7/2	*432 075*	61	17	$3d^8(^1D)5f\ ^2G°$
		5/2	*432 353*	42	16	$3d^8(^3P)5f\ ^4D°$
$3d^8(^3P)5f$	$^4G°$	7/2	*432 442*	63	17	$3d^8(^3P)5f\ ^2G°$
		5/2	*432 673*	67	26	$3d^8(^3P)5f\ ^2D°$
$3d^8(^3P)5f$	$^2D°$	3/2	*432 673*	71	14	$3d^8(^3P)5f\ ^4D°$
$3d^8(^1S)4f$	$^2F°$	7/2	*439 223*	100		
		5/2	*439 286*	100		
$3d^8(^1G)5f$	$^2P°$	3/2	*439 576*	100		
		1/2	*439 610*	100		
$3d^8(^1G)5f$	$^2D°$	5/2	*439 859*	100		
		3/2	*439 863*	100		
$3d^8(^1G)5f$	$^2F°$	5/2	*439 979*	100		
Zn V ($^3F_4$)	***Limit***		**480 490**			

Zn v

Z=30

Fe I isoelectronic sequence

Ground state $1s^22s^22p^63s^23p^63d^8\ ^3F_4$

Ionization energy 666 000 ± 7 000 cm^{-1} (82.6 ± 1eV)

The ground term $3d^8\ ^3F$ splitting was reported by Dick [1974], but with no classified lines. Subsequently Van Kleef *et al.* [1982] reobserved the spectrum from 200 to 1000Å with a spark discharge. They reported a wavelength uncertainty of ±0.003Å. They analyzed the $3d^8-3d^74p$ array and classified 266 lines in the range of 260−385 Å. All levels of $3d^8$ are given as well as 93 of the 110 levels of $3d^74p$. Their level uncertainty is ±1 cm^{-1}. They calculated the percentage composition of the levels with least squares fitted radial integrals.

The spectrum was observed by Van Kleef and Joshi [1983] in the range of 500−2000 Å with an uncertainty of ±0.005 Å. The array $3d^74s-3d^74p$ was studied and 447 lines were classified. All 38 levels of $3d^74s$ and 17 additional levels of $3d^74p$ were reported, thus completing this latter configuration. We give the levels of $3d^74p$ from this work, which contains improved values relative to the $3d^74s$ configuration. The level uncertainty is ±0.5 cm^{-1}. The percentage composition of the $3d^74s$ and the newly discovered levels of $3d^74p$ configurations are also reported.

Additional lines of the $3d^8-3d^74p$ array were observed by Van Kleef *et al.* [1984] in the range of 363−394 Å. These arise from transitions among the known levels.

The value for the ionization energy was obtained by Lotz [1967] by extrapolation.

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Zn v

Configuration	Term	J	Level (cm^{-1})	Leading percentages		
$3d^8$	^3F	4	0	100		
		3	2 466	100		
		2	4 036	98	2	$3d^8\ ^1D$
$3d^8$	^1D	2	18 400	79	20	$3d^8\ ^3P$
$3d^8$	^3P	2	22 663	80	19	$3d^8\ ^1D$
		1	23 107	100		
		0	23 510	100		
$3d^8$	^1G	4	30 600	100		
$3d^8$	^1S	0	69 904	100		
$3d^7(^4F)4s$	^5F	5	198 961.7	99	1	$3d^7(^2G)4s\ ^3G$
		4	200 644.0	99	1	$3d^7(^4F)4s\ ^3F$
		3	201 972.7	99	1	"
		2	202 929.1	99	1	$3d^7(^2D2)4s\ ^3D$
		1	203 548.2	99	1	"
$3d^7(^4F)4s$	^3F	4	208 715.1	98	1	$3d^7(^4F)4s\ ^5F$
		3	210 972.5	99	1	"
		2	212 471.4	99	1	$3d^7(^2D2)4s\ ^1D$
$3d^7(^4P)4s$	^5P	3	221 631.3	99	1	$3d^7(^2D2)4s\ ^3D$
		2	222 042.1	93	7	$3d^7(^2P)4s\ ^3P$
		1	222 939.9	96	4	"

Zn V — Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages		
$3d^7(^2G)4s$	^3G	5	226 333.9	96	2	$3d^7(^2H)4s\ ^3H$
		4	227 195.3	92	4	$3d^7(^2G)4s\ ^1G$
		3	228 335.1	100		
$3d^7(^2P)4s$	^3P	2	230 434.6	46	43	$3d^7(^4P)4s\ ^3P$
		1	232 945.9	54	38	"
		0	231 121.8	56	44	"
$3d^7(^2G)4s$	^1G	4	231 830.8	87	6	$3d^7(^2H)4s\ ^3H$
$3d^7(^4P)4s$	^3P	2	231 996.9	55	36	$3d^7(^2P)4s\ ^3P$
		1	230 614.2	46	30	"
		0	234 581.5	56	44	"
$3d^7(^2H)4s$	^3H	6	234 846.0	100		
		5	235 729.5	94	4	$3d^7(^2H)4s\ ^1H$
		4	236 968.7	90	8	$3d^7(^2G)4s\ ^1G$
$3d^7(^2D2)4s$	^3D	3	235 598.6	76	23	$3d^7(^2D1)4s\ ^3D$
		2	237 031.9	64	17	"
		1	239 842.7	44	39	$3d^7(^2P)4s\ ^1P$
$3d^7(^2P)4s$	^1P	1	235 903.2	43	29	$3d^7(^2D2)4s\ ^3D$
$3d^7(^2H)4s$	^1H	5	240 446.1	95	3	$3d^7(^2H)4s\ ^3H$
$3d^7(^2D2)4s$	^1D	2	241 829.3	68	18	$3d^7(^2D1)4s\ ^1D$
$3d^7(^2F)4s$	^3F	2	255 481.7	100		
		3	255 763.2	99	1	$3d^7(^2F)4s\ ^1F$
		4	256 235.2	100		
$3d^7(^2F)4s$	^1F	3	260 879.8	99	1	$3d^7(^2F)4s\ ^3F$
$3d^7(^4F)4p$	$^5F°$	4	*283 933.0*	49	42	$3d^7(^4F)4p\ ^5D°$
		5	*284 115.5*	88	9	$3d^7(^4F)4p\ ^5G°$
		3	*285 602.6*	67	26	$3d^7(^4F)4p\ ^5D°$
		2	*286 935.9*	80	14	"
		1	*287 888.3*	92	6	"
$3d^7(^2D1)4s$	^3D	1	285 522.7	81	19	$3d^7(^2D2)4s\ ^3D$
		2	285 884.6	79	20	"
		3	286 575.4	77	23	"
$3d^7(^4F)4p$	$^5D°$	4	*286 943.2*	45	35	$3d^7(^4F)4p\ ^5F°$
		3	*288 704.1*	57	17	"
		2	*289 924.5*	61	22	$3d^7(^4F)4p\ ^5G°$
		1	*290 704.0*	81	12	$3d^7(^4P)4p\ ^5D°$
		0	*291 022.3*	86	13	"
$3d^7(^4F)4p$	$^5G°$	6	*288 499.9*	99	1	$3d^7(^2G)4p\ ^3H°$
		5	*288 902.8*	70	18	$3d^7(^4F)4p\ ^3G°$
		4	*289 827.0*	72	14	$3d^7(^4F)4p\ ^5F°$
		3	*290 423.9*	72	14	"
		2	*290 730.6*	71	13	$3d^7(^4F)4p\ ^5D°$
$3d^7(^2D1)4s$	^1D	2	291 106.6	77	21	$3d^7(^2D2)4s\ ^1D$

Zn v — Continued

Configuration	Term	*J*	Level (cm^{-1})	Leading percentages			
$3d^7(^4F)4p$	$^3G°$	5	*292 722.2*	78		21	$3d^7(^4F)4p$ $^5G°$
		4	*295 168.4*	87		11	"
		3	*296 795.7*	80		14	$3d^7(^4F)4p$ $^3D°$
$3d^7(^4F)4p$	$^3F°$	4	*293 463.1*	87		4	$3d^7(^2G)4p$ $^3F°$
		3	*295 293.2*	80		8	$3d^7(^4F)4p$ $^3D°$
		2	*296 756.7*	86		5	$3d^7(^2G)4p$ $^3F°$
$3d^7(^4F)4p$	$^3D°$	3	*297 033.2*	70		13	$3d^7(^4F)4p$ $^3G°$
		2	*298 374.7*	84		4	$3d^7(^4F)4p$ $^3F°$
		1	*299 371.8*	88		3	$3d^7(^4P)4p$ $^3D°$
$3d^7(^4P)4p$	$^5S°$	2	*298 800.7*	96		1	$3d^7(^4F)4p$ $^3D°$
$3d^7(^2P)4p$		1	*309 658.1*	27	$^3P°$	26	$3d^7(^4P)4p$ $^5D°$
$3d^7(^4P)4p$	$^5D°$	2	*310 264.6*	66		10	$3d^7(^4F)4p$ $^5D°$
		3	*310 518.7*	73		9	$3d^7(^4P)4p$ $^3D°$
		0	*310 659.4*	69		17	$3d^7(^2P)4p$ $^3P°$
		1	*311 295.7*	52		20	$3d^7(^4P)4p$ $^3S°$
		4	*311 796.3*	65		12	$3d^7(^2G)4p$ $^3F°$
$3d^7(^2G)4p$	$^3H°$	5	*311 294.5*	63		18	$3d^7(^2G)4p$ $^1H°$
		4	*312 534.0*	82		5	$3d^7(^2G)4p$ $^1G°$
		6	*313 300.0*	94		4	$3d^7(^2H)4p$ $^3I°$
$3d^7(^2G)4p$	^3F	4	311 359.1	44		26	$3d^7(^4P)4p$ ^5D
		3	314 197.4	66		21	$3d^7(^2G)4p$ ^3G
		2	316 586.4	92		5	$3d^7(^4F)4p$ ^3F
$3d^7(^2P)4p$	$^3P°$	0	*312 966.7*	61		15	$3d^7(^4P)4p$ $^5D°$
		2	*313 643.7*	59		8	$3d^7(^2D2)4p$ $^3P°$
		1	*314 229.1*	41		19	$3d^7(^4P)4p$ $^3S°$
$3d^7(^2G)4p$	$^1G°$	4	*314 837.5*	43		28	$3d^7(^2G)4p$ $^3F°$
$3d^7(^4P)4p$		2	*314 958.3*	25	$^5P°$	20	$3d^7(^2P)4p$ $^3D°$
$3d^7(^4P)4p$	$^5P°$	3	*315 239.4*	57		20	$3d^7(^4P)4p$ $^3D°$
		2	*315 800.9*	50		20	"
		1	*316 028.9*	53		23	$3d^7(^4P)4p$ $^3S°$
$3d^7(^2G)4p$	$^3G°$	5	*315 593.7*	79		13	$3d^7(^2G)4p$ $^1H°$
		4	*316 826.7*	71		11	$3d^7(^2G)4p$ $^3H°$
		3	*317 220.2*	43		22	$3d^7(^2G)4p$ $^1F°$
$3d^74p$		3	*315 840.1*	35	$3d^7(^2G)4p$ $^1F°$	15	$3d^7(^4P)4p$ $^3D°$
$3d^7(^4P)4p$	$^3D°$	3	*316 339.2*	39		22	$3d^7(^2G)4p$ $^3G°$
		1	*316 643.0*	40		29	$3d^7(^2P)4p$ $^3D°$
$3d^7(^2G)4p$	$^1H°$	5	*316 786.3*	61		29	$3d^7(^2G)4p$ $^3H°$
$3d^7(^2P)4p$	$^1S°$	0	*317 465.5*	60		30	$3d^7(^4P)4p$ $^3P°$
$3d^7(^2H)4p$	$^3G°$	5	*317 978.0*	90		5	$3d^7(^2F)4p$ $^3G°$
		4	*320 042.5*	85		7	"
		3	*321 775.9*	75		7	"

Zn V — Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages			
$3d^7(^4P)4p$	$^3P°$	2	*318 435.9*	48		17	$3d^7(^4P)4p$ $^3D°$
		1	*320 772.0*	46		20	$3d^7(^2D2)4p$ $^3D°$
		0	*322 969.4*	63		36	$3d^7(^2P)4p$ $^1S°$
$3d^7(^2H)4p$	$^3I°$	6	*318 926.9*	65		31	$3d^7(^2H)4p$ $^1I°$
		5	*320 257.4*	90		5	$3d^7(^2G)4p$ $^3H°$
		7	*320 618.1*	100			
$3d^74p$		1	*319 471.7*	29	$3d^7(^4P)4p$ $^3P°$	25	$3d^7(^2P)4p$ $^3D°$
$3d^7(^2P)4p$	$^3D°$	3	*319 632.0*	63		9	$3d^7(^4P)4p$ $^5P°$
		2	*322 223.6*	27	$3d^7(^2P)4p$ $^3D°$	26	$3d^7(^2D2)4p$ $^3D°$
$3d^74p$		2	*319 984.0*	31	$3d^7(^4P)4p$ $^3P°$	22	$3d^7(^4P)4p$ $^3D°$
$3d^7(^2D2)4p$	$^3D°$	3	*320 709.0*	50		14	$3d^7(^2D2)4p$ $^3F°$
$3d^74p$		2	*320 871.4*	21	$3d^7(^2D2)4p$ $^3D°$	20	$3d^7(^2P)4p$ $^3D°$
$3d^74p$		1	*321 830.2*	23	$3d^7(^2P)4p$ $^1P°$	22	$3d^7(^2D2)4p$ $^3D°$
$3d^7(^2H)4p$	$^1I°$	6	*323 631.9*	66		30	$3d^7(^2H)4p$ $^3I°$
$3d^7(^2D2)4p$	$^3F°$	4	*323 886.4*	77		20	$3d^7(^2D1)4p$ $^3F°$
		3	*324 525.7*	46		11	$3d^7(^2P)4p$ $^3D°$
		2	*325 067.6*	50		12	$3d^7(^2D2)4p$ $^3D°$
$3d^7(^2P)4p$	$^3S°$	1	*325 475.5*	62		8	$3d^7(^2P)4p$ $^1P°$
$3d^7(^2P)4p$	$^1P°$	1	*326 189.4*	42		13	$3d^7(^2P)4p$ $^3S°$
$3d^74p$		2	*326 664.3*	33	$3d^7(^2D2)4p$ $^1D°$	22	$3d^7(^2D2)4p$ $^3P°$
$3d^7(^2H)4p$	$^3H°$	6	*326 987.3*	96		2	$3d^7(^2H)4p$ $^1I°$
		5	*327 581.4*	92		4	$3d^7(^2H)4p$ $^1H°$
		4	*328 369.0*	94		2	$3d^7(^2H)4p$ $^1G°$
$3d^74p$		2	*329 085.0*	34	$3d^7(^2D2)4p$ $^3P°$	19	$3d^7(^2D2)4p$ $^1D°$
$3d^7(^2H)4p$	$^1G°$	4	*329 532.8*	65		32	$3d^7(^2G)4p$ $^1G°$
$3d^7(^2D2)4p$	$^1F°$	3	*330 068.9*	55		16	$3d^7(^2G)4p$ $^1F°$
$3d^7(^2D2)4p$	$^3P°$	1	*331 086.8*	48		13	$3d^7(^2P)4p$ $^1P°$
		0	*331 869.3*	67		15	$3d^7(^2P)4p$ $^3P°$
$3d^7(^2D2)4p$	$^1P°$	1	*332 180.8*	72		11	$3d^7(^2D1)4p$ $^1P°$
$3d^7(^2H)4p$	$^1H°$	5	*333 454.6*	94		3	$3d^7(^2H)4p$ $^3H°$
$3d^7(^2F)4p$	$^1D°$	2	*341 627.2*	54		34	$3d^7(^2F)4p$ $^3F°$
$3d^7(^2F)4p$	$^3G°$	3	*342 616.4*	68		19	$3d^7(^2F)4p$ $^3F°$
		4	*343 221.4*	53		26	"
		5	*345 790.4*	93		6	$3d^7(^2H)4p$ $^3G°$
$3d^7(^2F)4p$	$^3D°$	3	*344 070.3*	51		28	$3d^7(^2F)4p$ $^3F°$
		2	*345 624.3*	79		11	$3d^7(^2F)4p$ $^1D°$
		1	*345 790.0*	90		5	$3d^7(^2D1)4p$ $^3D°$

Zn V — Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages			
$3d^7(^2F)4p$	$^3F°$	2	*344 771.4*	59		30	$3d^7(^2F)4p$ $^1D°$
		3	*345 146.4*	46		34	$3d^7(^2F)4p$ $^3D°$
$3d^7(^2F)4p$		4	*345 723.4*	38	$^3G°$	36	$3d^7(^2F)4p$ $^3F°$
$3d^7(^2F)4p$	$^1G°$	4	*346 201.3*	63		33	$3d^7(^2F)4p$ $^3F°$
$3d^7(^2F)4p$	$^1F°$	3	*352 553.0*	95		2	$3d^7(^2F)4p$ $^3D°$
$3d^7(^2D1)4p$	$^3P°$	2	*368 832.9*	76		21	$3d^7(^2D2)4p$ $^3P°$
		1	*369 301.7*	78		17	"
		0	*369 842.5*	82		17	"
$3d^7(^2D1)4p$	$^3F°$	2	*371 051.3*	76		18	$3d^7(^2D2)4p$ $^3F°$
		3	*372 360.3*	73		19	"
		4	*374 240.6*	74		22	"
$3d^7(^2D1)4p$	$^1P°$	1	*376 434.4*	77		11	$3d^7(^2D2)4p$ $^1P°$
$3d^7(^2D1)4p$	$^1F°$	3	*377 144.3*	73		20	$3d^7(^2D2)4p$ $^1F°$
$3d^7(^2D1)4p$	$^3D°$	1	*380 464.4*	69		21	$3d^7(^2D2)4p$ $^3D°$
		2	*380 901.8*	63		19	"
		3	*382 420.2*	69		24	"
$3d^7(^2D1)4p$	$^1D°$	2	*381 670.0*	59		22	$3d^7(^2D2)4p$ $^1D°$
Zn VI ($^4F_{9/2}$)	***Limit***		**666 000**				

Zn VI

Z=30

Mn I isoelectronic sequence

Ground state $1s^2 2s^2 2p^6 3s^2 3p^6 3d^7\ ^4F_{9/2}$

Ionization energy 871 000 ± 8000 cm^{-1} (108 ± 1 eV)

The spectrum was observed with a sliding spark by Dick [1974] who deduced the $3d^7\ ^4F$ ground term levels. With spectra of sliding and triggered sparks, Van Kleef *et al.* [1984] extended the analysis to include all levels of $3d^7$ and 161 levels of $3d^6 4p$. They classified 277 lines in the range of 222−280 Å, measured with an uncertainty of ±0.005 Å indicating a level uncertainty of ±10 cm^{-1}.

van het Hof *et al.* [1994], revised and extended the van Kleef *et al.* earlier analysis in the 100−300 Å range using a triggered spark. They classified 538 lines. Their improved wavelength values differed from the previous ones by ±0.010 Å. They were able to confirm all 19 levels of the $3d^7$ ground configuration and all but 10 of the $3d^6 4p$ configuration. In addition they established 16 new levels. We give the results of van het Hof *et al.* with an uncertainty estimate of ±10 cm^{-1}. The lowest term of the $3d^6 4p$ configuration, $3d^6(^5D)4p\ ^6D°$, was not found. We give their calculated level values and calculated percentage compositions of the levels.

The value for the ionization energy was obtained by Lotz [1967] by extrapolation.

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Zn VI

Configuration	Term	J	Level (cm^{-1})	Leading percentages		
$3d^7$	^4F	9/2	0	99		
		7/2	2 132	100		
		5/2	3 618	100		
		3/2	4 613	99		
$3d^7$	^4P	5/2	23 455	99		
		3/2	23 641	86	14	$3d^7\ ^2P$
		1/2	24 875	95	5	"
$3d^7$	^2G	9/2	25 266	95	4	$3d^7\ ^2H$
		7/2	27 286	100		
$3d^7$	^2P	3/2	30 381	73	13	$3d^7\ ^4P$
		1/2	32 157	95	5	"
$3d^7$	^2H	11/2	34 066	100		
		9/2	35 975	96	4	$3d^7\ ^2G$
$3d^7$	$^2D2$	5/2	34 770	76	23	$3d^7\ ^2D1$
		3/2	37 908	68	16	"
$3d^7$	^2F	5/2	55 347	100		
		7/2	56 137	100		
$3d^7$	$^2D1$	3/2	85 958	80	20	$3d^7\ ^2D1$
		5/2	87 036	76	23	"
$3d^6(^5D)4p$	$^6D°$	9/2	*[369 436]*	96		
		7/2	*[369 786]*	93		
		5/2	*[370 466]*	95		
		3/2	*[371 032]*	97		
		1/2	*[371 400]*	98		

Zn VI — Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages			
$3d^6(^5D)4p$	$^6F°$	7/2	*378 331*	84		5	$3d^6(^5D)4p$ $^4D°$
		5/2	*378 410*	90		5	"
		11/2	*[378 462]*	99			
		9/2	*378 442*	89		7	$3d^6(^5D)4p$ $^4F°$
		3/2	*378 454*	92		5	$3d^6(^5D)4p$ $^4D°$
		1/2	*378 465*	94		5	"
$3d^6(^5D)4p$	$^6P°$	7/2	*380 938*	71		15	$3d^6(^5D)4p$ $^4D°$
		5/2	*383 438*	74		18	"
		3/2	*385 129*	76		18	"
$3d^6(^5D)4p$	$^4D°$	7/2	*383 826*	74		21	$3d^6(^5D)4p$ $^6P°$
		5/2	*384 920*	71		22	"
		3/2	*385 660*	71		21	"
		1/2	*385 984*	89		5	$3d^6(^5D)4p$ $^6F°$
$3d^6(^5D)4p$	$^4F°$	9/2	*384 680*	90		8	$3d^6(^5D)4p$ $^6F°$
		7/2	*386 658*	92		6	"
		5/2	*387 971*	94			
		3/2	*388 854*	96			
$3d^6(^5D)4p$	$^4P°$	5/2	*390 511*	95			
		3/2	*391 820*	96			
		1/2	*392 460*	97			
$3d^6(^3P2)4p$	$^4P°$	3/2	*405 352*	21		19	$3d^6(^3P1)4p$ $^4P°$
$3d^6(^3H)4p$	$^4G°$	11/2	*406 972*	69		17	$3d^6(^3F2)4p$ $^4G°$
		9/2	*407 509*	37		25	"
		7/2	*408 185*	30		17	"
		5/2	*417 889*	30		13	"
$3d^64p$		5/2	*407 719*	19	$3d^6(^3P2)4p$ $^4P°$	17	$3d^6(^3P1)4p$ $^4P°$
$3d^64p$		7/2	*407 968*	19	$3d^6(^3F2)4p$ $^4G°$	13	$3d^6(^3H)4p$ $^4H°$
$3d^64p$		9/2	*408 074*	34	$3d^6(^3H)4p$ $^4H°$	31	$3d^6(^3H)4p$ $^4I°$
$3d^6(^3H)4p$	$^4I°$	11/2	*408 009*	48		32	$3d^6(^3H)4p$ $^4H°$
		13/2	*408 054*	45		36	"
		9/2	*410 081*	46		18	$3d^6(^3H)4p$ $^2G°$
$3d^6(^3F2)4p$	$^4G°$	5/2	*408 439*	42		34	$3d^6(^3H)4p$ $^4G°$
		9/2	*415 669*	28		12	"
		7/2	*415 913*	26		14	"
		11/2	*416 251*	47		17	$3d^6(^3H)4p$ $^2I°$
$3d^64p$		7/2	*410 262*	21	$3d^6(^3H)4p$ $^4H°$	18	$3d^6(^3F2)4p$ $^4D°$
$3d^64p$		5/2	*410 747*	27	$3d^6(^3P2)4p$ $^2D°$	23	$3d^6(^3P2)4p$ $^4P°$
$3d^6(^3F2)4p$	$^4F°$	5/2	*410 548*	45		14	$3d^6(^3F1)4p$ $^4F°$
		9/2	*411 513*	38		14	"
		3/2	*410 923*	43		13	"
$3d^64p$		3/2	*411 061*	21	$3d^6(^3P2)4p$ $^4D°$	16	$3d^6(^3P2)4p$ $^4F°$
$3d^6(^3H)4p$	$^4I°$	11/2	*411 558*	43		39	$3d^6(^3H)4p$ $^4H°$

Zn VI — Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages			
$3d^6(^3P2)4p$	$^4D°$	7/2	411 723	49		25	$3d^6(^3P1)4p$ $^4D°$
		1/2	413 629	54		23	"
		5/2	415 333	39		17	"
$3d^6(^3H)4p$	$^4H°$	13/2	411 824	52		34	$3d^6(^3H)4p$ $^4I°$
$3d^64p$		9/2	412 154	28	$3d^6(^3H)4p$ $^4H°$	23	$3d^6(^3H)4p$ $^2G°$
$3d^64p$		7/2	412 176	21	$3d^6(^3F2)4p$ $^4F°$	19	$3d^6(^3H)4p$ $^2G°$
$3d^64p$		7/2	413 087	38	$3d^6(^3F2)4p$ $^4D°$	11	$3d^6(^3H)4p$ $^2G°$
$3d^6(^3F2)4p$	$^4D°$	5/2	413 856	49		11	$3d^6(^3F2)4p$ $^4F°$
		3/2	414 554	57		12	$3d^6(^3D)4p$ $^4D°$
		1/2	414 913	61		13	"
$3d^6(^3H)4p$	$^2I°$	13/2	413 862	75		19	$3d^6(^3H)4p$ $^4I°$
		11/2	414 977	67		8	$3d^6(^3F2)4p$ $^4G°$
$3d^64p$		3/2	414 104	19	$3d^6(^3P2)4p$ $^4P°$	17	$3d^6(^3P1)4p$ $^4P°$
$3d^64p$		3/2	415 400	22	$3d^6(^3P2)4p$ $^4D°$	16	$3d^6(^3P2)4p$ $^2D°$
$3d^64p$		5/2	415 733	20	$3d^6(^3F2)4p$ $^2F°$	17	$3d^6(^3G)4p$ $^4G°$
$3d^6(^3G)4p$	$^4F°$	9/2	416 400	49		25	$3d^6(^3G)4p$ $^4G°$
		3/2	420 280	49		15	$3d^6(^3D)4p$ $^4F°$
$3d^64p$		11/2	417 122	31	$3d^6(^3G)4p$ $^2H°$	21	$3d^6(^3G)4p$ $^4G°$
$3d^64p$		7/2	417 684	16	$3d^6(^3G)4p$ $^4F°$	11	$3d^6(^3F2)4p$ $^2F°$
$3d^64p$		7/2	417 762	29	$3d^6(^3G)4p$ $^4F°$	20	$3d^6(^3G)4p$ $^4G°$
$3d^64p$		1/2	417 995	27	$3d^6(^3P2)4p$ $^2S°$	23	$3d^6(^3P2)4p$ $^2P°$
$3d^64p$		9/2	418 021	27	$3d^6(^3G)4p$ $^2H°$	14	$3d^6(^3F2)4p$ $^2G°$
$3d^6(^3G)4p$	$^4G°$	11/2	418 943	44		17	$3d^6(^3H)4p$ $^4G°$
		5/2	420 511	40		23	$3d^6(^3G)4p$ $^4F°$
$3d^64p$		5/2	419 119	34	$3d^6(^3G)4p$ $^4F°$	17	$3d^6(^3G)4p$ $^4G°$
$3d^6(^3P2)4p$	$^2P°$	3/2	419 181	38		25	$3d^6(^3P1)4p$ $^2P°$
$3d^64p$		9/2	419 454	27	$3d^6(^3F2)4p$ $^2G°$	14	$3d^6(^3G)4p$ $^4G°$
$3d^6(^3F2)4p$	$^2G°$	7/2	419 901	51		11	$3d^6(^3F1)4p$ $^2G°$
$3d^64p$		9/2	419 910	28	$3d^6(^3G)4p$ $^4G°$	20	$3d^6(^3H)4p$ $^2H°$
$3d^64p$		7/2	420 207	33	$3d^6(^3G)4p$ $^4G°$	20	$3d^6(^3G)4p$ $^4F°$
$3d^6(^3P2)4p$	$^2S°$	1/2	420 732	43		16	$3d^6(^3P1)4p$ $^2S°$
$3d^6(^3G)4p$	$^4H°$	13/2	420 630	83		11	$3d^6(^3H)4p$ $^4H°$
		7/2	420 748	50		13	$3d^6(^3F2)4p$ $^2G°$
		11/2	420 839	66		12	$3d^6(^3H)4p$ $^2H°$
		9/2	420 868	61		10	$3d^6(^3G)4p$ $^4G°$

Zn VI — Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages			
$3d^6(^3F2)4p$	$^2D°$	5/2	423 242	55		11	$3d^6(^3P2)4p$ $^2D°$
		3/2	424 307	58		17	"
$3d^6(^3G)4p$	$^2F°$	5/2	424 972	35		19	$3d^6(^3D)4p$ $^2F°$
		7/2	425 616	43		20	"
$3d^6(^3H)4p$	$^2H°$	11/2	425 663	51		34	$3d^6(^3G)4p$ $^2H°$
		9/2	426 749	29		27	
$3d^6(^1I)4p$	$^2K°$	13/2	425 914	95			
$3d^6(^3D)4p$	$^4P°$	5/2	427 638	82		4	$3d^6(^3D)4p$ $^2D°$
		3/2	428 283	62		12	$3d^6(^3D)4p$ $^2P°$
		1/2	430 340	55		14	"
$3d^6(^1G2)4p$	$^2H°$	9/2	428 708	34		16	$3d^6(^3G1)4p$ $^2H°$
		11/2	433 554	41		27	$3d^6(^1G1)4p$ $^2H°$
$3d^6(^3G)4p$	$^2G°$	7/2	428 708	60		10	$3d^6(^1G2)4p$ $^2F°$
		9/2	429 334	55		13	$3d^6(^3H)4p$ $^2H°$
$3d^6(^1I)4p$	$^2H°$	11/2	429 087	55		15	$3d^6(^1G2)4p$ $^2H°$
		9/2	433 592	60		14	"
$3d^64p$		1/2	429 367	33	$3d^6(^3D)4p$ $^4P°$	26	$3d^6(^3D)4p$ $^4D°$
$3d^6(^3D)4p$	$^4F°$	3/2	430 411	50		25	$3d^6(^3G)4p$ $^4F°$
		5/2	430 898	44		20	"
		9/2	43 932	66		11	"
$3d^64p$		3/2	430 905	29	$3d^6(^3D)4p$ $^2P°$	21	$3d^6(^3D)4p$ $^4P°$
$3d^64p$		7/2	430 992	20	$3d^6(^3D)4p$ $^4D°$	19	$3d^6(^3D)4p$ $^4F°$
$3d^6(^1G2)4p$	$^2G°$	7/2	431 387	29		11	$3d^6(^3H)4p$ $^2G°$
		9/2	432 330	43		18	$3d^6(^1G1)4p$ $^2G°$
$3d^6(^3D)4p$	$^4D°$	5/2	431 959	60		18	$3d^6(^3D)4p$ $^4F°$
		3/2	432 264	43		36	$3d^6(^3D)4p$ $^2P°$
		7/2	432 578	44		11	$3d^6(^3D)4p$ $^4F°$
$3d^64p$		7/2	432 352	38	$3d^6(^3D)4p$ $^4F°$	14	$3d^6(^1G2)4p$ $^2F°$
$3d^64p$		1/2	432 420	37	$3d^6(^3D)4p$ $^4D°$	32	$3d^6(^3D)4p$ $^2P°$
$3d^6(^1G2)4p$	$^2F°$	5/2	433 261	32		17	$3d^6(^3G)4p$ $^2F°$
$3d^6(^3D)4p$	$^2D°$	3/2	434 794	54		18	$3d^6(^1D2)4p$ $^2P°$
		5/2	435 704	77		5	$3d^6(^3D)4p$ $^2F°$
$3d^6(^1I)4p$	$^2I°$	13/2	434 803	96			
		11/2	434 892	71		14	$3d^6(^1I)4p$ $^2H°$
$3d^64p$		3/2	436 263	23	$3d^6(^1D2)4p$ $^2P°$	20	$3d^6(^3D)4p$ $^2D°$
$3d^6(^3D)4p$	$^2F°$	7/2	436 648	59		16	$3d^6(^1D2)4p$ $^2F°$
		5/2	437 355	36		30	"
$3d^6(^1S2)4p$	$^2P°$	1/2	437 755	34		18	$3d^6(^1D2)4p$ $^2P°$
		3/2	444 093	36		21	"

Zn VI — Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages			
$3d^6(^1D2)4p$	$^2D^\circ$	$^5/_2$	*439 782*	32		18	$3d^6(^1F)4p\ ^2D^\circ$
		$^3/_2$	*440 438*	53		10	"
$3d^6(^1D2)4p$	$^2F^\circ$	$^5/_2$	*441 546*	26		18	$3d^6(^1G2)4p\ ^2F^\circ$
		$^7/_2$	*442 599*	46		11	"
$3d^6(^1D2)4p$	$^2P^\circ$	$^1/_2$	*441 975*	45		20	$3d^6(^1S2)4p\ ^2P^\circ$
$3d^6(^1F)4p$	$^2G^\circ$	$^7/_2$	*446 463*	84			
		$^9/_2$	*449 369*	91			
$3d^6(^1F)4p$	$^2D^\circ$	$^5/_2$	*449 179*	46		22	$3d^6(^1D2)4p\ ^2D^\circ$
		$^3/_2$	*451 820*	57		12	$3d^6(^3P1)4p\ ^4D^\circ$
$3d^6(^3P1)4p$	$^4D^\circ$	$^1/_2$	*450 618*	40		34	$3d^6(^3F1)4p\ ^4D^\circ$
$3d^6(^3F1)4p$	$^4D^\circ$	$^3/_2$	*450 614*	30		25	$3d^6(^3P1)4p\ ^4D^\circ$
		$^5/_2$	*451 793*	40		29	"
		$^7/_2$	*451 825*	54		22	"
		$^1/_2$	*466 410*	48		21	"
$3d^6(^1F)4p$	$^2F^\circ$	$^5/_2$	*455 221*	77		6	$3d^6(^1F)4p\ ^2D^\circ$
		$^7/_2$	*455 260*	79		5	$3d^6(^1G2)4p\ ^2F^\circ$
$3d^6(^3P1)4p$	^2S	$^1/_2$	457 768	60		23	$3d^6(^3P2)4p\ ^2S$
$3d^6(^3F1)4p$	$^4G^\circ$	$^7/_2$	*459 909*	75		16	$3d^6(^3F2)4p\ ^4G^\circ$
		$^9/_2$	*460 567*	68		16	"
$3d^6(^3P1)4p$	$^4S^\circ$	$^3/_2$	*461 483*	74		22	$3d^6(^3P2)4p\ ^4S^\circ$
$3d^6(^3F1)4p$	$^2D^\circ$	$^3/_2$	*463 942*	47		22	$3d^6(^3P1)4p\ ^2D^\circ$
		$^5/_2$	*465 229*	40		23	"
$3d^6(^3P1)4p$	$^4P^\circ$	$^1/_2$	*464 552*	46		36	$3d^6(^3P2)4p\ ^4P^\circ$
		$^3/_2$	*464 802*	50		39	"
		$^5/_2$	*466 653*	27		21	"
$3d^6(^3F1)4p$	$^2G^\circ$	$^9/_2$	*465 464*	59		14	$3d^6(^3F2)4p\ ^2G^\circ$
		$^7/_2$	*466 848*	58		13	$3d^6(^3F2)4p\ ^4F^\circ$
$3d^6(^3F1)4p$	$^4D^\circ$	$^3/_2$	*467 155*	31		19	$3d^6(^3P1)4p\ ^4D^\circ$
$3d^64p$		$^5/_2$	*467 889*	20	$3d^6(^3P1)4p\ ^4P^\circ$	19	$3d^6(^3F1)4p\ ^4F^\circ$
$3d^6(^3F1)4p$	$^4F^\circ$	$^3/_2$	*468 006*	48		15	$3d^6(^3F2)4p\ ^4F^\circ$
		$^5/_2$	*469 405*	39		13	"
$3d^64p$		$^7/_2$	*468 240*	31	$3d^6(^3F1)4p\ ^4F^\circ$	17	$3d^6(^3P1)4p\ ^4D^\circ$
$3d^64p$		$^5/_2$	*469 405*	39	$3d^6(^3F1)4p\ ^4F^\circ$	19	$3d^6(^3F1)4p\ ^4D^\circ$
$3d^64p$		$^7/_2$	*470 210*	26	$3d^6(^3F1)4p\ ^4F^\circ$	21	$3d^6(^3P1)4p\ ^4D^\circ$
$3d^64p$		$^3/_2$	*470 317*	26	$3d^6(^3F1)4p\ ^2D^\circ$	18	$3d^6(^3P1)4p\ ^2D^\circ$
$3d^6(^3P1)4p$	$^2P^\circ$	$^1/_2$	*471 906*	53		33	$3d^6(^3P2)4p\ ^2P^\circ$
		$^3/_2$	*473 555*	42		28	"
$3d^6(^3P1)4p$	$^2D^\circ$	$^5/_2$	*471 915*	32		25	$3d^6(^3F1)4p\ ^2D^\circ$

Zn VI — Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages			
$3d^6(^3F1)4p$	$^2F^\circ$	$7/2$	*472 381*	41		21	$3d^6(^1G1)4p\ ^2F^\circ$
		$5/2$	*473 643*	62		24	$3d^6(^3F2)4p\ ^2F^\circ$
$3d^6(^1G1)4p$	$^2H^\circ$	$9/2$	*473 427*	56		32	$3d^6(^1G2)4p\ ^2H^\circ$
		$11/2$	*476 353*	62		35	"
$3d^64p$		$7/2$	*475 945*	31	$3d^6(^1G1)4p\ ^2G^\circ$	16	$3d^6(^1G1)4p\ ^2F^\circ$
$3d^6(^1G1)4p$	$^2F^\circ$	$5/2$	*477 658*	51		23	$3d^6(^1G2)4p\ ^2F^\circ$
$3d^6(^1G1)4p$	$^2G^\circ$	$9/2$	*479 010*	62		25	$3d^6(^1G2)4p\ ^2G^\circ$
		$7/2$	*479 749*	36		15	"
$3d^6(^1D1)4p$	$^2D^\circ$	$3/2$	*501 720*	78		16	$3d^6(^1D2)4p\ ^2D^\circ$
		$5/2$	*502 704*	78		16	"
$3d^6(^1D1)4p$	$^2F^\circ$	$5/2$	*509 721*	68		21	$3d^6(^1D2)4p\ ^2F^\circ$
		$7/2$	*512 085*	72		22	"
$3d^6(^1D1)4p$	$^2P^\circ$	$3/2$	*511 415*	63		24	$3d^6(^1D2)4p\ ^2P^\circ$
		$1/2$	*512 261*	64		24	"
Zn VII ($^5D_4$)	***Limit***		**1 080 000**				

Zn VII

Z=30

Cr I isoelectronic sequence

Ground state $1s^22s^22p^63s^23p^63d^6\ ^5D_4$

Ionization energy 1 080 000 ± 10 000 cm^{-1} (134 ± 1.2 eV)

An analysis of this spectrum has been carried out by van het Hoff *et al.* [1993]. They report 338 classified lines of the $3d^6-3d^54p$ array in the range of 178–219 Å with an uncertainty of ±0.004 Å. With these lines they established 30 of the 34 levels of the $3d^6$ configuration and 103 of the 214 levels of the $3d^54p$ with a level uncertainty of ±10 cm^{-1}. By means of a fitted calculation they determined the percentage composition of the levels in LS-coupling. We quote their results.

The value for the ionization energy was obtained by Lotz [1967] by extrapolation.

References

Lotz, W. [1967], J. Opt. Soc. Am. **57**, 873.

van het Hoff, G. J., Joshi, Y. N., Raassen, A. J. J., and Ryabtsev, A. N. [1993], Phys. Scr. **47**, 531.

Zn VII

Configuration	Term	J	Level (cm^{-1})	Leading percentages		
$3d^6$	^{5}D	4	0	99		
		3	1 567	100		
		2	2 579	99		
		1	3 230	99		
$3d^6$	^{3}P2	2	32 319	61	37	$3d^6\ ^3$P1
		1	36 747	63	36	"
		0				
$3d^6$	^{3}H	6	33 630	99		
		5	34 358	94	6	$3d^6\ ^3$G
		4	34 559	71	14	$3d^6\ ^3$F2
$3d^6$	^{3}F2	4	36 364	56	25	$3d^6\ ^3$H
		3	36 953	74	10	$3d^6\ ^3$F1
		2	37 536	80	19	"
$3d^6$	^{3}G	5	41 450	94	6	$3d^6\ ^3$H
		4	42 875	90	6	$3d^6\ ^3$F2
		3	43 405	93	6	"
$3d^6$	^{1}I	6	51 469	99		
$3d^6$	^{3}D	2	51 684	95	3	$3d^6\ ^1$D2
		1	51 908	99		
		3	52 228	99		
$3d^6$	^{1}G2	4	52 978	65	32	$3d^6\ ^1$G1
$3d^6$	^{1}D2	2	60 829	74	20	$3d^6\ ^1$D1
$3d^6$	^{1}F	3	71 841	97	2	$3d^6\ ^3$F1
$3d^6$	^{3}P1	1	83 723	63	37	$3d^6\ ^3$P2
		2	86 502	62	38	"

Zn VII — Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages			
$3d^6$	^{3}F1	2	85 431	81		19	$3d^6\ ^3$F2
		4	85 493	77		22	"
		3	85 894	78		20	"
$3d^6$	^{1}G1	4	96 864	66		33	$3d^6\ ^1$G2
$3d^6$	^{1}D1	2	129 380	78		22	$3d^6\ ^1$D2
$3d^5(^6S)4p$	$^5P^\circ$	3	*468 437*	94			
		2	*469 602*	96			
		1	*470 310*	97			
$3d^5(^4G)4p$	$^5F^\circ$	5	*507 704*	52		35	$3d^5(^4G)4p\ ^5H^\circ$
		4	*508 903*	53		11	$3d^5(^4D)4p\ ^3F^\circ$
$3d^5(^4G)4p$	$^5H^\circ$	5	*508 927*	41		31	$3d^5(^4G)4p\ ^5F^\circ$
$3d^5(^4D)4p$	$^5P^\circ$	3	*512 025*	33		30	$3d^5(^4P)4p\ ^5P^\circ$
$3d^5(^4P)4p$	$^5P^\circ$	1	*513 017*	65		12	$3d^5(^4D)4p\ ^5P^\circ$
$3d^5(^4G)4p$	$^3F^\circ$	3	*513 590*	76		4	$3d^5(^4F)4p\ ^3F^\circ$
		4	*514 001*	84		5	"
$3d^5(^4G)4p$	$^3H^\circ$	6	*514 596*	89		5	$3d^5(^4G)4p\ ^5H^\circ$
		5	*515 395*	91		4	"
		4	*515 818*	93			
$3d^5(^4D)4p$	$^5F^\circ$	3	*516 964*	67		12	$3d^5(^4G)4p\ ^5F^\circ$
		4	*517 872*	68		12	$3d^5(^4P)4p\ ^5D^\circ$
		5	*518 826*	90		6	$3d^5(^4G)4p\ ^5F^\circ$
$3d^5(^4D)4p$	$^5D^\circ$	3	*519 203*	47		21	$3d^5(^4P)4p\ ^5D^\circ$
		4	*519 689*	63		22	"
		2	*520 079*	50		17	"
		1	*520 937*	44		15	"
$3d^5(^4G)4p$	$^3G^\circ$	3	*520 746*	85			
		4	*520 903*	87			
		5	*520 975*	89			
$3d^5(^4P)4p$	$^3D^\circ$	3	*520 862*	54		14	$3d^5(^4D)4p\ ^5P^\circ$
		2	*521 685*	46		17	"
$3d^5(^4D)4p$	$^3D^\circ$	2	*524 785*	61		12	$3d^5(^4D)4p\ ^5P^\circ$
$3d^5(^4D)4p$	$^5P^\circ$	3	*525 052*	35		22	$3d^5(^4P)4p\ ^5P^\circ$
$3d^5(^4D)4p$	$^3F^\circ$	4	*525 452*	76		6	$3d^5(^2G2)4p\ ^3F^\circ$
		3	*526 611*	63		12	$3d^5(^4P)4p\ ^3D^\circ$
		2	*526 728*	70		12	"
$3d^5(^4P)4p$	$^3S^\circ$	1	*528 902*	85		5	$3d^5(^4D)4p\ ^3P^\circ$
$3d^5(^2I)4p$	$^3K^\circ$	6	*529 600*	64		28	$3d^5(^2I)4p\ ^3I^\circ$
		7	*530 373*	52		36	"
$3d^54p$		6	*532 458*	35	$3d^5(^2I)4p\ ^3H^\circ$	34	$3d^5(^2I)4p\ ^3I^\circ$

Zn VII — Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages			
$3d^5(^2D3)4p$	$^3F^\circ$	3	*533 367*	31		20	$3d^5(^2F1)4p$ $^3F^\circ$
		4	*536 383*	28		22	$3d^5(^2F1)4p$ $^3F^\circ$
$3d^5(^2I)4p$	$^1H^\circ$	5	*534 889*	40		38	$3d^5(^2I)4p$ $^3I^\circ$
$3d^5(^2I)4p$	$^3H^\circ$	6	*535 187*	51		32	$3d^5(^2I)4p$ $^3I^\circ$
		4	*535 706*	57		8	$3d^5(^2G2)4p$ $^3H^\circ$
		5	*536 119*	70		16	$3d^5(^2I)4p$ $^1H^\circ$
$3d^5(^2I)4p$	$^1K^\circ$	7	*536 427*	87		7	$3d^5(^2I)4p$ $^3K^\circ$
$3d^54p$		4	*538 290*	36	$3d^5(^2F1)4p$ $^1G^\circ$	14	$3d^5(^2I)4p$ $^3H^\circ$
$3d^54p$		3	*539 042*	37	$3d^5(^2F1)4p$ $^3G^\circ$	11	$3d^5(^2D3)4p$ $^3D^\circ$
$3d^5(^4F)4p$	$^5G^\circ$	3	*539 245*	59		15	$3d^5(^2F1)4p$ $^3D^\circ$
		6	*541 659*	45		25	$3d^5(^2I)4p$ $^1I^\circ$
$3d^54p$		2	*540 785*	37	$3d^5(^2D3)4p$ $^3D^\circ$	20	$3d^5(^4F)4p$ $^5F^\circ$
$3d^54p$		1	*540 926*	28	$3d^5(^2D3)4p$ $^3P^\circ$	20	$3d^5(^2D3)4p$ $^3D^\circ$
$3d^54p$		4	*541 001*	29	$3d^5(^4F)4p$ $^5D^\circ$	26	$3d^5(^4F)4p$ $^5F^\circ$
$3d^5(^2G2)4p$	$^3H^\circ$	4	*541 679*	32		28	$3d^5(^2H)4p$ $^3H^\circ$
$3d^5(^2F1)4p$	$^3F^\circ$	4	*541 914*	47		27	$3d^5(^2F1)4p$ $^3G^\circ$
$3d^5(^2I)4p$	$^1I^\circ$	6	*542 524*	50		41	$3d^5(^4F)4p$ $^5G^\circ$
$3d^5(^2F1)4p$	$^3G^\circ$	5	*542 727*	77		10	$3d^5(^4F)4p$ $^5F^\circ$
$3d^54p$		5	*542 911*	38	$3d^5(^4F)4p$ $^5F^\circ$	22	$3d^5(^2G2)4p$ $^3H^\circ$
$3d^54p$		2	*542 948*	28	$3d^5(^2F1)4p$ $^3D^\circ$	20	$3d^5(^2F1)4p$ $^3F^\circ$
$3d^54p$		3	*542 953*	18	$3d^5(^2F1)4p$ $^3F^\circ$	17	$3d^5(^2D3)4p$ $^3F^\circ$
$3d^5(^2H)4p$	$^3G^\circ$	4	*544 009*	42		15	$3d^5(^2G2)4p$ $^3G^\circ$
$3d^5(^4F)4p$	$^5D^\circ$	4	*545 041*	42		32	$3d^5(^4F)4p$ $^5F^\circ$
		3	*546 111*	41		16	"
		1	*546 150*	69		11	"
		2	*546 350*	57		16	"
$3d^5(^2H)4p$	$^3H^\circ$	6	*545 375*	29		24	$3d^5(^2G2)4p$ $^3H^\circ$
		4	*553 496*	34		26	"
$3d^5(^2H)4p$	$^3I^\circ$	5	*547 115*	78		9	$3d^5(^2H)4p$ $^3H^\circ$
		6	*548 610*	61		16	$3d^5(^2H)4p$ $^1I^\circ$
		7	*550 407*	94			
$3d^54p$		4	*547 214*	16	$3d^5(^2G2)4p$ $^3F^\circ$	16	$3d^5(^2F1)4p$ $^1G^\circ$
$3d^54p$		3	*547 639*	22	$3d^5(^2G2)4p$ $^3G^\circ$	22	$3d^5(^2G2)4p$ $^3F^\circ$
$3d^5(^2F1)4p$	$^1D^\circ$	2	*548 543*	35	$3d^5(^2F1)4p$ $^1D^\circ$	22	$3d^5(^2D3)4p$ $^1D^\circ$

Zn VII — Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages			
$3d^5(^4F)4p$	$^3G^\circ$	5	548 718	63		11	$3d^5(^4F)4p\ ^5F^\circ$
		4	549 029	54		11	$3d^5(^2G2)4p\ ^3F^\circ$
$3d^5(^2G)4p$	$^3F^\circ$	2	549 914	40		14	$3d^5(^2F1)4p\ ^1D^\circ$
$3d^5(^2F1)4p$	$^1F^\circ$	3	550 245	57		10	$3d^5(^4F)4p\ ^3G^\circ$
$3d^5(^2H)4p$	$^1I^\circ$	6	551 664	64		16	$3d^5(^2H)4p\ ^3I^\circ$
$3d^5(^4F)4p$	$^3F^\circ$	4	552 271	45		31	$3d^5(^2F2)4p\ ^3F^\circ$
		3	553 781	49		20	$3d^5(^4F)4p\ ^3D^\circ$
		2	556 426	37		17	$3d^5(^2G2)4p\ ^3F^\circ$
$3d^54p$		5	553 288	31	$3d^5(^2G2)4p\ ^3H^\circ$	28	$3d^5(^2G2)4p\ ^3G^\circ$
$3d4p$		5	554 688	22	$3d(^2H)4p\ ^3H^\circ$	20	$3d(^2F2)4p\ ^3G^\circ$
$3d^5(^2F2)4p$	$^3G^\circ$	3	554 852	26		23	$3d^5(^2G2)4p\ ^3G^\circ$
		4	554 910	25		14	$3d^5(^4F)4p\ ^3G^\circ$
		5	562 694	55		31	$3d^5(^2H)4p\ ^3G^\circ$
$3d^54p$		4	555 722	25	$3d^5(^2F2)4p\ ^1G^\circ$	14	$3d^5(^2G2)4p\ ^3G^\circ$
$3d^5(^2G2)4p$	$^3H^\circ$	6	555 976	44		34	$3d^5(^2H)4p\ ^3H^\circ$
$3d^5(^2F2)4p$	$^3F^\circ$	3	556 329	31		16	$3d^5(^4F)4p\ ^3F^\circ$
		4	557 817	40		17	"
$3d^5(^2G2)4p$	$^1H^\circ$	5	556 553	41		32	$3d^5(^2H)4p\ ^1H^\circ$
$3d^5(^2G2)4p$	$^1F^\circ$	3	557 396	45		9	$3d^5(^2G2)4p\ ^3F^\circ$
$3d^5(^2F2)4p$	$^3D^\circ$	3	560 203	45		14	$3d^5(^4F)4p\ ^3D^\circ$
$3d^5(^2H)4p$	$^3G^\circ$	3	561 139	40		27	$3d^5(^2F2)4p\ ^3G^\circ$
$3d^5(^2H)4p$	$^1G^\circ$	4	565 431	41		33	$3d^5(^2F2)4p\ ^1G^\circ$
$3d^5(^2F2)4p$	$^1F^\circ$	3	567 442	83		5	$3d^5(^2F1)4p\ ^1F^\circ$
$3d^5(^2D3)4p$	$^3F^\circ$	4	579 763	90		6	$3d^5(^2G2)4p\ ^3F^\circ$
$3d^5(^2G1)4p$	$^3F^\circ$	4	587 661	65		16	$3d^5(^2G1)4p\ ^3G^\circ$
		3	589 006	50		38	"
$3d^5(^2G1)4p$	$^3H^\circ$	4	588 305	73		13	$3d^5(^2G1)4p\ ^3F^\circ$
		5	588 694	67		20	$3d^5(^2G1)4p\ ^3G^\circ$
$3d^5(^2G1)4p$	$^3G^\circ$	3	591 658	55		38	$3d^5(^2G1)4p\ ^3F^\circ$
		4	592 319	77		11	$3d^5(^2G1)4p\ ^3H^\circ$
		5	592 887	71		25	"
$3d^5(^2G1)4p$	$^1H^\circ$	5	596 199	87		5	$3d^5(^2G1)4p\ ^3H^\circ$
$3d^5(^2G1)4p$	$^1G^\circ$	4	596 209	90			

Zn VII — Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages		
$3d^5(^2P)4p$	$^3S°$	1	*619 368*	78	15	$3d^5(^2P)4p$ $^1P°$
$3d^5(^2D1)4p$	$^3D°$	3	*634 998*	56	17	$3d^5(^2D3)4p$ $^3D°$
Zn VIII ($^6S_{5/2}$)	***Limit***		**1 080 000**			

Zn VIII

Z=30

V I isoelectronic sequence

Ground state $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5\ ^6S_{5/2}$

Ionization energy 1 403 000 ± 14 000 cm^{-1} (174 ± 1.8 eV)

Three lines of this spectrum have been classified by Alexander *et al.* [1968], the $3d^5\ ^6S_{5/2}-{}^6P$ triplet. The wavelengths are 160.75, 160.94, and 161.01 Å arising from the $^6P_{7/2,5/2,3/2}$, respectively. No wavelength uncertainty is given.

The value for the ionization energy was obtained by Lotz by isoelectronic extrapolation.

Zn VIII

Configuration	Term	J	Level (cm^{-1})
$3d^5$	^6S	$^5/_2$	0
$3d^4(^5D)4p$	^6P	$^3/_2$	621 100
		$^5/_2$	621 300
		$^7/_2$	622 100
Zn IX ($^5D_0$)	*Limit*		**1 403 000**

References

Alexander, E., Fraenkel, B. S., Feldmann, U., Jacobs, A., and Makovky, J. [1968], J. Quant. Spectrosc. Radiat. Transfer **2**, 725.
Lotz, W. [1967] J. Opt. Soc. Am. **57**, 873.

Zn IX

Z=30

Ti I isoelectronic sequence

Ground state $1s^2 2s^2 2p^6 3s^2 3p^6 3d^4\ ^5D_0$

Ionization energy 1 637 000 ± 16 000 cm^{-1} (203 ± 2 eV)

No lines of this spectrum have been classified.

The value for the ionization energy was obtained by Lotz [1967] by isoelectronic extrapolation.

Reference

Lotz, W. [1967], J. Opt. Soc. Am. **57**, 873.

Zn X

Z=30

Sc I isoelectronic sequence

Ground state $1s^22s^22p^63s^23p^63d^3\ ^4F_{3/2}$

Ionization energy 1 920 000 ± 16 000 cm^{-1} (238 ± 2 eV)

No lines of this spectrum have been classified.

The value for the ionization energy was obtained by Lotz [1967] by isoelectronic extrapolation.

Reference

Lotz, W. [1967], J. Opt. Soc. Am. **57**, 873.

Zn XI

Z=30

Ca I isoelectronic sequence

Ground state $1s^22s^22p^63s^23p^63d^2\ ^3F_2$

Ionization energy 2 210 000±24 000 cm^{-1} (274±3 eV)

Even-Zohar and Fraenkel [1968] classified 14 lines of the $3d^2-3d\,4f$ array, but most are unconnected and do not provide energy levels. We derived the energy levels from their wavelengths and classifications. The wavelength uncertainty is ±0.005 Å, giving a level uncertainty of ±50 cm^{-1}. We estimated the value for the $3d^2\ ^1D_2$ level by extrapolation, with an uncertainty of ±200 cm^{-1}.

The value for the ionization energy was derived by Lotz (1967) by isoelectronic extrapolation.

References

Even-Zohar, M., and Fraenkel, B. S. (1968), J. Opt. Soc. Am. **68**, 1420.
Lotz, W. (1967), J. Opt. Soc. Am. **57**, 873.

Zn XI

Configuration	Term	J	Level (cm^{-1})
$3d^2$	^3F	2	0
		3	1 890
		4	4 120
$3d^2$	^1D	2	26 070+x
$3d^2$	^3P	0	
		1	
		2	31 330+x
$3d\,4f$	$^3F°$	2	*977 140*
		3	*977 700*
		4	*978 780*
$3d\,4f$	$^3G°$	3	*983 700*
		4	*985 170*
		5	*985 990*
$3d\,4f$	$^1D°$	2	*988 800+x*
$3d\,4f$	$^1F°$	3	*991 130+x*
$3d\,4f$	$^3D°$	3	*992 930+x*
Zn XII ($^2D_{3/2}$)	***Limit***		**2 210 000**

Zn XII

Z=30

K I isoelectronic sequence

Ground state $1s^2 2s^2 2p^6 3s^2 3p^6 3d\ ^2D_{3/2}$

Ionization energy 2 507 000 ± 8 000 cm⁻¹ (310.8 ± 1.0 eV)

Goldsmith and Fraenkel [1970] report eight lines of the $3p^6 3d-3p^5 3d^2$ array, observed in a spark discharge. In an isoelectronic study of this array from Cu to Mo with a laser-produced plasma Sugar *et al.* [1989] identified seven lines. Four of these agree with the identifications of Goldsmith and Fraenkel. We quote the results of Sugar *et al.*, whose wavelength uncertainty is given as ±0.005 Å and level uncertainty is ±30 cm⁻¹. Their identification of the off-diagonal transition $3p^6 3d\ ^2D_{3/2}-3p^5 3d^2(^3P)\ ^2P^\circ_{3/2}$ determines the ^2D ground state splitting. These results supersede the wavelengths given earlier by Sugar and Kaufman [1986].

Even-Zohar and Fraenkel [1968] identified the $3d-4f$ and $3d-5f$ doublets, and remark that the nf levels are probably perturbed by the $3p^5 3d 4s$ configuration. Their wavelength uncertainty is ±0.01 Å, giving an energy level uncertainty of ±300 cm⁻¹.

The value for the ionization energy was derived by Lotz [1967] by isoelectronic extrapolation.

Zn XII

Configuration	Term	J	Level (cm⁻¹)
$3p^6 3d$	^2D	3/2	0
		5/2	5 095
$3p^5(^2P^\circ)3d^2(^3F)$	$^2F^\circ$	5/2	*712 950*
$3p^5(^2P^\circ)3d^2(^1G)$	$^2F^\circ$	7/2	*727 530*
$3p^5(^2P^\circ)3d^2(^3P)$	$^2P^\circ$	1/2	*781 280*
		3/2	*788 480*
$3p^5(^2P^\circ)3d^2(^3F)$	^2D	5/2	788 700
		3/2	789 000
$3p^6 4f$	$^2F^\circ$	7/2	*1 459 960*
		5/2	*1 464 750*
$3p^6 5f$	$^2F^\circ$	7/2	*1 833 380*
		5/2	*1 837 930*
Zn XIII ($^1S_0$)	***Limit***		**2 507 000**

References

Even-Zohar, M. and Fraenkel, B. S. [1968], J. Opt. Soc. Am. **58**, 1420.
Goldsmith, S., and Fraenkel, B. S. [1970], Astrophys. J. **161**, 317.
Lotz, W. [1967], J. Opt. Soc. Am. **57**, 873.
Sugar, J., and Kaufman, V. [1986], J. Opt. Soc. Am. **34**, 797.
Sugar, J., Kaufman, V., and Rowan, W. L. [1989], J. Opt. Soc. Am. B **6**, 142.

Zn XIII

Z=30

Ar I isoelectronic sequence

Ground state $1s^2 2s^2 2p^6 3s^2 3p^6\ ^1S_0$

Ionization energy 3 385 000 ± 8 000 cm^{-1} (419.7 ± 1.0 eV)

The resonance transition $3p^6\ ^1S_0 - 3p^5 3d\ ^1P^\circ_1$ was observed by Goldsmith and Fraenkel [1970] in a vacuum spark at 131.082 ± 0.005 Å. This transition was observed by Sugar *et al.* [1987] in a laser-produced plasma. They obtained the value 131.046 ± 0.010 Å. They also observed the transition $3p^6\ ^1S_0 - 3p^5 3d\ ^3D^\circ_1$ at 163.985 ± 0.010 Å. We quote the results of Sugar *et al.* Their level uncertainty is ±50 cm^{-1}.

Two resonance lines from $3p^5 4s$ were reported by Even-Zohar and Fraenkel [1968] with an uncertainty of ±0.010 Å and a level uncertainty of ±300 cm^{-1}.

The value for the ionization energy was obtained by Lotz [1967] by isoelectronic extrapolation.

Zn XIII

Configuration	Term	J	Level (cm^{-1})
$3p^6$	^1S	0	0
$3p^5 3d$	$^3D^\circ$	1	*609 810*
$3p^5 3d$	$^1P^\circ$	1	*763 090*
$3p^5 4s$	$(^3/_2, ^1/_2)^\circ$	1	*1 629 830*
$3p^5 4s$	$(^1/_2, ^1/_2)^\circ$	1	*1 659 810*
Zn XIV ($^2P^\circ_{3/2}$)	***Limit***		***3 385 000***

References

Even-Zohar, M., and Fraenkel, B. S. [1968], J. Opt. Soc. Am. **58**, 1420.
Goldsmith, S., and Fraenkel, B. S. [1970], Astrophys. J. **161**, 317.
Lotz, W. [1967], J. Opt. Soc. Am. **57**, 873.
Sugar, J., Kaufman, V., and Rowan, W. L. [1987], J. Opt. Soc. Am. B **4**, 1927.

Zn XIV

$Z=30$

Cl I isoelectronic sequence

Ground state $1s^2 2s^2 2p^6 3s^2 3p^5\ ^2P^\circ_{3/2}$

Ionization energy 3 662 000 ± 36 000 cm^{-1} (454 ± 4.5 eV)

The ground term $3p^5\ ^2P^\circ$ interval is determined by the magnetic-dipole transition observed at 2922.3±0.1 Å by Burrell *et al.* [1984]. This gives a ground term splitting of 34 210 ± 1 cm^{-1}.

Fawcett and Hayes [1975] identified the two transitions $3s^2 3p^5\ ^2P^\circ_{1/2} - 3s^2 3p^4(^3P)3d\ ^2D_{5/2}$ and $^2P^\circ_{3/2} - ^2D_{5/2}$ in a laser-produced plasma. Improved wavelengths were given by Kaufman *et al.* [1989], who extended the number of classified lines of this array to six, in the range of 129−141 Å, using a similar light source. Their wavelength uncertainty was ±0.005 Å. The transition $3s^2 3p^5\ ^2P^\circ_{1/2} - 3s^2 3p^4(^3P)3d\ ^2P_{1/2}$ given in this reference for the isoelectronic sequence from Cu to Mo was corrected by Kaufman *et al.* [1990] in Table 9 of this later publication. The $3s^2 3p^4 3d$ level uncertainty is ±30 cm^{-1}.

The value for the ionization energy was derived by Lotz [1967] by isoelectronic extrapolation.

References

Fawcett, B. C., and Hayes, R. W. [1975], J. Opt. Soc. Am. **65**, 623.
Burrell, K. H., Groebner, R. J., Brooks, N. H., and Rottler, L. [1984], Phys. Rev. A **29**, 1343.
Lotz, W. [1967], J. Opt. Soc. Am. **57**, 873.
Kaufman, V., Sugar, J., and Rowan, W. L. [1989], J. Opt. Soc. Am. B **6**, 1444.
Kaufman, V., Sugar, J., and Rowan, W. L. [1990], J. Opt. Soc. Am. B **7**, 1169.

Zn XIV

Configuration	Term	J	Level (cm^{-1})
$3s^2 3p^5$	$^2P^\circ$	3/2	*0*
		1/2	*34 210*
$3s^2 3p^4(^1D)3d$	^2S	1/2	705 310
$3s^2 3p^4(^3P)3d$	^2P	3/2	733 660
		1/2	746 370
$3s^2 3p^4(^3P)3d$	^2D	5/2	741 880
		3/2	771 700
Zn XV ($^3P_2$)	***Limit***		**3 662 000**

Zn XV

Z=30

S I isoelectronic sequence

Ground state $1s^22s^22p^63s^23p^4\ ^3P_2$

Ionization energy 3 952 000 ± 40 000 cm^{-1} (490 ± 5 eV)

Roberts *et al.* [1987] identified two M1 transitions in a tokamak plasma: the $3s^23p^4\ ^3P_2-^3P_1$ at 3451.4 Å (in air) and tentatively the $3s^23p^4\ ^3P_2-^1D_2$ at 1702.8 Å. Using a laser-generated plasma, Kaufman *et al.* [1990] observed and classified eleven lines of the transition arrays $3s^23p^4-3s3p^5$ and $3s^23p^4-3s^23p^33d$. They fall in the range of 137−270 Å and are measured with an uncertainty of ±0.007 Å. Kaufman *et al.* derived a value for the $3s^23p^4\ ^1S_0$ level by interpolation on an isoelectronic plot of observed minus calculated levels. They then obtained the $3s^23p^4\ ^3P_2-^3P_0$ interval from a calculation fitted to the known levels. They also give percentage compositions for the levels of the $3s^23p^4$ configuration. We quote these and give our calculated percentages for the mixed $3s3p^5$ and $3s^23p^33d$ configurations. We adopt their level values with an estimated uncertainty of ±50 cm^{-1}. These results supersede the earlier analysis of this spectrum by Sugar and Kaufman [1986]. Fawcett and Hayes [1975] identified the $3s^23p^4\ ^3P_2-3s^23p^3(^4S^\circ)3d\ ^3D^\circ_3$ transition at 139.87 Å and the $^1D_2-^1F_3$ line at 140.13 Å, which is confirmed by the present analysis by Kaufman *et al.*

The value for the ionization energy was obtained by Lotz [1967] by isoelectronic extrapolation.

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Zn XV

Configuration	Term	J	Level (cm^{-1})	Leading percentages		
$3s^23p^4$	^3P	2	0	91	9	$3s^23p^4\ ^1D$
		0	[26 481]	84	12	$3s^23p^4\ ^1S$
		1	28 974	100		
$3s^23p^4$	^1D	2	58 727	91	9	$3s^23p^4\ ^3P$
$3s^23p^4$	^1S	0	119 210	84	12	$3s^23p^4\ ^3P$
$3s3p^5$	$^3P^\circ$	2	*397 460*	83	12	$3s^23p^3(^2D^\circ)3d\ ^3P^\circ$
		1	*398 780*	79	12	"
$3s^23p^3(^2D^\circ)3d$	$^3P^\circ$	2	*689 570*	77	14	$3s3p^5\ ^3P^\circ$
$3s^23p^3(^4S^\circ)3d$	$^3D^\circ$	3	*715 090*	46	25	$3s^23p^3(^2P^\circ)3d\ ^3D^\circ$
		2	*729 700*	32	25	"
$3s^23p^3(^2D^\circ)3d$	$^1D^\circ$	2	*756 480*	55	18	$3s^23p^3(^2P^\circ)3d\ ^1D^\circ$
$3s^23p^3(^2D^\circ)3d$	$^1F^\circ$	3	*772 440*	61	32	$3s^23p^3(^2P^\circ)3d\ ^1F^\circ$
$3s^23p^3(^2P^\circ)3d$	$^1P^\circ$	1	*812 700*	85	4	$3s^23p^3(^4S^\circ)3d\ ^3D^\circ$
Zn XVI ($^4S^\circ_{3/2}$)	***Limit***		***3 952 000***			

Zn XVI

Z=30

P I isoelectronic sequence

Ground state $1s^22s^22p^63s^23p^3\ ^4S^o_{3/2}$

Ionization energy 4 372 000 ± 44 000 cm^{-1} (542 ± 5.5 eV)

Wavelengths for all magnetic dipole transitions in the $3s^23p^3$ ground configuration have been derived by interpolation on isoelectronic plots of observed minus calculated levels by Sugar *et al.* [1991]. The uncertainty in the levels derived from them is ±20 cm^{-1}.

Fawcett and Hayes [1975] identified two lines of the $3s^23p^3-3s^23p^23d$ array: the $^4S^o_{3/2}-(^3P)^4P_{5/2}$ at 152.42 Å and the $^2D^o_{5/2}-(^3P)\ ^2F_{7/2}$ at 146.24 Å. Sugar *et al.* [1991], using a laser-generated plasma, observed and classified six lines of this array. They fall in the range of 146−153 Å and are measured with an uncertainty of ±0.005 Å. Sugar *et al.* also give interpolated values (as described above) for three additional lines. These are given in parentheses.

Energy levels derived from these data are given by Sugar *et al.* with an uncertainty of ±20 cm^{-1} for the $3s^23p^3$ levels and ±40 cm^{-1} for the levels of $3s^23p^23d$. They confirm the classifications by Fawcett and Hayes. They also give percentage compositions for the $3s^23p^3$ levels. We quote their results. This work supersedes the earlier analysis of this spectrum by Sugar and Kaufman [1986]. The two level values at 663 600 cm^{-1} and 717 970 cm^{-1} were obtained by Sugar *et al.* [1991] by interpolation of observed-minus-calculated energies with an uncertainty of ±50 cm^{-1}.

We have calculated the percentage composition of the levels of the interacting $3s3p^4$ and $3s^23p^23d$ configurations.

The value for the ionization energy was derived by Lotz [1967] by isoelectronic extrapolation.

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Zn XVI

Configuration	Term	J	Level (cm^{-1})	Leading percentages		
$3s^23p^3$	$^4S^o$	3/2	*0*	91	7	$3s^23p^3\ ^2P^o$
$3s^23p^3$	$^2D^o$	3/2	*50 266*	79	16	$3s^23p^3\ ^2P^o$
		5/2	*62 488*	100		
$3s^23p^3$	$^2P^o$	1/2	*97 579*	100		
		3/2	*116 594*	77	19	$3s^23p^3\ ^2D^o$
$3s^23p^2(^3P)3d$	$^4P^o$	5/2	656 202	83	7	$3s3p^4\ ^4P$
		3/2	663 600	61	11	$3s^23p^2(^1S)3d\ ^2D$
$3s^23p^2(^1D)3d$	^2D	3/2	713 229	73	13	$3s3p^4\ ^2D$
		5/2	717 970	53	35	$3s^23p^2(^1S)3d\ ^2D$
$3s^23p^2(^3P)3d$	^2F	7/2	746 375	63	36	$3s^23p^2(^1D)3d\ ^2F$
$3s^23p^2(^1D)3d$	^2P	3/2	747 766	49	28	$3s^23p^2(^3P)3d\ ^2P$
$3s^23p^2(^3P)3d$	^2D	5/2	780 896	41	25	$3s^23p^2(^1S)3d\ ^2D$
Zn XVII ($^3P_0$)	***Limit***		**4 372 000**			

Zn XVII

Z=30

Si I isoelectronic sequence

Ground state $1s^22s^22p^63s^23p^2\ ^3P_0$

Ionization energy 4 670 000 ± 50 000 cm^{-1} (579 ± 6 eV)

The ground term $3s^23p^2\ ^3P_0-^3P_1$ interval is determined from the M1 transition at 4355.0 ± 0.3 Å (in air) measured in a tokamak plasma by Roberts *et al.* [1987]. The $3s^23p^2\ ^3P_1-^3P_2$ is obtained from the difference of two M1 lines: the $^3P_1-^1D_2$ at 1676.9 ± 0.2 Å from Roberts *et al.* and the $^3P_2-^1D_2$ from the tokamak plasma measurements by Burrell *et al.* [1984] at 2284.6 ± 0.1 Å. An interpolated value for the M1 transition $3p^2\ ^3P_1-^1S_0$ derived by Sugar *et al.* [1990] at 878.7 ± 0.3 Å was used to obtain the value for the level $3p^2\ ^1S_0$.

The transitions $3s3p^3\ ^5S_2^\circ-3s^23p^2\ ^3P_2$, $^3P_1$ were observed by Träbert *et al.* [1988] with a beam-foil spectrum. The transition arrays $3s^23p^2-3s3p^3$ and $3s^23p^2-3s^23p3d$ were observed by Sugar *et al.* with a laser-produced plasma. We obtained the levels of $3s3p^3$ (except the $^5S_2^\circ$) and $3s^23p3d$ from this work. Their wavelength uncertainty is reported as ±0.005 Å for their observations from 94−112 Å. One of these transitions, the $3s^23p^2\ ^3P_2-3s^23p3d\ ^3D_3^\circ$, was identified earlier by Fawcett and Hayes [1975]. Levels of the $3s^23p^2$ ground configuration determined by M1 lines have an uncertainty of ±5 cm^{-1}. Those of $3s3p^3$ and $3s^23p3d$ have an uncertainty of ±25 cm^{-1}. Several lines of $3p^2-3p4d$, $3p3d-3p4f$, and $3s3p^3-3p4f$ in the range of 41−46 Å are tentatively assigned by Kastner *et al.* [1978]. We omit these pending further confirmation. These results supercede an earlier analysis of this spectrum by Sugar and Kaufman [1986]. Wavelengths and some line classifications have been revised in the later work and percentage compositions of the levels are given. The value for the ionization energy was obtained by Lotz [1967] by isoelectronic extrapolation.

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Zn XVII

Configuration	Term	J	Level (cm^{-1})	Leading percentages		
$3s^23p^2$	^3P	0	0	92	8	$3s^23p^2\ ^1S$
		1	22 956	100		
		2	38 841	78	22	$3s^23p^2\ ^1D$
$3s^23p^2$	^1D	2	82 594	78	22	$3s^23p^2\ ^3P$
$3s^23p^2$	^1S	0	136 755	92	8	$3s^23p^2\ ^3P$
$3s3p^3$	$^5S^\circ$	2	*299 300*	97	3	$3s3p^3\ ^3P^\circ$
$3s3p^3$	$^3D^\circ$	3	*397 116*	92	8	$3s^23p3d\ ^3D^\circ$
$3s3p^3$	$^3P^\circ$	2	*450 203*	70	11	$3s3p^3\ ^3D^\circ$
$3s3p^3$	$^3S^\circ$	1	*544 971*	70	25	$3s3p^3\ ^1P^\circ$
$3s3p^3$	$^1P^\circ$	1	*587 440*	60	27	$3s3p^3\ ^3S^\circ$
$3s^23p3d$	$^3P^\circ$	2	*628 172*	50	18	$3s3p^3\ ^1D^\circ$
		0	*659 108*	93	7	$3s3p^3\ ^3P^\circ$
		1	*664 389*	55	36	$3s3p^3\ ^3D^\circ$
$3s^23p3d$	$^3D^\circ$	1	*639 465*	52	36	$3s3p^3\ ^3P^\circ$
		3	*665 946*	88	8	$3s3p^3\ ^3D^\circ$
		2	*669 159*	52	33	$3s3p^3\ ^3P^\circ$
$3s^23p3d$	$^1D^\circ$	2	*654 590*	39	24	$3s3p^3\ ^3D^\circ$
$3s^23p3d$	$^1F^\circ$	3	*724 707*	97	3	$3s3p^3\ ^3D^\circ$
$3s^23p3d$	$^1P^\circ$	1	*743 614*	84	12	$3s3p^3\ ^1P^\circ$
Zn XVIII ($^2P^\circ_{1/2}$)	***Limit***		***4 670 000***			

Zn XVIII

Z=30

Al I isoelectronic sequence

Ground state $1s^22s^22p^63s^23p\ ^2P^\circ_{1/2}$

Ionization energy 4 990 000 ± 50 000 cm^{-1} (619 ± 6 eV)

The first observations of this spectrum were made by Fawcett and Hayes [1975] with a laser-produced plasma. They identified the $3s^23p\ ^2P^\circ-3s^23d\ ^2D$ doublet and the $3s^23p\ ^2P^\circ_{3/2}-3s3p^2\ ^2P_{3/2}$ line with an uncertainty of ±0.03 Å. The spectrum was then observed in a tokamak discharge by Hinnov *et al.* [1986], who identified 10 lines of the arrays $3s^23p-3s^23d$ and $3s^23p-3s3p^2$ as well as the M1 transition $3s^23p$ ($^2P^\circ_{1/2}-^2P^\circ_{3/2}$) with a wavelength uncertainty of ±0.05 Å. Sugar *et al.* [1988] remeasured the spectrum observed in a laser-produced plasma with an uncertainty of ±0.01 Å. We quote the level values from Sugar *et al.* with an uncertainty estimate of ±50 cm^{-1}. They derived the value for the $3s^23p\ ^2P^\circ$ ground state interval from the M1 line reported by Burrell *et al.* [1984] at 2532.0 ± 0.1 Å. The $3s^23p\ ^2P^\circ-3s3p^2\ ^4P$ multiplet was observed with a beam-foil device by Träbert *et al.* [1988]. Their measurement uncertainty is ±0.4 Å. Litzén and Redfors [1988] used a laser-produced plasma to observe the $3s3p^2\ ^4P-3p^3\ ^4S^\circ$ lines with an uncertainty of ±0.01 Å. We use this result to determine the ^4P splitting and the $^4S^\circ$ level relative to $3s3p^2\ ^4P_{1/2}$ and the less accurate data of Träbert *et al.* to determine their position relative to the ground state. The bracketed $3s3p^2\ ^2D$ levels are determined from predicted wavelengths by Sugar *et al.*

The value for the ionization energy was obtained by Lotz [1967] by extrapolation.

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Zn XVIII

Configuration	Term	J	Level (cm^{-1})
$3s^23p$	$^2P^\circ$	1/2	*0*
		3/2	*39 483*
$3s3p^2$	^4P	1/2	295 200
		3/2	312 993
		5/2	331 359
$3s3p^2$	^2D	3/2	[398 390]
		5/2	[405 760]
$3s3p^2$	^2S	1/2	472 601
$3s3p^2$	^2P	1/2	513 373
		3/2	524 382
$3s^23d$	^2D	3/2	609 252
		5/2	614 272
$3p^3$	$^4S^\circ$	3/2	*773 682*
Zn XIX ($^1S_0$)	***Limit***		**4 990 000**

Zn XIX

Z=30

Mg I isoelectronic sequence

Ground state $1s^22s^22p^63s^2\ ^1S_0$

Ionization energy 5 630 000 ± 57 000 cm^{-1} (698 ± 7 eV)

Fawcett and Hayes [1975] identified the $^1S-^1P°$ resonance line and four transitions in the $3s3p-3s3d$ array with a laser-produced plasma. New observations with a similar light source were made by Sugar and Kaufman [1986]. They identified 45 lines in the range of 174–316 Å belonging to the arrays $3s3p-3s3d$, $3s3p-3p^2$, $3s3d-3p3d$, and $3p^2-3p3d$. In a subsequent paper [1987] they classify six additional lines and report that the wavelengths given in their earlier paper [1986] should be reduced by 0.01 Å, as determined by observations with a tokamak plasma. Litzén and Redfors [1987] gave classifications for seven lines of the arrays $3s3p-3p^2$ and $3s3d-3p3d$. They also give percentage compositions for the levels.

In a report on the Mg I isoelectronic sequence from Cu to Mo Sugar *et al.* [1989] give revised values for the Zn XIX wavelengths with an uncertainty estimate of ±0.005 Å. They also give classifications in the $3p3d-3d^2$ array, including three lines identified earlier by Redfors [1988]. We give the level values from Sugar *et al.* [1989] with an uncertainty of ±50 cm^{-1}.

Fawcett and Hayes identified n=3−4 and n=3−5 transitions in the range of 31−46 Å with an uncertainty of ±0.01 Å. These identifications were extended by Khan *et al.* [1977] and Khan [1978] with a wavelength uncertainty of ±0.02 Å. We give the n=4,5 levels derived from the wavelengths of Fawcett and Hayes, supplemented by additional identifications of Khan *et al.* and Khan. The uncertainty of these levels is ±1000 cm^{-1}.

The value for the ionization energy was obtained by Lotz [1967] by extrapolation.

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Zn XIX

Configuration	Term	J	Level (cm^{-1})	Leading percentages		
$3s^2$	^{1}S	0	0	98	2	$3p^2\ ^1$S
$3s3p$	^{3}P°	0	*295 248*	100		
		1	*306 361*	98		
		2	*336 699*	100		
$3s3p$	^{1}P°	1	*453 375*	95	3	$3p3d\ ^1$P°
$3p^2$	^{3}P	0	702 263	93	7	$3p^2\ ^1$S
		1	726 491	100		
		2	763 375	77	17	$3p^2\ ^1$D
$3p^2$	^{1}D	2	721 495	64	23	$3p^2\ ^3$P
$3p^2$	^{1}S	0	855 309	91	7	$3p^2\ ^3$P
$3s3d$	^{3}D	1	866 723	100		
		2	869 280	100		
		3	873 355	100		
$3s3d$	^{1}D	2	970 492	81	19	$3p^2\ ^1$D

Zn XIX — Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages		
$3p3d$	$^3F^\circ$	2	*1 182 908*	83	16	$3p3d$ $^1D^\circ$
		3	*1 203 780*	96	3	$3p3d$ $^3D^\circ$
		4	*1 229 421*	100		
$3p3d$	$^1D^\circ$	2	*1 218 687*	72	14	$3p3d$ $^3F^\circ$
$3p3d$	$^3D^\circ$	1	*1 251 919*	76	21	$3p3d$ $^3P^\circ$
		2	*1 258 933*	49	38	"
		3	*1 278 949*	95	3	$3p3d$ $^3F^\circ$
$3p3d$	$^3P^\circ$	0	*1 281 809*	100		
		1	*1 282 212*	78	22	$3p3d$ $^3D^\circ$
		2	*1 283 253*	52	46	$3p3d$ $^3P^\circ$
$3p3d$	$^1F^\circ$	3	*1 361 498*	98	2	$3p3d$ $^3D^\circ$
$3p3d$	$^1P^\circ$	1	*1 376 746*	95	3	$3s3p$ $^1P^\circ$
$3d^2$	^3F	2	1 751 233			
		3	1 755 640			
		4	1 760 664			
$3d^2$	^1G	4	1 802 536			
$3s4s$	$^3S^\circ$	1	*2 657 000*			
$3s4p$	$^1P^\circ$	1	*2 823 000*			
$3s4d$	^3D	1	2 993 000			
		2	3 003 100			
		3	3 007 100			
$3s4d$	^1D	2	3 008 600			
$3s4f$	$^3F^\circ$	4	*3 101 000*			
		3	*3 102 000*			
$3s4f$	$^1F^\circ$	3	*3 141 000*			
$3p4f$	$^3F^\circ$	4	*3 442 000*			
$3p4f$	$^3D^\circ$	2	*3 455 000*			
		1	*3 491 000*			
$3p4f$	^3G	4	3 459 000			
		5	3 493 600			
$3p4f$	$^1F^\circ$	3	*3 483 000*			
$3p4f$	^1G	4	3 527 000			
$3s5d$	^3D	3	3 971 700			
		2	3 972 000			
		1	4 007 000			
$3s5f$	$^3F^\circ$	4	*4 018 000*			
Zn XX ($^2S_{1/2}$)	***Limit***		**5 630 000**			

Zn XX

Z=30

Na I isoelectronic sequence

Ground state $1s^22s^22p^63s\ ^2S_{1/2}$

Ionization energy 5 947 260 ± 300 cm^{-1} (737.366 ± 0.04 eV)

The $3s-3p$ and $3p-3d$ doublets were identified in a laser-produced plasma by Fawcett and Hayes [1975] and measured with an uncertainty of ±0.03 Å. With a low-inductance vacuum spark Feldman *et al.* [1967] identified the $3d-4f$ doublet. Improved wavelengths were derived by Reader *et al.* [1987] by smoothing the difference between measured and theoretical values along the isoelectronic sequence. They report an uncertainty of ±0.007 Å for these doublets. We use their wavelengths to derive the levels of the $3p$, $3d$, and $4f$ terms with uncertainties for $3p$ and $3d$ of ±4 cm^{-1} and ±400 cm^{-1} for $4f$.

Feldman *et al.* also identified the $3s-4p$, the $3p-4s$, $4d$, and $5d$, and the $3d-5f$ doublets. The spectrum was reobserved in a laser-produced plasma by Kononov *et al.* [1979] who gave improved wavelengths for the doublets of Feldman *et al.* and added $3s-5p$, $3d-6f$ and $7f$, $4s-5p$, $4p-5d$, $4d-5f$, and $4f-5g$. Their measurement uncertainty is ±0.005 Å for these lines in the range of 22–100 Å, giving a level uncertainty of ±200 cm^{-1}. These results are used in conjunction with the smoothed wavelengths of Reader *et al.* to derive the levels.

The value for the ionization energy was derived by Kononov *et al.* by applying a polarization formula to the $5g$ term.

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Zn XX

Configuration	Term	J	Level (cm^{-1})
$2p^63s$	^2S	1/2	0
$2p^63p$	$^2P^o$	1/2	*347 003*
		3/2	*390 060*
$2p^63d$	^2D	3/2	858 830
		5/2	865 899
$2p^64s$	^2S	1/2	2 781 040
$2p^64p$	$^2P^o$	1/2	*2 920 300*
		3/2	*2 937 400*
$2p^64d$	^2D	3/2	3 111 100
		5/2	3 114 200
$2p^64f$	$^2F^o$	5/2	*3 194 350*
		7/2	*3 195 600*
$2p^65p$	$^2P^o$	1/2	*4 052 800*
		3/2	*4 061 100*
$2p^65d$	^2D	3/2	4 143 400
		5/2	4 145 000
$2p^65f$	$^2F^o$	5/2	*4 185 000*
		7/2	*4 185 400*
$2p^65g$	^2G	7/2	4 190 300
		9/2	4 190 800
$2p^66d$	^2D	3/2	4 703 200
		5/2	4 704 100
$2p^66f$	$^2F^o$	5/2	*4 724 500*
		7/2	*4 724 800*
$2p^67f$	$^2F^o$	5/2,7/2	*5 048 000*
Zn XXI ($^1S_0$)	***Limit***		**5 947 260**

Zn XXI

Z=30

Ne I isoelectronic sequence

Ground state $1s^22s^22p^6\ {}^1S_0$

Ionization energy 14 890 000 ± 15 000 cm^{-1} (1846 ± 2 eV)

Feldman *et al.* [1967], by means of a low-inductance spark, observed six resonance lines arising from the $2p^53s$, $2p^53d$, and $2s2p^63p$ configurations. Burkhalter *et al.* [1975] increased this number to eleven, adding lines from $2p^54s$ and $2p^54d$ with a wavelength uncertainty of ±0.01 Å. Boiko *et al.* [1978] added transitions from $2p^55d$ to $2p^59d$ and improved the uncertainty of the wavelengths to ±0.002 Å. Hutcheon *et al.* [1980] made new measurements with an uncertainty comparable to Boiko *et al.*, including $2p^53d-5d$ and adding $2s2p^64p$. The spectrum was reobserved by Gordon *et al.* with a laser-produced plasma. They gave transitions through $2s^22p^56d$ including 18 lines with an uncertainty of ±0.005 Å. We use the measurements of Boiko *et al.* which give a level uncertainty of ±3000 cm^{-1}. Three transitions from the $2s^22p^53p$ configuration were observed in a line-focus laser by McLean *et al.* [1992] at 212.17 Å, 262.32 Å, and 267.23 Å with an uncertainty of ±0.06 Å.

The value for the ionization energy was derived by Hutcheon [1980] from the *nd* series. We obtain the same value within 1 eV with the Cowan [1981] HFR code.

Zn XXI

Configuration	Term	J	Level (cm^{-1})
$2s^22p^6$	^1S	0	0
$2s^22p^53s$	$(^3/_2,^1/_2)^\circ$	1	*8 496 900*
$2s^22p^53s$	$(^1/_2,^1/_2)^\circ$	1	*8 683 600*
$2s^22p^53p$	$(^3/_2,^3/_2)$	2	8 881 000
$2s^22p^53p$	$(^1/_2,^3/_2)$	2	9 060 800
$2s^22p^53p$	$(^1/_2,^1/_2)$	0	9 157 900
$2s^22p^53d$	$(^3/_2,^3/_2)^\circ$	1	*9 262 700*
$2s^22p^53d$	$(^3/_2,^5/_2)^\circ$	1	*9 378 200*
$2s^22p^53d$	$(^1/_2,^3/_2)^\circ$	1	*9 584 000*
$2s2p^63p$	$(^1/_2,^1/_2)^\circ$	1	*10 188 000*
$2s2p^63p$	$(^1/_2,^3/_2)^\circ$	1	*10 244 000*
$2s^22p^54s$	$(^3/_2,^1/_2)^\circ$	1	*11 465 000*
$2s^22p^54s$	$(^1/_2,^1/_2)^\circ$	1	*11 658 000*
$2s^22p^54d$	$(^3/_2,^3/_2)^\circ$	1	*11 762 000*
$2s^22p^54d$	$(^3/_2,^5/_2)^\circ$	1	*11 810 000*
$2s^22p^54d$	$(^1/_2,^3/_2)^\circ$	1	*11 990 000*
$2s^22p^55d$	$(^3/_2,^5/_2)^\circ$	1	*12 923 000*
$2s2p^64p$	$(^1/_2,^1/_2)^\circ$	1	*12 967 000*
$2s2p^64p$	$(^1/_2,^3/_2)^\circ$	1	*12 972 000*
$2s^22p^55d$	$(^1/_2,^3/_2)^\circ$	1	*13 115 000*
$2s^22p^56d$	$(^3/_2,^5/_2)^\circ$	1	*13 532 000*
$2s^22p^56d$	$(^1/_2,^3/_2)^\circ$	1	*13 723 000*
$2s^22p^57d$	$(^3/_2,^5/_2)^\circ$	1	13 893 000
$2s^22p^57d$	$(^1/_2,^3/_2)^\circ$	1	*14 080 000*
$2s^22p^58d$	$(^3/_2,^5/_2)^\circ$	1	*14 138 000*
$2s^22p^59d$	$(^3/_2,^5/_2)^\circ$	1	*14 284 000*
$2s^22p^58d$	$(^1/_2,^3/_2)^\circ$	1	*14 320 000*
$2s^22p^59d$	$(^1/_2,^3/_2)^\circ$	1	*14 497 000*
Zn XXII ($^2P^\circ_{3/2}$)	***Limit***		***14 890 000***

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Zn XXII

Z=30

F I isoelectronic sequence

Ground state $1s^2 2s^2 2p^5\ {}^2P^\circ_{3/2}$

Ionization energy 15 860 000 ± 160 000 cm^{-1} (1966 ± 20 eV)

The two lines of the transition $2s^2 2p^5 - 2s2p^6$ were reported by Behring *et al.* [1976] and Kononov *et al.* [1977] with a wavelength uncertainty of ±0.01 Å. Behring *et al.* [1985] reobserved these lines with a laser-generated plasma and obtained an improved uncertainty of ±0.005 Å. We use their values to derive the levels of these two configurations with an uncertainty of ±50 cm^{-1}.

Burkhalter *et al.* [1977] identified six lines of the $2p^5 - 2p^4 3s$ and eight lines of the $2p^5 - 2p^4 3d$ arrays in a laser-generated plasma in the range of 10−11 Å. Boiko *et al.* observed the same arrays but increased the number of lines of each to 7 and 17, respectively. Hutcheon *et al.* [1980] gives the same arrays again with 9 and 16 lines, respectively. These arrays are then given by Gordon *et al.* [1980], differing by one line from Hutcheon *et al.* in the $2p^5 - 2p^4 3s$ array. However, Gordon *et al.* also observed the $2p^5 - 2p^4 4s$, $4d$, and $2p^5 - 2s2p^5 3p$ arrays. Their wavelength uncertainty is ±0.005 Å. The measurements from all four papers generally agree within this uncertainty. We use the wavelengths of Gordon *et al.* for deriving the energy levels with an uncertainty of ±5000 cm^{-1}. They also give the percentage composition of these levels.

The value for the ionization energy was derived by Lotz [1967] by extrapolation. The Cowan [1981] HFR code gives a value of 15 811 000 cm^{-1}.

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Zn XXII

Configuration	Term	J	Level (cm^{-1})	Leading percentages			
$2s^2 2p^5$	$^2P^\circ$	3/2	*0*				
		1/2	*196 868*				
$2s2p^6$	^2S	1/2	1 352 430				
$2s^2 2p^4(^3P)3s$	^4P	5/2	8 929 000	85		14	$2s^2 2p^4(^1D)3s\ ^2D$
		1/2	9 051 000	60		31	$2s^2 2p^4(^1S)3s\ ^2S$
		3/2	9 111 000	77		21	$2s^2 2p^4(^3P)3s\ ^2P$
$2s^2 2p^4(^3P)3s$	^2P	3/2	8 965 000	60		21	$2s^2 2p^4(^3P)3s\ ^4P$
		1/2	9 138 000	78		20	"
$2s^2 2p^4(^1D)3s$	^2D	5/2	9 204 000	85		14	$2s^2 2p^4(^3P)3s\ ^4P$
		3/2	9 211 000	80		19	$2s^2 2p^4(^3P)3s\ ^2P$
$2s^2 2p^4(^1S)3s$	^2S	1/2	9 461 000	66		20	$2s^2 2p^4(^3P)3s\ ^4P$
$2s^2 2p^4(^3P)3d$	^4P	1/2	9 723 000	51		27	$2s^2 2p^4(^3P)3d\ ^2P$
		3/2	9 745 000	40		29	$2s^2 2p^4(^3P)3d\ ^2D$
$2s^2 2p^4(^3P)3d$		5/2	9 761 000	27	^2D	25	$2s^2 2p^4(^3P)3d\ ^2F$
$2s^2 2p^4(^3P)3d$	^4D	1/2	9 844 000	67		17	$2s^2 2p^4(^3P)3d\ ^2P$

Zn XXII — Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages			
$2s^22p^4(^3P)3d$		3/2	9 883 000	36	^4D	19	$2s^22p^4(^3P)3d\ ^4P$
$2s^22p^4(^3P)3d$	^2P	3/2	9 899 000	43		18	$2s^22p^4(^1D)3d\ ^2P$
$2s^22p^4(^3P)3d$		5/2	9 902 000	37	^2F	32	$2s^22p^4(^3P)3d\ ^2D$
$2s^22p^4(^1D)3d$	^2S	1/2	9 976 000	76		15	$2s^22p^4(^3P)3d\ ^4P$
$2s^22p^4(^1D)3d$	^2P	3/2	9 994 000	64		15	$2s^22p^4(^3P)3d\ ^2P$
		1/2	10 055 000	57		35	"
$2s^22p^4(^1D)3d$		5/2	10 003 000	34	^2F	31	$2s^22p^4(^1D)3d\ ^2D$
$2s^22p^4(^1D)3d$	^2D	3/2	10 039 000	62		27	$2s^22p^4(^3P)3d\ ^2D$
$2s2p^5(^3P^\circ)3p$	^4D	5/2	10 458 000	50		30	$2s2p^5(^3P^\circ)3p\ ^2D$
		3/2	10 612 000	43		26	$2s2p^5(^3P^\circ)3p\ ^4P$
$2s2p^5(^3P)3p$		3/2	10 506 000	37	^2P	27	$2s2p^5(^3P)3p\ ^4D$
$2s2p^5(^3P^\circ)3p$	^4P	5/2	10 533 000	51		48	$2s2p^5(^3P^\circ)3p\ ^2D$
$2s2p^5(^3P^\circ)3p$	^2P	3/2	10 562 000	50		39	$2s2p^5(^3P^\circ)3p\ ^4D$
		1/2	10 593 000	42		26	$2s2p^5(^3P^\circ)3p\ ^2S$
$2s2p^5(^3P^\circ)3p$	^2S	1/2	10 715 000	46		32	$2s2p^5(^3P^\circ)3p\ ^2P$
$2s2p^5(^1P^\circ)3p$	^2D	3/2	10 884 000	79		11	$2s2p^5(^1P^\circ)3p\ ^2P$
		5/2	10 935 000	90		5	$2s2p^5(^3P^\circ)3p\ ^4D$
$2s2p^5(^1P^\circ)3p$	^2P	1/2	10 931 000	85		6	$2s2p^5(^3P^\circ)3p\ ^2S$
		3/2	10 951 000	81		10	$2s2p^5(^1P^\circ)3p\ ^2D$
$2s^22p^4(^3P)4s$	^2P	3/2	12 111 000	67		17	$2s^22p^4(^1D)4s\ ^2D$
$2s^22p^4(^1D)4s$	^2D	5/2	12 367 000	84		16	$2s^22p^4(^3P)4s\ ^4P$
$2s^22p^4(^3P)4d$	^2D	3/2,5/2	12 427 000	43		19	$2s^22p^4(^3P)4d\ ^2F$
$2s^22p^4(^3P)4s$	^4P	3/2	12 461 000	82		18	$2s^22p^4(^3P)4s\ ^2P$
$2s^22p^4(^3P)4d$	^4F	3/2	12 511 000	40		33	$2s^22p^4(^1S)4d\ ^2D$
$2s^22p^4(^3P)4d$	^2P	3/2	12 590 000	43		25	$2s^22p^4(^3P)4d\ ^2D$
$2s^22p^4(^1D)4d$	^2D	5/2	12 674 000	61		24	$2s^22p^4(^1D)4d\ ^2F$
		3/2	12 689 000	75		16	$2s^22p^4(^3P)4d\ ^2D$
$2s^22p^4(^1D)4d$	^2P	3/2	12 674 000				
		1/2	12 689 000	64		22	$2s^22p^4(^3P)4d\ ^2P$
$2s^22p^4(^1S)4d$	^2D	3/2	12 941 000	65		14	$2s^22p^4(^3P)4d\ ^4F$
Zn XXIII ($^3P_2$)	*Limit*		**15 860 000**				

Zn XXIII

Z=30

O I isoelectronic sequence

Ground state $1s^22s^22p^4\ ^3P_2$

Ionization energy 16 810 000 ± 170 000 cm^{-1} (2084 ± 21 eV)

Eight lines of the array $2s^22p^4-2s2p^5$ were reported by Behring *et al.* [1976] and by Kononov *et. al.* [1977], both with wavelength uncertainties of ±0.01 Å. New measurements were obtained by Behring *et al.* [1985] with a laser-generated plasma. They improved the wavelength uncertainty to ±0.005 Å and identified the transition $2s2p^5\ ^1P_1^\circ-2p^6\ ^1S_0$. We give the levels derived from their wavelength measurements with an uncertainty of ±80 cm^{-1}.

Observations of the $2p^4-2p^33d$, $4d$ and $2p^4-2p^33s$ arrays in the range of 7.4−10.7 Å were made by Gordon *et al.* [1980] with a laser-generated plasma. Their wavelength uncertainty estimate is ±0.005 Å. However, their wavelength resolution is not sufficient for deriving reliable values for the energy levels.

The value for the ionization energy was obtained by Lotz [1967] by extrapolation. The value derived with the Cowan [1981] HFR code is 16 814 000 cm^{-1}.

Zn XXIII

Configuration	Term	J	Level (cm^{-1})
$2s^22p^4$	^3P	2	0
		0	110 340
		1	179 060
$2s^22p^4$	^1D	2	267 120
$2s^22p^4$	^1S	0	512 070
$2s2p^5$	$^3P^\circ$	2	*1 176 110*
		1	*1 282 970*
		0	*1 380 580*
$2s2p^5$	$^1P^\circ$	1	*1 626 230*
$2p^6$	^1S	0	2 697 570
Zn XXIV ($^4S^\circ_{3/2}$)	***Limit***		***16 810 000***

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Zn XXIV

Z=30

N I isoelectronic sequence

Ground state $1s^22s^22p^3\ ^4S^o_{3/2}$

Ionization energy 18 020 000 ± 180 000 cm^{-1} (2234 ± 22 eV)

Three lines of this spectrum were identified by Behring *et al.* [1976] and two by Kononov *et al.* [1977]. The spectrum was reobserved by Behring *et al.* [1985] with a laser-produced plasma; fifteen lines were reported with a measurement uncertainty of ±0.005 Å. These were classified in transition arrays $2s^22p^3-2s2p^4$ and $2s2p^4-2p^5$. We give the level values derived from these wavelengths with an uncertainty of ±100 cm^{-1}. The level $2s^22p^3\ ^2P^o_{3/2}$ and two levels derived from it have no observed connection to the ground state. We adopt a value for the $2s^22p^3\ ^2P^o_{3/2}$ from the predicted magnetic dipole transition $2s^22p^3\ (^2P^o_{1/2}-^2P^o_{3/2})$ given by Kaufman and Sugar [1986] as 694.4±0.3 Å and affix +x to it and the two levels dependent on it. There appears to be a misprint for the level $2s2p^4\ ^2P_{1/2}$ given by Behring *et al.* [1985] as 1 766 650 cm^{-1}. We derive 1 767 650 cm^{-1} from their data.

The value for the ionization energy was obtained by Lotz [1967] by extrapolation. We calculated 1 782 000 cm^{-1} with the Cowan [1981] HFR code.

Zn XXIV

Configuration	Term	J	Level (cm^{-1})
$2s^22p^3$	$^4S^o$	3/2	*0*
$2s^22p^3$	$^2D^o$	3/2	*188 130*
		5/2	*254 110*
$2s^22p^3$	$^2P^o$	1/2	*357 130*
		3/2	*501 140+x*
$2s2p^4$	^4P	5/2	956 600
		3/2	1 084 810
		1/2	1 110 540
$2s2p^4$	^2D	3/2	1 328 550
		5/2	1 371 750
$2s2p^4$	^2S	1/2	1 516 340
$2s2p^4$	^2P	3/2	1 578 630
		1/2	1 767 650+x
$2p^5$	$^2P^o$	3/2	*2 451 700*
		1/2	*2 657 600+x*
Zn XXV ($^3P_0$)	***Limit***		**18 020 000**

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Zn XXV

Z=30

C I isoelectronic sequence

Ground state $1s^2 2s^2 2p^2\ ^3P_0$

Ionization energy 19 040 000 ± 190 000 cm^{-1} (2361 ± 24 eV)

Five lines of the $2s^2 2p^2 - 2s2p^3$ array were identified by Behring *et al.* [1985] in a laser-generated plasma. They are in the range of 77–97 Å and are measured with an uncertainty of ±0.005 Å. They used a value for the F-like transition of 86.540 Å as a calibration line. We derived the energy levels from these data and use a predicted value for the $2s^2 2p^2$ $^3P_0 - ^3P_1$ interval obtained by Kaufman and Sugar [1986] with an estimated uncertainty of ±100 cm^{-1}.

The value for the ionization energy was derived by Lotz [1967] by extrapolation. We obtained a calculated value of 19 062 000 cm^{-1} with the Cowan [1981] HFR code.

Zn XXV

Configuration	Term	J	Level (cm^{-1})
$2s^2 2p^2$	^3P	0	0
		1	157 700+x
		2	218 054+x
$2s2p^3$	$^3D°$	1	*1 026 180*
$2s2p^3$	$^3P°$	2	*1 295 000+x*
$2s2p^3$	$^3S°$	1	*1 428 120+x*
$2s2p^3$	$^1D°$	2	*1 514 890+x*
Zn XXVI ($^2P°_{1/2}$)	***Limit***		***19 040 000***

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Zn XXVI

Z=30

B I isoelectronic sequence

Ground state $1s^2 2s^2 2p\ ^2P°_{1/2}$

Ionization energy 20 110 000 ± 200 000 cm^{-1} (2493 ± 25 eV)

No spectroscopic observations are reported for this ion.

The value for the ionization energy was obtained by Lotz [1967] by extrapolation. We calculated the value 20 132 000 cm^{-1} with the Cowan [1981] HFR code.

References

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Zn XXVII

Z=30

Be I isoelectronic sequence

Ground state $1s^2 2s^2\ ^1S_0$

Ionization energy 21 490 000 ± 20 000 cm^{-1} (2664 ± 26 eV)

Twenty-nine spectral lines in the range of 7.9−9 Å emitted by a laser-produced plasma were measured by Boiko *et al.* [1977] with an uncertainty of ±0.002 Å. They were classified as n=2−3 transitions.

No $2s^2-2s2p$ resonance lines have been measured. We use values interpolated by Kim [1991], who plotted the difference between predictions of Dirac-Fock theory with QED corrections and the measured values to obtain corrections to the theory. By this means he derived values for the $2s2p\ ^3P_1^\circ$ and $^1P_1^\circ$ levels as well as the $^3P_1^\circ-^3P_2^\circ$ interval. These values are used in conjunction with the classified lines of Boiko to derive upper level values with an uncertainty of 6000 cm^{-1}. Kim *et al.* [1988] have calculated values for the $2s3p\ ^3P_1^\circ$ and $^1P_1^\circ$ levels of 12 368 000 and 12 429 500 cm^{-1}, respectively. Comparison of their calculated values for other members of this sequence with measured values by Boiko *et al.* indicate that Boiko's estimated measurement uncertainty should probably be doubled. Transitions between $2p^2$ and $2p3d$ are given, but their connection with the known lower levels has not been identified.

The value for the ionization energy was calculated with the Cowan [1981] HFR code.

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Zn XXVII

Configuration	Term	J	Level (cm^{-1})
$2s^2$	^1S	0	0
$2s2p$	$^3P^\circ$	1	*[459 615]*
		2	*[640 470]*
$2s2p$	$^1P^\circ$	1	*[954 808]*
$2s3s$	^3S	1	12 132 000
$2s3p$	$^3P^\circ$	1	*[12 368 000]*
$2s3p$	$^1P^\circ$	1	*[12 429 500]*
$2s3d$	^3D	1	12 525 000
$2s3d$	^1D	2	12 615 000
$2p3p$	^1D	2	12 734 000
$2p3p$	^3D	1	12 817 000
		2	12 946 000
		3	13 126 000
$2p3p$	^1P	1	12 925 000
$2p3p$	^3S	1	13 020 000
$2p3p$	^3P	2	13 055 000
$2s3s$	^1S	0	13 313 000
Zn XXVIII ($^2S_{1/2}$)	***Limit***		**21 490 000**

Zn XXVIII

Z=30

Li I isoelectronic sequence

Ground state $1s^22s\ ^2S_{1/2}$

Ionization energy 22 450 000 ± 22 000 cm^{-1} (2783 ± 3 eV)

No experimental data for this ion have been found. By plotting the difference between observed and calculated transition energies Seely [1989] has predicted values for the $2s-2p$ transitions of 216.059 Å and 142.466 Å with an uncertainty of at most ±0.005 Å by comparison with recent measurements.

We have calculated the value for the ionization energy with the Cowan [1981] HFR code.

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Zn XXVIII

Configuration	Term	J	Level (cm^{-1})
$1s^22s$	^2S	1/2	0
$1s^22p$	$^2P^o$	1/2	*[462 836]*
		3/2	*[701 922]*
Zn XXIX ($^1S_0$)	***Limit***		**22 450 000**

Zn XXIX

Z=30

He I isoelectronic sequence

Ground state $1s^2\ ^1S_0$

Ionization energy 95 698 900 ± 2 000 cm^{-1} (11 865.16 ± 0.25 eV)

A value for the $1s^2\ ^1S_0-1s2p\ ^1P_1^o$ transition energy of 72 575 300±2600 cm^{-1} was measured by Aglitsky *et al.* [1988] from observations with a vacuum spark. Drake [1988] reported a theoretical value of 72 577 600 ±100 cm^{-1}. An improved calculation by Cheng *et al.* [1994] gives a value 1400 cm^{-1} larger.

We give calculated values by Cheng *et al.* for the $1s2s$ and $1s2p$ levels and the ionization energy. We adopt an uncertainty of two parts in 10^5 representing the approximate difference between the best observations in this region of the sequence (see Beiersdorfer *et al.* [1989] and Cheng). Drake's n=2 levels are 64 ± 18 cm^{-1} lower than the levels circulated privately by him in 1985, which include levels of the n=3 shell. We include the latter increased by 1600 cm^{-1}, which is the difference in the binding energy of the ground state from Cheng *et al.*

Calculated values for the $1snl$ (n=2−5 and l=0−2), $2s^2$, $2s2p$, and $2p^2$ levels have been given by Vainshtein and Safronova [1985]. By comparison with Cheng *et al.*, we add 3000 cm^{-1} to these values and obtain $1snl$ (n=4−5, l=0−2), $2s^2$, $2s2p$, and $2p^2$ levels.

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Zn XXIX

Configuration	Term	J	Level (cm^{-1})
1s^2	^{1}S	0	0
1s2s	^{3}S	1	[71 886 400]
1s2p	^{3}P°	0	[*72 165 900*]
		1	[*72 186 600*]
		2	[*72 415 600*]
1s2s	^{1}S	0	[72 188 400]
1s2p	^{1}P°	1	[*72 578 900*]
1s3s	^{3}S	1	[85 212 700]
1s3p	^{3}P°	0	[*85 289 800*]
		1	[*85 295 600*]
		2	[*85 364 000*]
1s3s	^{1}S	0	[85 293 200]
1s3d	^{3}D	2	[85 403 900]
		1	[85 405 200]
		3	[85 428 900]
1s3p	^{1}P°	1	[*85 408 300*]
1s3d	^{1}D	2	[85 431 900]
1s4s	^{3}S	1	[89 828 600]
1s4p	^{3}P°	0	[*89 860 800*]
		1	[*89 863 300*]
		2	[*89 892 100*]
1s4s	^{1}S	0	[89 862 000]
1s4d	^{3}D	2	[89 908 900]
		1	[89 909 400]
		3	[89 918 900]
1s4p	^{1}P°	1	[*89 910 900*]
1s4d	^{1}D	2	[89 920 800]
1s5s	^{3}S	1	[91 953 400]
1s5p	^{3}P°	0	[*91 969 900*]
		1	[*91 971 200*]
		2	[*91 985 900*]
1s5s	^{1}S	0	[91 970 500]
1s5d	^{3}D	2	[91 994 500]
		1	[91 994 800]
		3	[91 995 600]
1s5p	^{1}P°	1	[*91 994 500*]
1s5d	^{1}D	2	[92 000 500]
Zn XXX (^{2}S$_{1/2}$)	***Limit***		**95 698 900**
2s^2	^{1}S	0	[146 350 000]
2s2p	^{3}P°	0	[*146 390 000*]
		1	[*146 445 000*]
		2	[*146 676 000*]
2p^2	^{3}P	0	[146 721 000]
		1	[146 885 000]
		2	[146 952 000]
2s2p	^{1}P°	1	[*146 995 000*]
2p^2	^{1}D	2	[147 224 000]
2p^2	^{1}S	0	[147 526 000]

Zn XXX

Z=30

H I isoelectronic sequence

Ground state $1s\ ^2S_{1/2}$

Ionization energy 99 923 450 ± 40 cm^{-1} (12 388.933 ± 0.005 eV)

By beam-foil excitation Hailey *et al.* [1985] measured the $2p\ ^2P°$ fine structure as 38.2 ± 0.8 eV. An unresolved blend of the $1s-2p$ resonance lines was observed by Aglitskiy *et al.* [1985] at 1.249 ± 0.002 Å using a low-inductance vacuum spark.

We give theoretical values for the $1s$, $2s$, and $2p$ levels as well as the ionization energy calculated by Johnson and Soff [1985]. The estimated uncertainty of these quantities relative to the ground state is ±40 cm^{-1} while that of the $2p\ ^2P°$ fine structure interval is ±2 cm^{-1}. Johnson and Soff's values agree exactly with those calculated by Mohr [1983].

For n=3 to 5 the values for the energy levels were obtained by subtracting the binding energies calculated by Erickson [1977] from the Johnson and Soff value for the binding energy of the $1s$ ground state. Assuming that the Lamb shift scales as $(^1/_n)^3$, we estimate the error in Erickson's calculations for the ns levels as $^8/_{n^3}$ times his error of 322 cm^{-1} for $2s$. The resulting error estimates for $3s$, $4s$, and $5s$ are ±95 cm^{-1}, ±40 cm^{-1}, and ±20 cm^{-1}, respectively. The corresponding total estimated errors with respect to the ground state are thus 100, 60, and 45 cm^{-1} for the $3s$, $4s$, and $5s$ levels, respectively. For the remaining levels with $n \geqslant 3$ we estimate the uncertainty to be ±40 cm^{-1}

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Zn XXX

Configuration	Term	J	Level (cm^{-1})
$1s$	^2S	1/2	0
$2p$	$^2P°$	1/2	*[74 853 190]*
		3/2	*[75 158 798]*
$2s$	^2S	1/2	[74 860 628]
$3p$	$^2P°$	1/2	*[88 815 210]*
		3/2	*[88 905 830]*
$3s$	^2S	1/2	[88 817 550]
$3d$	^2D	3/2	[88 905 667]
		5/2	[88 935 197]
$4p$	$^2P°$	1/2	*[93 689 390]*
		3/2	*[93 727 577]*
$4s$	^2S	1/2	[93 690 380]
$4d$	^2D	3/2	[93 727 507]
		5/2	[93 739 978]
$4f$	$^2F°$	5/2	*[93 739 505]*
		7/2	*[93 746 156]*
$5p$	$^2P°$	1/2	*[95 940 104]*
		3/2	*[95 959 637]*
$5s$	^2S	1/2	[95 940 613]
$5d$	^2D	3/2	[95 959 601]
		5/2	[95 965 986]
$5f$	$^2F°$	5/2	*[95 965 975]*
		7/2	*[95 969 152]*
$5g$	^2G	7/2	[95 969 146]
		9/2	[95 971 047]
	Limit		**99 923 450**