Energy Levels of Molybdenum, Mo I through Mo XLII

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The energy levels of the molybdenum atom, in all stages of ionization for which experimental data are available, have been compiled. Ionization energies, either experimental or theoretical, and experimental g-factors are given. Leading components of calculated eigenvectors are listed.

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

Contents

1. Introduction

There has been a spectacular increase in the known spectroscopic data for most of the ionization stages of molybdenum following the use of this refractory element in the interior construction of various tokamak fusion energy machines. Both electric dipole (E1) and magnetic dipole (M1) transitions have been extensively observed and classified, the latter serving as a diagnostic tool for measuring the plasma ion temperature, impurity transport, plasma rotation, and excitation rates. The M1 lines have also been useful in uniting fragmentary systems of energy levels.

A compilation of observed E1 and M1 lines of Mo VI to Mo XLII by Shirai *et al.* [1987] has just been published, as well as a compilation of observed and calculated M1 lines, including transition probabilities, by Kaufman and Sugar [1986]. An earlier compilation by Moore [1958] contained energy levels of Mo I through Mo VIII, of which only Mo I and Mo II remain mostly unchanged except for recently improved wavelength measurements of Mo I. The present compilation reports experimentally determined energy levels of Mo I to XXXIV and calculated values for Mo XL to XLII.

With the large number of publications of spectral analyses in a relatively short period of time came the need to evaluate carefully many conflicting results. We have therefore tried to point out the results to be avoided as well as those we currently accept as correct. More than the usual number of such conflicts has appeared in the literature of this element, perhaps partly arising from the process of gaining experience with new light sources such as laser-plasmas, tokamaks, exploding wires, etc., and partly from the urgent need for these data by the laser and tokamak research community.

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For the most part we have compiled data from published work. In some cases the authors have generously provided their results in advance of publication. Examples are the greatly improved level values of Mo I obtained from new observations of the spectrum with a Fourier-transform spectrometer by Brault and Whaling, and new analyses of Mo III and IV arising from a collaborative effort between the National Bureau of Standards and the spectroscopic group at Madrid University. In some cases where energy levels are compiled from several sources their published values are somewhat altered in order to take advantage of the best wavelengths for each configuration. In such cases the classifications of lines are the primary data.

All energy levels are given in units of cm^{-1}. Ionization energies are also given in eV with the conversion factor $8065.5450(54)\ \mathrm{cm}^{-1}/\mathrm{eV}$ published by Taylor [1985]. These values are usually derived from Rydberg series by the authors or by us from their data. Where series data are not available we have used ionization-energy values calculated by Cowan [1981], which have an accuracy of about 1.0%, or Carlson *et al.* [1970] whose accuracy is about 4%. These uncertainties are estimated from comparisons with recent experimental values.

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. When the first and second resultant terms are the same but have different parentages, and their share of the eigenvector composition sums to 40% or more, the level is named as the higher percentage term. In cases where these percentages differ by one or two percent (an insignificant difference), either term may be selected for the level name, and the lower percentage may appear first. For the 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 can 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. Martin, Zalubas, and Hagan [1978] give a complete summary of the coupling notations used here, tables of the allowed terms for equivalent electrons, etc.

The text for each ion does not include a complete review of the literature but is intended to credit the major contributions. In assembling the data for each spectrum, we referred to the following bibliographies:

i. Papers cited by Moore [1958]
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 NBS Atomic Energy Levels Data Center

2. Acknowledgments

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References for the Introduction

Brault, J. W., and Whaling, W. [1987], private communication.

Carlson, T. A., Nestor, Jr., C. W., Wasserman, N., and McDowell, J. D. [1970], At. Data Nucl. Data Tables **2**, 63.

Cowan, R. D. [1981], *The Theory of Atomic Structure and Spectra*, (Univ. California Press, Berkeley).

Hagan, L. [1977], *Bibliography on Atomic Energy Levels and Spectra, July 1971 through June 1975*, Natl. Bur. Stand. (U.S.) Spec. Publ. 363, Suppl. 1 (U.S. Gov't Printing Office, Washington, DC).

Hagan, L., and Martin, W. C. [1972], *Bibliography on Atomic Energy Levels and Spectra, July 1968 through June 1971*, Natl. Bur. Stand. (U.S.) Spec. Publ. 363 (U.S. Gov't Printing Office, Washington, D.C.).

Kaufman, V., and Sugar, J. [1986], J. Phys. Chem. Ref. Data **15**, 321.

Martin, W. C., Zalubas, R., and Hagan, L. [1978], *Atomic Energy Levels—The Rare-Earth Elements*, Natl. Stand. Ref. Data Ser., Natl. Bur. Stand. (U.S.), 60, 422 pp.

Moore, C. E. [1958], *Atomic Energy Levels*, Natl. Bur. Stand. (U.S.) Circ. 467, Vol. III (reissued in 1971 as Natl. Stand. Ref. Data Ser., Natl. Bur. Stand. (U.S.) 35, Vol. III).

Moore, C. E. [1969], *Bibliography on the Analyses of Optical Atomic Spectra*, Natl. Bur. Stand. (U.S.) Spec. Publ. 306-3 (U.S. Gov't Printing Office, Washington, DC).

Musgrove, A., and Zalubas R. [1985], *Bibliography on Atomic Energy Levels and Spectra, July 1979 through December 1983*, Natl. Bur. Stand. (U.S.) Spec. Publ. 363, Suppl. 3 (U. S. Gov't Printing Office, Washington, DC).

Nielson, C. W., and Koster, G. F., *Spectroscopic Coefficients for the* p^n*,* d^n*, and* f^n *Configurations*, 275 pp. (M.I.T. Press, Cambridge, MA 1963).

Shirai, T., Nakai, Y., Ozawa, K., Ishii, K., Sugar, J., and Mori, K. [1987], J. Phys. Chem. Ref. Data **16**, 327.

Taylor, B. N. [1985], J. Res. Natl. Bur. Stand. (U.S.) **90**, 91.

Zalubas, R., and Albright, A. [1980], *Bibliography on Atomic Energy Levels and Spectra, July 1975 through June 1979*, Natl. Bur. Stand. (U.S.) Spec. Publ. 363, Suppl. 2 (U.S. Gov't Printing Office, Washington, DC).

3. Tables of Energy Levels

Mo I

$Z=42$

Ground state $1s^22s^22p^63s^23p^63d^{10}4s^24p^64d^55s\ ^7\mathrm{S}_3$

Ionization energy $57\,204.3 \pm 0.3\ \mathrm{cm}^{-1}$ $(7.09243 \pm 0.00004\ \mathrm{eV})$

Several early papers dating from 1923 to 1933 are superseded by the observations by Kiess and Harvey whose unpublished analysis is reported in a compilation by Moore [1958]. It is based on 7500 observed lines from 2000 to 11 850 Å, 80% of which were classified. In addition many g-values were derived from Zeeman-effect observations by these authors.

Recently the spectrum was observed with a Fourier transform spectrometer and a hollow cathode light source by Brault and Whaling. They measured 2837 lines of Mo I in the range of 2940–11 500 Å with a wavenumber accuracy of 1.2 parts in 10^7. With these data they improved the accuracy of the known levels by an order of magnitude, found 28 new ones, and showed that 29 of Kiess and Harvey's levels are probably not real. The latter are given here with the original two decimal place values and are followed by question marks. The rest are from the new work, which is still in progress. The present results may still be improved.

In the Kiess and Harvey analysis, 107 levels of odd parity are designated only by number, the odd parity symbol, and the J-value. To distinguish the new levels found by Brault and Whaling, they are given decimal fractional numbers. These authors have also reassigned the level at 39 600 cm^{-1} from $z\ ^5\mathrm{H}^\circ_7$ to $z\ ^5\mathrm{G}^\circ_6$ (eliminating the old level 39 522 which they could not verify) and substituted their new level 40 653 for the old $z\ ^5\mathrm{H}^\circ_6$ level at 39 635, which they also could not verify. The J-value of the level 97° was changed from 5 to 6 by Whaling *et al.* [1986] on the basis of finding no transitions to the levels of $J=4$ and one to a level with $J=7$.

A calculation of the even parity configurations $4d^45s^2$, $4d^55s$, and $4d^6$ with configuration interaction was carried out by Trees and Harvey [1952] and used to designate these levels. However, no eigenvectors were given except for a single example of severe mixing of the a and $b\ ^3\mathrm{P}$ with the a and $b\ ^3\mathrm{D}$ terms. No calculations of the odd configurations were made.

A value for the ionization energy of 57 191(20) cm^{-1} was determined from the 3-member $4d^5ns\ ^7\mathrm{S}$ series and corrected with reference to the 4-member $4d^{10}ns$ series of Ag I. The quoted value of 57 204.3(3) cm^{-1} was obtained by laser double-resonance by Rayner *et al.* [1987].

References

Brault, J. W., and Whaling, W. [1987], private communication. These authors will distribute their line list upon request.

Moore, C. E. [1958], *Atomic Energy Levels*, Natl. Bur. Stand. (U.S.) Circ. 467, Vol. III (reissued in 1971 as Natl. Stand. Ref. Data Ser., Natl. Bur. Stand. (U.S.) 35, Vol. III).

Rayner, D. M., Mitchell, S. A., Bourne, O. L., and Hackett, P. A. [1987], J. Opt. Soc. Am. B **4**, 900.

Trees, R. E., and Harvey, M. M. [1952], J. Res. Natl. Bur. Stand. (U.S.) **49**, 397.

Whaling, W., Chevako, P., and Lawler, J. E. [1986], J. Quant. Spectrosc. Radiat. Transfer **36**, 491.

Mo I

Configuration	Term	J	Level (cm^{-1})	g	Leading percentages
$4d^5(^6\mathrm{S})5s$	$a\ ^7\mathrm{S}$	3	0.000	1.992	
$4d^5(^6\mathrm{S})5s$	$a\ ^5\mathrm{S}$	2	10 768.332	1.980	
$4d^45s^2$	$a\ ^5\mathrm{D}$	0	10 965.947	0.000	
		1	11 142.784	1.490	
		2	11 454.362	1.498	
		3	11 858.498	1.488	
		4	12 346.280	1.483	
$4d^5(^4\mathrm{G})5s$	$a\ ^5\mathrm{G}$	2	16 641.081	0.331	
		3	16 692.905	0.918	
		4	16 747.720	1.141	
		6	16 783.856	1.318	
		5	16 784.522	1.284	

Mo I — Continued

Configuration	Term	J	Level (cm^{-1})	g	Leading percentages
$4d^5(^4P)5s$	$a\ ^5P$	3	18 229.152	1.636	
		2	18 356.491	1.789	
		1	18 479.582	2.424	
$4d^5(^4D)5s$	$b\ ^5D$	0	19 969.847	−0.037	
		1	20 130.313	1.579	
		4	20 157.802	1.482	
		2	20 280.968	1.537	
		3	20 350.507	1.495	
$4d^45s^2$	$a\ ^3P$	0	20 607.435	0.000	
		1	22 244.375	0.977	
		2	22 875.942	1.361	
$4d^5(^4D)5s$	$a\ ^3D$	1	20 930.425	1.056	
		2	20 950.853	1.289	
		3	21 618.630	1.320	
$4d^5(^4G)5s$	$a\ ^3G$	3	20 947.940	0.767	
		4	21 153.884	1.051	
		5	21 343.204	1.213	
$4d^45s^2$	$a\ ^3F$	4	23 516.476	1.117	
		2	23 534.407	0.667	
		3	23 668.079	1.079	
$4d^45s^2$	$a\ ^3H$	4	24 096.294	0.973	
		5	24 465.771	1.128	
		6	24 823.482	1.142	
$4d^45s^2$	$a\ ^1S$	0	24 472.140		
$4d^6$	$c\ ^5D$	4	25 455.636	1.458	
		3	25 707.071	1.355	
		2	25 794.608	1.09	
		1	25 820.622		
		0	25 980.338		
$4d^5(^2I)5s$	$a\ ^3I$	5	25 516.912	0.796	
		6	25 548.887	1.028	
		7	25 638.567	1.147	
$4d^5(^6S)5p$	$z\ ^7P^\circ$	2	*25 614.367*	2.299	
		3	*25 871.887*	1.892	
		4	*26 320.420*	1.736	
$4d^5(^4F)5s$	$a\ ^5F$	5	25 905.490	1.394	
		4	25 997.337	1.322	
		3	26 189.445	1.307	
		1	26 283.821		
		2	26 335.816	1.031	
$4d^5(^4P)5s$	$b\ ^3P$	1	26 414.806	1.41	
		0	26 450.019		
		2	27 415.053	1.41	
$4d^45s^2$	$a\ ^1G$	4	26 635.820	1.014	

Mo I — Continued

Configuration	Term	J	Level (cm^{-1})	g	Leading percentages
$4d^5(^2D)5s$	$b\ ^3D$	3	26 638.742	1.234	
		2	26 758.660	1.24	
		1	27 362.456	1.06	
$4d^5(^2F)5s$	$b\ ^3F$	2	27 093.242	0.890	
		4	27 765.594	1.125	
		3	27 774.422	1.055	
$4d^45s^2$	$b\ ^3G$	4	27 341.925	1.075	
		3	27 383.838	0.913	
		5	27 726.714	1.219	
$4d^45s(^6D)5p$	$z\ ^7F^\circ$	0	*27 866.684*		
		1	*28 274.290*		
		2	*28 666.545*	2.312	
		3	*28 848.146*	1.905	
		4	*29 171.107*		
		5	*29 781.120*	1.496	
		6	*30 496.016*	1.513	
$4d^5(^2I)5s$	$a\ ^1I$	6	28 241.014	1.015	
$4d^5(^6S)5p$	$z\ ^5P^\circ$	1	*28 715.242*	2.500	
		2	*28 836.592*	1.831	
		3	*28 923.668*	1.668	
$4d^5(^4F)5s$	$c\ ^3F$	2	29 641.989	1.02	
		3	30 159.582	1.089	
		4	30 501.944	1.111	
$4d^5(^2H)5s$	$b\ ^3H$	4	29 842.148	0.864	
		5	29 981.714	1.091	
		6	30 113.151	1.12	
$4d^45s(^6D)5p$	$z\ ^7D^\circ$	1	*30 846.584*	2.894	
		2	*31 154.935*	2.034	
		3	*31 654.786*	1.744	
		4	*32 123.128*	1.658	
		5	*32 611.837*	1.568	
$4d^45s(^6D)5p$	$y\ ^7P^\circ$	2	*31 299.876*	2.273	
		3	*31 533.206*	1.84	
		4	*31 913.171*	1.73	
$4d^45s^2$	$b\ ^1I$	6	31 484.615	1.028	
$4d^5(^2G)5s$	$c\ ^3G$	4	31 510.559		
		5	32 279.021		
$4d^5(^2G)5s$	$b\ ^1G$	4	32 688.270	0.960	
$4d^45s(^6D)5p$	$y\ ^5P^\circ$	1	*32 898.742*	2.550	
		2	*33 299.029*	1.838	
		3	*33 955.010*	1.659	
$4d^5(^2H)5s$	$a\ ^1H$	5	33 904.506	1.026	

Mo I — Continued

Configuration	Term	J	Level (cm^{-1})	g	Leading percentages
$4d^45s(^6D)5p$	$z\ ^5F^\circ$	1	*34 248.354*	−0.004	
		2	*34 434.660*	1.010	
		3	*34 740.380*	1.258	
		4	*35 169.407*	1.346	
		5	*35 719.270*	1.395	
$4d^6$	$c\ ^3H$	6	34 810.153	1.09	
		5	34 912.076	1.10	
		4	35 042.114	0.79	
$4d^45s(^6D)5p$	$z\ ^5D^\circ$	0	*37 128.043*	0.000	
		1	*37 292.965*	1.489	
		2	*37 579.174*	1.473	
		3	*37 968.418*	1.492	
		4	*38 423.030*	1.482	
$4d^45s(^4D)5p$	$y\ ^5D^\circ$	0	*37 365.610*	0.000	
		1	*37 901.516*	1.491	
		2	*38 522.192*	1.471	
		3	*39 159.828*	1.251	
		4	*39 915.644*	1.463	
	1°	1	*38 626.50?*	1.443	
$4d^5(^4G)5p$	$z\ ^5G^\circ$	2	*38 983.332*	0.428	
		3	*39 121.439*	1.070	
		4	*39 289.564*		
		5	*39 445.182*		
		6	*39 600.000*		
$4d^45s(^4D)5p$	$x\ ^5P^\circ$	1	*39 358.533*	2.485	
		2	*39 462.647*	1.696	
		3	*39 960.469*	1.282	
$4d^6$	$c\ ^1I$	6	39 521.056	0.982	
$4d^5(^6S)6s$	$e\ ^7S$	3	39 675.532	1.992	
$4d^5(^4G)5p$	$z\ ^5H^\circ$	3	*39 749.894*		
		4	*40 067.717*		
		5	*40 367.264*		
		6	*40 653.701*		
$4d^45s(^4D)5p$	$z\ ^3P^\circ$	1	*39 779.89?*		
		2	*39 821.354*	1.346	
$4d^45s(^4D)5p$	$z\ ^3F^\circ$	2	*39 989.061*	1.350	
		3			
		4	*40 843.482*	1.256	
$4d^45s(^4D)5p$	$z\ ^3D^\circ$	1	*40 036.940*	0.781	
		2	*40 566.167*	1.160	
		3	*40 964.040*	1.278	
	2°	2	*40 240.84?*		

Mo I — Continued

Configuration	Term	J	Level (cm^{-1})	g	Leading percentages
$4d^5(^4\mathrm{P})5p$	$x\ ^5\mathrm{D}^\circ$	3	*40 488.277*	1.470	
		1	*40 698.382*	1.393	
		0	*40 735.918*	0.000	
		2	*40 828.781*	1.474	
$4d^5(^6\mathrm{S})6s$	$e\ ^5\mathrm{S}$	2	40 840.331		
$4d^5(^4\mathrm{G})5p$	$y\ ^5\mathrm{F}^\circ$	1	*41 011.664*	1.235	
		2	*41 031.974*	1.053	
		3	*41 224.386*	1.259	
		5	*41 347.664*	1.385	
		4	*41 395.523*	1.343	
	3°	1	*41 398.340*	1.067	
$4d^5(^4\mathrm{G})5p$	$y\ ^3\mathrm{F}^\circ$	2	*41 484.450*	0.781	
		3	*41 849.838*	1.084	
		4	*42 087.533*	1.225	
	3.1°	2	*41 807.000*		
$4d^5(^4\mathrm{D})5p$	$w\ ^5\mathrm{D}^\circ$	1	*42 156.079*	1.438	
		0	*42 173.008*	0.000	
		2	*42 237.314*	1.442	
		3	*42 422.323*	1.425	
		4	*42 741.804*	1.403	
$4d^5(^4\mathrm{G})5p$	$z\ ^3\mathrm{H}^\circ$	4	*42 185.838*	0.851	
		5	*42 283.180*		
		6	*42 344.929*	1.258	
	3.2°	2	*42 783.153*		
	3.3°	1	*42 936.720*		
$4d^5(^4\mathrm{G})5p$	$z\ ^3\mathrm{G}^\circ$	3	*42 969.964*	0.884	
		4	*43 196.876*	1.097	
		5	*43 945.680*	1.359	
$4d^5(^4\mathrm{D})5p$	$x\ ^5\mathrm{F}^\circ$	2	*43 045.465*	1.030	
		3	*43 245.567*	1.248	
		5	*43 299.059*	1.363	
		4	*43 529.884*	1.365	
	3.4°	5	*43 566.437*		
$4d^45s(^4\mathrm{H})5p$	$z\ ^5\mathrm{I}^\circ$	4	*43 598.471*	0.779	
		5	*44 330.156*	0.956	
$4d^45s(^4\mathrm{H})5p$	$y\ ^5\mathrm{H}^\circ$	3	*43 697.423*	0.554	
		4	*44 012.319*	0.867	
		5	*44 444.51?*		
		6	*44 694.826*		
		7	*45 405.90?*		
	3.5°	5	*43 967.098*		

Mo I — Continued

Configuration	Term	J	Level (cm^{-1})	g	Leading percentages
$4d^45s(^4\mathrm{H})5p$	$y\ ^3\mathrm{G}^\circ$	3	*43 975.441*		
		4	*44 460.583*	1.075	
		5	*44 759.769*	1.170	
$4d^5(^4\mathrm{D})5p$	$y\ ^3\mathrm{D}^\circ$	1	*44 041.026*		
		2	*44 524.504*	1.123	
		3	*44 921.172*		
$4d^5(^6\mathrm{S})5d$	$e\ ^7\mathrm{D}$	1	44 935.711		
		2	44 940.344		
		3	44 947.356	1.94	
		4	44 957.079	1.650	
		5	44 970.159	1.605	
	3.6°	4	*44 951.544*		
	3.7°	1	*45 081.071*		
	4°	2	*45 388.700*		
$4d^5(^2\mathrm{G})5p$	$x\ ^3\mathrm{G}^\circ$	3	*45 414.779*	0.794	
		4	*45 556.237*	1.108	
		5	*45 835.526*	1.100	
$4d^45s(^4\mathrm{F})5p$	$w\ ^5\mathrm{F}^\circ$	2	*45 425.123*	1.286	
		1	*45 457.767*	0.104	
		3	*45 634.691*	1.162	
		4	*45 869.523*	1.334	
$4d^5(^4\mathrm{D})5p$	$x\ ^3\mathrm{F}^\circ$	2	*45 709.998*	0.890	
		3	*45 938.514*	1.110	
		4	*45 969.168*	1.135	
$4d^5(^6\mathrm{S})5d$	$e\ ^5\mathrm{D}$	4	45 785.593		
		3	45 792.737		
		2	45 800.131		
		1	45 805.377		
		0	45 807.37?		
$4d^5(^4\mathrm{P})5p$	$z\ ^3\mathrm{S}^\circ$	1	*45 834.721*	2.048	
$4d^5(^4\mathrm{F})5p$	$x\ ^3\mathrm{D}^\circ$	1	*45 974.34?*		
		2	*46 301.842*	1.078	
		3	*46 808.367*	1.275	
	5°	4	*46 135.945*		
$4d^5(^4\mathrm{F})5p$	$v\ ^5\mathrm{F}^\circ$	1	*46 447.893*		
		2	*46 452.405*		
		3	*46 453.388*		
		4	*46 756.458*	1.304	
	5.1°	2	*46 539.301*		
	6°	4	*46 590.034*	1.160	
	7°	1	*46 720.024*		
	8°	2	*46 754.734*		

Mo I — Continued

Configuration	Term	J	Level (cm^{-1})	g	Leading percentages
$4d^5(^2\mathrm{I})5p$	$z\ ^3\mathrm{I}^\circ$	5	*46 861.000*	0.937	
		6	*47 171.708*	1.13	
		7	*47 492.90?*	1.14	
$4d^5(^2\mathrm{D})5p$	$w\ ^3\mathrm{F}^\circ$	2	*46 874.412*		
		3	*46 926.304*	1.093	
$4d^5(^2\mathrm{D})5p$	$w\ ^3\mathrm{D}^\circ$	1	*46 894.990*		
		2	*47 110.181*	1.156	
		3	*47 184.522*	1.290	
	9°	3	*46 955.834*	1.66	
	10°	1	*47 038.709*		
	11°	2	*47 051.658*	0.917	
	12°	3	*47 064.572*	1.13	
	13°	3	*47 177.061*		
$4d^45s(^4\mathrm{F})5p$	$y\ ^5\mathrm{G}^\circ$	2	*47 186.322*		
		3	*47 311.127*	0.862	
		4	*47 409.329*	1.200	
		5	*47 659.000*	1.252	
		6	*47 704.609*	1.30	
	14°	1	*47 248.084*	1.164	
	15°	2	*47 282.133*		
	16°	0	*47 324.332*	0.00	
	17°	1	*47 402.144*	0.889	
	17.1°	4	*47 409.183*		
	18°	5	*47 491.592*	1.112	
	18.1°	7	*47 561.619*		
	19°	2	*47 587.567*	1.12	
	19.1°	3	*47 631.648*		
	20°	4	*47 710.850*	1.056	
	21°	1	*47 713.85?*		
$4d^45s(^4\mathrm{D})5p$	$v\ ^3\mathrm{D}^\circ$	1	*47 779.362*	0.076	
		2	*48 085.181*	1.044	
		3	*48 205.891*	1.37	

Mo I — Continued

Configuration	Term	J	Level (cm^{-1})	g	Leading percentages
$4d^45s(^4D)5p$	$u\ ^5F^\circ$	2	*47 827.191*	1.09	
		1	*48 022.162*	0.29	
		3	*48 028.183*	1.283	
		4	*48 192.009*	1.293	
		5	*48 547.380*	1.370	
	22°	3	*47 848.348*		
$4d^5(^2I)5p$	$y\ ^3H^\circ$	4	*47 876.757*		
		5	*48 189.154*	1.206	
		6	*48 400.209*	1.195	
	23°	2	*48 038.89?*		
	24°	6	*48 120.460*	1.20	
$4d^5(^2F)5p$	$v\ ^3F^\circ$	2	*48 238.208*	0.758	
		3	*48 398.946*	1.174	
$4d^5(^6S)7s$	$f\ ^7S$	3	48 367.864		
$4d^45s(^4D)5p$	$v\ ^5D^\circ$	2	*48 408.687*	1.440	
		1	*48 410.88?*		
		3	*48 532.119*	1.496	
		4	*48 870.471*	1.454	
	24.1°	4	*48 431.459*		
$4d^5(^2G)5p$	$x\ ^3H^\circ$	4	*48 622.076*	0.926	
		5	*48 818.952*	0.972	
		6	*49 061.760*	1.108	
$4d^5(^6S)7s$	$f\ ^5S$	2	48 742.274		
	25°	1	*48 775.269*		
	25.1°	7	*48 791.344*		
$4d^45s(^4G)5p$	$x\ ^5G^\circ$	2	*48 875.813*		
		3	*48 997.228*	0.60	
		4	*49 146.754*	1.164	
		5	*49 302.075*	1.25	
		6	*49 408.530*	1.150	
$4d^5(^2I)5p$	$z\ ^1H^\circ$	5	*48 922.188*	0.970	
	26°	1	*48 955.732*	0.77	
	26.1°	2	*49 078.669*		
	27°	1	*49 169.268*		
$4d^45s(^4G)5p$	$t\ ^5F^\circ$	1	*49 189.701*	0.31	
		2	*49 346.196*	1.20	
		3	*49 468.023*	1.216	
		4	*49 590.828*	1.245	
		5	*49 650.658*	1.352	
	28°	3	*49 259.406*	1.348	

Mo I — Continued

Configuration	Term	J	Level (cm^{-1})	g	Leading percentages
$4d^45s(^4\mathrm{H})5p$	$y\ ^3\mathrm{I}^\circ$	5	*49 350.588*	0.914	
		6	*49 400.368*	1.108	
		7	*49 565.135*	1.122	
	29°	4	*49 369.475*	1.475	
	29.1°	1	*49 390.979*		
$4d^45s(^4\mathrm{P})5p$	$w\ ^5\mathrm{P}^\circ$	1	*49 484.068*	2.378	
		2	*49 711.894*	2.16	
		3	*51 209.662*	1.66	
	30°	5	*49 595.606*	1.008	
$4d^45s(^6\mathrm{D})6s$	$f\ ^7\mathrm{D}$	1	49 608.111	2.990	
		2	49 852.184		
		3	50 155.527		
		4	50 790.261	1.613	
		5	51 275.691	1.611	
$4d^5(^4\mathrm{F})5p$	$u\ ^3\mathrm{F}^\circ$	3	*49 789.746*	1.061	
		2	*49 801.329*		
		4	*50 134.158*	1.210	
	30.1°	7	*49 813.338*		
$4d^45s(^4\mathrm{G})5p$	$w\ ^3\mathrm{G}^\circ$	4	*49 863.424*	1.054	
		5	*50 631.392*	1.123	
	31°	2	*49 880.46?*		
$4d^45s(^4\mathrm{D})5p$	$v\ ^5\mathrm{P}^\circ$	3	*49 999.575*	1.72	
		1	*50 113.099*	2.52	
		2	*51 049.60?*	1.61	
$4d^5(^2\mathrm{I})5p$	$z\ ^3\mathrm{K}^\circ$	7	*50 276.822*	1.046	
		6	*50 595.883*	0.968	
$4d^5(^6\mathrm{S})6d$	$g\ ^7\mathrm{D}$	4	50 323.387		
		5	50 364.243		
		3	50 371.74?		
	32°	2	*50 482.361*	1.07	
	33°	4	*50 625.116*	1.23	
	34°	3	*50 669.967*		
	35°	2	*50 769.72?*		
	36°	4	*50 770.12?*		
	37°	5	*50 801.556*	1.083	
	38°	2	*50 925.502*		

Mo I — Continued

Configuration	Term	J	Level (cm^{-1})	g	Leading percentages
$4d^45s(^4\text{H})5p$	$w\ ^3\text{H}^\circ$	4	*50 953.746*	0.937	
		5	*51 753.384*	1.059	
	39°	1	*51 070.34?*		
	39.1°	6	*51 117.208*		
	40°	1	*51 165.07?*		
	41°	4	*51 234.093*	1.26	
	41.1°	3	*51 324.459*		
	42°	2	*51 404.708*	1.675	
	42.1°	3	*51 568.561*		
	43°	4	*51 585.313*	1.040	
	43.1°	5	*51 622.570*		
	44°	2	*51 675.202*	1.146	
	45°	3	*51 808.875*	0.88	
	46°	6	*51 856.215*		
	47°	4	*51 858.766*	1.258	
	48°	1	*51 875.934*	0.87	
	49°	3	*51 884.451*	1.13	
	50°	2	*51 891.314*	0.56	
	50.1°	3	*52 043.378*		
	51°	4	*52 085.241*	1.266	
	52°	2	*52 087.998*		
	53°	3	*52 135.498*	0.91	
	54°	3	*52 181.918*	1.34	
	54.1°	2	*52 288.942*		
	55°	4	*52 404.761*	1.16	
	56°	2	*52 441.17?*		
	57°	5	*52 441.33?*		
	58°	2	*52 443.510*	1.12	
	59°	5	*52 465.385*	1.088	
	59.1°	3	*52 473.717*		

Mo I — Continued

Configuration	Term	J	Level (cm^{-1})	g	Leading percentages
$4d^45s(^6\mathrm{D})6s$	$f\,^5\mathrm{D}$	4	52 477.60?		
	60°	4	*52 579.336*	1.055	
	61°	5	*52 667.220*	1.18	
	62°	2	*52 740.482*		
	63°	1	*52 746.93?*		
	63.1°	6	*52 782.806*		
	64°	3	*52 902.150*		
	65°	1	*52 941.278*		
	66°	2	*52 964.564*		
	67°	4	*53 005.644*	1.35	
	67.1°	4	*53 108.776*		
	68°	5	*53 112.20?*	1.40	
	69°	6	*53 184.263*	1.04	
	70°	5	*53 197.855*	1.324	
	71°	3	*53 226.800*	1.01	
	72°	6	*53 290.674*		
	73°	3	*53 305.671*		
	74°	5	*53 327.366*		
	75°	4	*53 478.799*		
	76°	1	*53 482.858*		
	77°	2	*53 588.674*	1.43	
	78°	3	*53 595.110*	1.18	
	79°	7	*53 636.731*	1.125	
	80°	3	*53 643.755*	1.37	
	81°	3	*53 735.839*		
	82°	4	*53 800.380*	1.49	
	83°	4	*53 855.099*	1.17	
	84°	5	*53 937.694*	1.14	
	85°	4	*53 964.385*	1.016	
	86°	1	*54 184.34?*		

Mo I — Continued

Configuration	Term	J	Level (cm^{-1})	g	Leading percentages
	87°	4	*54 292.162*	1.04	
	88°	1	*54 341.00?*		
	89°	2	*54 342.839*	1.48	
	90°	1	*54 531.128*		
	91°	1	*54 571.814*	0.75	
	92°	5	*54 704.485*	0.911	
	93°	7	*54 738.518*	1.10	
	94°	3	*54 839.231*	0.31	
	95°	3	*54 888.968*	0.84	
	96°	4	*55 025.689*	1.050	
	97°	6	*55 139.706*	0.968	
	98°	3	*55 327.60?*		
	99°	3	*55 352.718*		
	100°	5	*55 387.359*	1.12	
	101°	4	*55 529.804*		
	102°	4	*55 907.670*	1.09	
	103°	5	*55 975.853*	1.10	
$4d^5(^2H)5p$	$y\ ^1H^\circ$	5	*56 161.808*	0.96	
	104°	3	*56 380.79?*	0.03	
$4d^5(^2H)5p$	$z\ ^1I^\circ$	6	*56 716.603*	1.00	
	105°	6	*56 890.730*	1.21	
	106°	4	*56 945.788*		
	107°	5	*57 029.984*	0.98	
	108°	3	*57 144.26?*		
Mo II ($^6S_{5/2}$)	***Limit***		**57 204.3**		
	109°	4	*57 818.12*		
	110°	4	*58 090.10*		
	111°	3	*58 192.82*		
	112°	6	*58 525.71*	1.15	
	113°	5	*58 998.62*	0.88	

Mo I — Continued

Configuration	Term	J	Level (cm^{-1})	g	Leading percentages
	114°	3	*59 236.59*		
	115°	2	*59 249.76*		
	116°	5	*59 436.61*	1.07	
	117°	5	*59 612.36*	1.09	
	118°	5	*59 841.11*	0.930	
	119°	6	*60 192.00*		
	120°	7	*61 470.51*		

Mo II

$Z = 42$

Nb I isoelectronic sequence

Ground state $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 4d^5$ $^6S_{5/2}$

Ionization energy 130 300 ± 1000 cm^{-1} (16.16 ± 0.12 eV)

The only extensive observations and analysis of this spectrum were given by Kiess [1958] who measured 3800 lines in the range of 1500–6000 Å and Zeeman patterns for 970 of them. The wavelength uncertainty is ±0.01 Å. With these data he derived the levels quoted here.

Catalán and Rico [1952] estimated the value for the ionization energy by interpolation among the singly ionized atoms from Sr to Cd.

References

Catalán, M. A., and Rico, F. R. [1952], An. R. Soc. Esp. Fis. Quim., Ser. A **48**, 328.
Kiess, C. C. [1958], J. Res. Natl. Bur. Stand. **60**, 375.

Mo II

Configuration	Term	J	Level (cm^{-1})	g	Leading percentages
$4d^5$	$a\ ^6S$	5/2	0.00		
$4d^4(^5D)5s$	$a\ ^6D$	1/2	11 783.36	3.301	
		3/2	12 034.06	1.847	
		5/2	12 417.28	1.635	
		7/2	12 900.33	1.584	
		9/2	13 460.70	1.543	
$4d^5$	$a\ ^4G$	5/2	15 199.25	0.61	
		7/2	15 330.56		
		9/2	15 427.73		
		11/2	15 446.97		
$4d^5$	$a\ ^4P$	5/2	15 691.22	1.595	
		3/2	15 699.16		
		1/2	15 890.12		
$4d^5$	$a\ ^4D$	1/2	16 796.14	0.758	
		7/2	16 946.78	1.404	
		3/2	17 174.10	1.391	
		5/2	17 344.10	1.433	
$4d^5$	$a\ ^2D$	5/2	22 444.36	1.082	
		3/2	22 864.36	0.688	
$4d^5$	$a\ ^2I$	11/2	22 980.48		
		13/2	23 248.19		
$4d^5$	$a\ ^4F$	9/2	23 832.86	1.300	
		7/2	23 853.35	1.219	
		5/2	23 934.36	1.018	
		3/2	24 137.65	0.514	

Mo II — Continued

Configuration	Term	J	Level (cm^{-1})	g	Leading percentages
$4d^4(^5D)5s$	$b\ ^4D$	$^1/_2$	24 372.12	0.058	
		$^3/_2$	24 659.20	1.194	
		$^5/_2$	25 112.27	1.269	
		$^7/_2$	25 341.58	1.387	
$4d^5$	$a\ ^2F$	$^7/_2$	24 509.30	1.130	
		$^5/_2$	24 836.09	1.054	
$4d^4(^3H)5s$	$a\ ^4H$	$^7/_2$	26 041.18	0.798	
		$^9/_2$	26 488.15	0.984	
		$^{11}/_2$	26 739.47	1.130	
		$^{13}/_2$	27 113.83	1.193	
$4d^5$	$a\ ^2G$	$^9/_2$	26 068.60	1.065	
		$^7/_2$	26 405.61	0.785	
$4d^4(a\ ^3P)5s$	$b\ ^4P$	$^1/_2$	26 603.55	2.530	
		$^3/_2$	27 627.55	1.700	
		$^5/_2$	29 022.12	1.574	
$4d^5$	$b\ ^2F$	$^7/_2$	27 410.30	1.148	
		$^5/_2$	27 878.89	0.900	
$4d^5$	$a\ ^2H$	$^{11}/_2$	27 627.00	1.086	
		$^9/_2$	27 724.69	0.987	
$4d^4(a\ ^3F)5s$	$b\ ^4F$	$^5/_2$	28 876.82	1.035	
		$^3/_2$	28 883.69	0.529	
		$^7/_2$	28 988.96	1.135	
		$^9/_2$	29 034.17	1.278	
$4d^5$	$a\ ^2S$	$^1/_2$	28 950.36	1.968	
$4d^4(^3G)5s$	$b\ ^4G$	$^5/_2$	29 699.32	0.758	
		$^7/_2$	30 019.36	1.059	
		$^9/_2$	30 213.46	1.192	
		$^{11}/_2$	30 391.28	1.268	
$4d^4(a\ ^3P)5s$	$a\ ^2P$	$^1/_2$	32 124.04	0.672	
		$^3/_2$	34 419.26	1.175	
$4d^5$	$b\ ^2D$	$^5/_2$	32 879.55	1.213	
		$^3/_2$	33 086.28	0.889	
$4d^4(^3H)5s$	$b\ ^2H$	$^9/_2$	33 045.37	0.983	
		$^{11}/_2$	33 601.07	1.057	
$4d^4(a\ ^1G)5s$	$b\ ^2G$	$^7/_2$	33 146.30	0.904	
		$^9/_2$	33 254.46	1.043	
$4d^4(^3D)5s$	$c\ ^4D$	$^3/_2$	33 525.16	1.230	
		$^7/_2$	33 549.28	1.406	
		$^5/_2$	33 869.72	1.323	
		$^1/_2$	33 895.06	0.021	
$4d^4(^1I)5s$	$b\ ^2I$	$^{13}/_2$	35 099.46	1.053	
		$^{11}/_2$	35 406.02		

Mo II — Continued

Configuration	Term	J	Level (cm^{-1})	g	Leading percentages
$4d^4(a\,^3\mathrm{F})5s$	$c\,^2\mathrm{F}$	5/2	36 288.80	0.913	
		7/2	36 741.30	1.065	
$4d^4(^3\mathrm{G})5s$	$c\,^2\mathrm{G}$	7/2	37 431.45	0.927	
		9/2	38 053.88	1.105	
$4d^4(a\,^1\mathrm{D})5s$	$c\,^2\mathrm{D}$	3/2	39 243.45	0.800	
		5/2	39 912.95	1.203	
$4d^4(^3\mathrm{D})5s$	$d\,^2\mathrm{D}$	5/2	41 421.34		
		3/2	41 542.00	0.761	
$4d^4(a\,^1\mathrm{S})5s$	$b\,^2\mathrm{S}$	1/2	41 873.66	1.993	
$4d^5$	$d\,^2\mathrm{G}$	7/2	42 169.30		
		9/2	42 306.62		
$4d^4(^1\mathrm{F})5s$	$d\,^2\mathrm{F}$	5/2	42 925.34		
		7/2	42 992.18	1.085	
$4d^4(b\,^3\mathrm{F})5s$	$c\,^4\mathrm{F}$	3/2			
		5/2			
		7/2			
		9/2	*44 212.16*		
$4d^4(^5\mathrm{D})5p$	$z\,^6\mathrm{F}^\circ$	1/2	*45 853.08*	−0.650	
		3/2	*46 148.12*	1.072	
		5/2	*46 614.14*	1.305	
		7/2	*47 231.98*	1.375	
		9/2	*47 999.47*	1.415	
		11/2	*48 959.68*		
$4d^4(^5\mathrm{D})5p$	$z\,^4\mathrm{P}^\circ$	1/2	*47 208.36*	2.779	
		3/2	*48 022.45*	1.818	
		5/2	*48 860.57*	1.742	
$4d^4(^5\mathrm{D})5p$	$z\,^6\mathrm{P}^\circ$	3/2	*49 040.82*	2.305	
		7/2	*49 481.04*	1.672	
		5/2	*49 608.74*	1.718	
$4d^4(^5\mathrm{D})5p$	$z\,^6\mathrm{D}^\circ$	1/2	*49 949.45*	3.155	
		3/2	*50 192.00*	1.802	
		7/2	*50 302.54*	1.552	
		5/2	*50 577.36*	1.597	
		9/2	*50 705.52*	1.502	
$4d^4(^5\mathrm{D})5p$	$z\,^4\mathrm{F}^\circ$	3/2	*51 372.90*	0.412	
		5/2	*51 732.39*	1.045	
		7/2	*52 217.30*	1.262	
		9/2	*52 843.10*	1.362	
$4d^4(^5\mathrm{D})5p$	$z\,^4\mathrm{D}^\circ$	1/2	*54 238.80*	0.042	
		3/2	*54 687.61*	1.197	
		5/2	*55 215.85*	1.376	
		7/2	*55 706.57*	1.413	

Mo II — Continued

Configuration	Term	J	Level (cm^{-1})	g	Leading percentages
$4d^4(a\,^3P)5p$	$y\,^4D^\circ$	$^1/_2$	*57 319.55*	0.200	
		$^3/_2$	*58 140.75*	1.183	
		$^5/_2$	*59 347.94*	1.263	
		$^7/_2$	*60 702.16*	1.305	
$4d^4(^3H)5p$	$z\,^4H^\circ$	$^7/_2$	*57 892.06*	0.710	
		$^9/_2$	*58 196.68*	0.960	
		$^{11}/_2$	*58 760.95*	1.110	
		$^{13}/_2$	*59 491.83*	1.206	
$4d^4(a\,^3P)5p$	$z\,^2S^\circ$	$^1/_2$	*58 527.00*	1.651	
$4d^4(a\,^3F)5p$	$z\,^4G^\circ$	$^5/_2$	*59 053.32*	0.672	
		$^7/_2$	*59 478.34*	0.923	
		$^9/_2$	*60 227.00*	0.884	
		$^{11}/_2$	*61 116.18*	1.210	
$4d^4(^3H)5p$	$z\,^4I^\circ$	$^9/_2$	*59 679.75*	1.027	
		$^{11}/_2$	*60 924.53*	0.936	
		$^{13}/_2$	*61 647.76*	1.103	
		$^{15}/_2$	*62 151.66*		
$4d^4(a\,^3F)5p$	$z\,^2D^\circ$	$^3/_2$	*59 840.70*	0.862	
		$^5/_2$	*60 992.47*	1.205	
$4d^4(^3H)5p$	$z\,^2G^\circ$	$^7/_2$	*60 135.37*	1.011	
		$^9/_2$	*60 973.14*	1.101	
$4d^4(a\,^3P)5p$	$y\,^4P^\circ$	$^1/_2$	*61 134.25*	2.299	
		$^3/_2$	*61 456.77*	1.656	
		$^5/_2$	*62 425.47*	1.185	
$4d^4(a\,^3P)5p$	$z\,^2P^\circ$	$^3/_2$	*61 746.58*	1.220	
		$^1/_2$	*62 096.05*	1.075	
$4d^4(a\,^3F)5p$	$x\,^4D^\circ$	$^5/_2$	*62 342.27*	1.067	
		$^7/_2$	*62 491.78*	1.252	
		$^3/_2$	*62 551.04*	0.707	
		$^1/_2$	*62 937.45*	0.030	
	1°	$^5/_2$	*62 594.53*	1.14	
$4d^4(^3H)5p$	$z\,^2I^\circ$	$^{11}/_2$	*62 728.35*	0.902	
		$^{13}/_2$	*62 980.24*	1.091	
$4d^4(^3H)5p$	$y\,^4G^\circ$	$^7/_2$	*62 917.94*	1.004	
		$^9/_2$	*62 953.75*	1.214	
		$^5/_2$	*63 041.47*	0.851	
		$^{11}/_2$	*63 207.43*	1.272	
$4d^4(a\,^3F)5p$	$y\,^4F^\circ$	$^3/_2$	*63 002.58*	0.899	
		$^7/_2$	*63 104.63*	1.060	
		$^5/_2$	*63 392.52*	1.002	
		$^9/_2$	*63 783.10*		
	2°	$^7/_2$	*63 012.24*	1.186	

Mo II — Continued

Configuration	Term	J	Level (cm^{-1})	g	Leading percentages
$4d^4(^3\mathrm{G})5p$	$y\ ^4\mathrm{H}^\circ$	7/2	63 298.23	0.933	
		9/2	63 497.54	1.024	
		11/2	64 139.98	1.166	
		13/2	65 114.83		
$4d^4(^3\mathrm{G})5p$	$z\ ^2\mathrm{F}^\circ$	7/2	63 876.68	1.105	
		5/2	64 394.64	0.802	
$4d^4(^3\mathrm{G})5p$	$x\ ^4\mathrm{F}^\circ$	3/2	63 903.90	0.535	
		5/2	64 167.84	1.012	
		7/2	64 203.09	1.208	
		9/2	64 326.40	1.258	
$4d^4(^3\mathrm{H})5p$	$z\ ^2\mathrm{H}^\circ$	9/2	64 130.22	0.934	
		11/2	65 074.71	1.112	
$4d^4(a\ ^3\mathrm{P})5p$	$z\ ^4\mathrm{S}^\circ$	3/2	64 750.66	1.926	
$4d^4(a\ ^3\mathrm{F})5p$	$y\ ^2\mathrm{G}^\circ$	7/2	64 852.22	1.040	
		9/2	65 694.91	1.105	
$4d^4(a\ ^3\mathrm{F})5p$	$y\ ^2\mathrm{F}^\circ$	7/2	65 260.95		
		5/2	65 272.77	0.856	
$4d^4(^3\mathrm{G})5p$	$y\ ^2\mathrm{H}^\circ$	9/2	65 282.58		
		11/2	65 424.65	1.175	
$4d^4(a\ ^3\mathrm{P})5p$	$y\ ^2\mathrm{D}^\circ$	3/2	65 444.30	0.769	
		5/2	66 082.31	1.166	
$4d^4(^3\mathrm{G})5p$	$x\ ^4\mathrm{G}^\circ$	5/2	65 732.23	0.751	
		7/2	66 087.55		
		9/2	66 391.46		
		11/2	66 743.72	1.209	
	3°	7/2	65 831.24	1.070	
$4d^4(^3\mathrm{D})5p$	$w\ ^4\mathrm{D}^\circ$	1/2	66 373.65		
		3/2	66 399.44	1.075	
		5/2	66 667.98	1.289	
		7/2	66 716.34	1.436	
$4d^4(a\ ^1\mathrm{G})5p$	$x\ ^2\mathrm{F}^\circ$	7/2	67 391.42	1.130	
		5/2	67 658.13		
$4d^4(^3\mathrm{D})5p$	$x\ ^4\mathrm{P}^\circ$	5/2	67 712.92	1.426	
		3/2	68 441.66	1.535	
		1/2	69 049.75	2.410	
$4d^4(^3\mathrm{G})5p$	$x\ ^2\mathrm{G}^\circ$	7/2	67 760.30	0.921	
		9/2	68 052.47	1.150	
$4d^4(^3\mathrm{D})5p$	$w\ ^4\mathrm{F}^\circ$	3/2	67 821.60		
		5/2	68 015.92		
		7/2	68 179.70		
		9/2	68 323.50	1.250	

Mo II — Continued

Configuration	Term	J	Level (cm^{-1})	g	Leading percentages
$4d^4(^1I)5p$	$z\ ^2K^\circ$	13/2	*67 888.85*	0.933	
		15/2	*69 047.45*		
$4d^4(^1I)5p$	$y\ ^2I^\circ$	11/2	*68 472.84*		
		13/2	*68 908.60*		
$4d^4(^3D)5p$	$y\ ^2P^\circ$	1/2	*68 645.50*	0.768	
		3/2	*68 902.80*	1.420	
$4d^4(^3D)5p$	$w\ ^2F^\circ$	5/2	*69 729.90*	0.885	
		7/2	*70 101.55*	1.075	
$4d^4(a\ ^1G)5p$	$x\ ^2H^\circ$	9/2	*70 003.84*		
		11/2	*70 670.57*		
$4d^4(a\ ^1D)5p$	$x\ ^2D^\circ$	5/2	*70 713.10*		
		3/2	*70 738.00*	0.946	
$4d^4(a\ ^1G)5p$	$w\ ^2G^\circ$	9/2	*71 011.20*		
		7/2	*71 193.53*		
$4d^4(^1I)5p$	$w\ ^2H^\circ$	11/2	*71 546.56*		
		9/2	*71 920.22*		
$4d^4(a\ ^1S)5p$	$x\ ^2P^\circ$	1/2	*71 966.30*	0.670	
		3/2	*73 218.97*	1.082	
$4d^4(^3D)5p$	$w\ ^2D^\circ$	3/2	*72 039.00*	1.086	
		5/2	*72 829.62*	1.156	
$4d^4(a\ ^1D)5p$	$v\ ^2F^\circ$	5/2	*72 484.19*		
		7/2	*73 032.28*		
$4d^4(a\ ^1D)5p$	$w\ ^2P^\circ$	1/2	*73 546.75*		
		3/2	*74 050.37*	1.289	
$4d^4(^1F)5p$	$u\ ^2F^\circ$	5/2	*74 146.50*		
		7/2	*74 491.54*		
$4d^4(b\ ^3F)5p$	$t\ ^2F^\circ$	7/2	*74 749.55*		
		5/2	*74 926.17*		
$4d^4(b\ ^3F)5p$	$w\ ^4G^\circ$	5/2	*74 858.86*		
		7/2	*75 834.37*		
		9/2	*76 584.60*		
		11/2	*77 663.92*		
$4d^4(^1F)5p$	$v\ ^2G^\circ$	9/2	*75 685.65*	1.140	
		7/2			
$4d^4(b\ ^3F)5p$	$v\ ^4F^\circ$	3/2			
		5/2	*75 810.62?*		
		9/2	*76 637.38*		
		7/2	*76 667.03*		
$4d^4(b\ ^3P)5p$	$v\ ^2D^\circ$	3/2			
		5/2	*75 819.80*		

Mo II — Continued

Configuration	Term	J	Level (cm^{-1})	g	Leading percentages
$4d^4(b\ ^3\mathrm{P})5p$	$^4\mathrm{D}^\circ$	1/2			
		3/2			
		5/2	*76 206.57*		
		7/2	*76 325.00*		
$4d^4(^1\mathrm{F})5p$	$u\ ^2\mathrm{D}^\circ$	3/2			
		5/2	*80 420.55*		
$4d^4(b\ ^3\mathrm{F})5p$	$u\ ^2\mathrm{G}^\circ$	7/2	*81 526.97*		
		9/2	*82 556.90*		
$4d^4(b\ ^1\mathrm{G})5p$	$t\ ^2\mathrm{G}^\circ$	9/2	*83 314.88*		
		7/2	*83 874.15*		
$4d^4(b\ ^1\mathrm{G})5p$	$v\ ^2\mathrm{H}^\circ$	9/2	*83 964.88*		
		11/2	*84 496.50*		
$4d^4(b\ ^1\mathrm{G})5p$	$s\ ^2\mathrm{F}^\circ$	7/2	*86 566.24*		
		5/2			
$4d^4(b\ ^3\mathrm{F})5p$	$t\ ^2\mathrm{D}^\circ$	5/2	*86 693.42*		
		3/2	*87 033.60*		
Mo III ($^5\mathrm{D}_0$)	***Limit***		130 300		

Mo III

$Z = 42$

Zr I isoelectronic sequence

Ground state $1s^22s^22p^63s^23p^63d^{10}4s^24p^64d^4\ {}^5D_0$

Ionization energy 218 800 ± 1000 cm^{-1} (27.13 ± 0.12 eV)

The early work on this spectrum was by Rico [1954, 1965] who reported levels of the $4d^4$, $4d^35s$, $4d^36s$, and $4d^35p$ configurations. New observations by Iglesias *et al.* [1988] with a wavelength uncertainty of ± 0.005 Å led to improved energy level values and to a significant extension of the analysis. The $4d^36s$ levels reported by Rico [1965] were not confirmed. The results of Iglesias *et al.* are quoted here, including their calculations of percentage compositions of the levels.

Catalán and Rico [1957] estimated the value for the ionization energy by a comparison of related third spectra.

References

Catalán, M. A., and Rico, F. R. [1957], An. R. Soc. Esp. Fis. Quim. Ser. A **53**, 83.

Iglesias, L., Cabeza, M. I., Rico, F., and Kaufman, V. [1988], Phys. Scr., to be published.

Rico, F. R. [1954], An. R. Soc. Esp. Fis. Quim. Ser. A **50**, 185.

Rico, F. R. [1965], An. R. Soc. Esp. Fis. Quim. Ser. A **61**, 103.

Mo III

Configuration	Term	J	Level (cm^{-1})	Leading percentages		
$4d^4$	^{5}D	0	0.00	98	1	^{3}P1
		1	242.04	99	1	
		2	668.24	99		
		3	1223.96	100		
		4	1872.31	99	1	^{3}F2
$4d^4$	^{3}P2	0	11 149.20	58	35	^{3}P1
		1	12 510.33	62	34	
		2	14 357.56	63	32	
$4d^4$	^{3}H	4	12 679.60	84	7	^{3}G
		5	13 275.51	93	6	^{3}G
		6	13 811.19	98	2	^{1}I
$4d^4$	^{3}F2	2	13 928.70	75	21	^{3}F1
		3	13 948.17	61	20	^{3}G
		4	14 296.10	63	14	^{3}F1
$4d^4$	^{3}G	3	15 871.20	79	17	^{3}F2
		4	16 282.76	81	10	^{3}F2
		5	16 714.38	93	6	^{3}H
$4d^4$	^{3}D	3	19 487.79	97	1	^{3}D2
		2	19 576.66	89	5	^{1}D2
$4d^4$	^{1}I	6	20 290.23	98	2	^{3}H
$4d^4$	^{1}G2	4	20 611.87	63	28	^{1}G1
$4d^4$	^{1}D2	2	22 806.16	69	17	^{1}D1
$4d^4$	^{1}S2	0	22 990.12	76	20	^{1}S1

Mo III — Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages			
$4d^4$	^{1}G1	4	36 164.03	64		27	^{1}G2
$4d^3(^4F)5s$	^{5}F	1	32 418.68	98			
		2	32 843.28	98			
		3	33 452.23	99			
		4	34 225.38	99			
		5	35 129.45	99		1	$(^2G)\ ^3G$
$4d^3(^4P)5s$	^{5}P	1	42 404.74	98		2	$(^2P)\ ^3P$
		2	42 521.83	58		36	$(^4F)\ ^3F$
		3	43 461.62	93		6	$(^4F)\ ^3F$
$4d^3(^4F)5s$	^{3}F	2	42 665.77	58		38	$(^4P)\ ^5P$
		3	43 561.76	87		6	$(^4P)\ ^5P$
		4	44 655.28	89		7	$(^2G)\ ^3G$
$4d^3(^2G)5s$	^{3}G	3	46 299.58	95		4	$(^4F)\ ^3F$
		4	46 601.58	85		7	$(^4F)\ ^3F$
		5	46 962.10	88		10	$(^2H)\ ^3H$
$4d^3(^2P)5s$	^{3}P	2	49 088.73	56		26	$(^2D2)\ ^3D$
$4d^3(^2H)5s$	^{3}H	4	49 541.67	85		9	$(^2G)\ ^1G$
		5	50 318.82	90		10	$(^2G)\ ^3G$
		6	50 481.62	100			
$4d^35s$		1	50 362.52	38	$(^2P)\ ^3P$	34	$(^2D2)\ ^3D$
$4d^3(^2D2)5s$	^{3}D	3	51 425.90	79		18	$(^2D1)\ ^3D$
		2	51 482.87	48		31	$(^2P)\ ^3P$
$4d^3(^2G)5s$	^{1}G	4	52 697.96	82		9	$(^2H)\ ^3H$
$4d^3(^4P)5s$	^{3}P	1	52 811.03	58		25	$(^2P)\ ^1P$
		0	53 407.46	91		4	$4d^4\ ^3P2$
		2	54 191.24	89		4	$(^2P)\ ^3P$
$4d^3(^2H)5s$	^{1}H	5	54 853.34	98		1	$(^2G)\ ^3G$
$4d^3(^2P)5s$	^{1}P	1	55 366.47	60		34	$(^4P)\ ^3P$
$4d^3(^2D2)5s$	^{1}D	2	56 741.86	68		18	$(^2D1)\ ^1D$
$4d^3(^2F)5s$	^{3}F	4	58 730.35	99			
		3	58 893.79	99			
$4d^3(^4F)5p$	^{5}G°	2	*73 853.18*	96		2	$(^4F)\ ^3F°$
		3	*74 724.77*	97		2	$(^4F)\ ^3F°$
		4	*75 816.51*	97		1	$(^4F)\ ^3G°$
		5	*77 113.31*	96		1	$(^4F)\ ^3G°$
		6	*78 689.38*	99		1	$(^2G)\ ^3H°$
$4d^3(^4F)5p$	^{3}D°	1	*75 972.36*	54		33	$(^4F)\ ^5F°$
		2	*76 836.82*	45		35	$(^4F)\ ^5F°$
		3	*80 354.46*	42		35	$(^4F)\ ^5D°$

Mo III — Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages			
$4d^3(^4\mathrm{F})5p$	$^5\mathrm{F}^\circ$	3	*78 158.36*	47		25	$(^4\mathrm{F})\ ^3\mathrm{D}^\circ$
		1	*78 677.94*	53		28	$(^4\mathrm{F})\ ^5\mathrm{D}^\circ$
		2	*79 013.98*	58		24	$(^4\mathrm{F})\ ^5\mathrm{D}^\circ$
		4	*79 497.10*	73		13	$(^4\mathrm{F})\ ^5\mathrm{D}^\circ$
		5	*80 343.19*	69		20	$(^4\mathrm{F})\ ^3\mathrm{G}^\circ$
$4d^3(^4\mathrm{F})5p$	$^5\mathrm{D}^\circ$	0	*78 568.39*	91		7	$(^4\mathrm{P})\ ^5\mathrm{D}^\circ$
		1	*78 947.76*	59		16	$(^4\mathrm{F})\ ^3\mathrm{D}^\circ$
		2	*79 467.93*	57		21	$(^4\mathrm{F})\ ^3\mathrm{D}^\circ$
		4	*80 095.55*	76		9	$(^4\mathrm{F})\ ^5\mathrm{F}^\circ$
$4d^35p$		3	*79 508.31*	42	$(^4\mathrm{F})\ ^5\mathrm{F}^\circ$	36	$(^4\mathrm{F})\ ^5\mathrm{D}^\circ$
$4d^3(^4\mathrm{F})5p$	$^3\mathrm{G}^\circ$	3	*81 040.69*	74		13	$(^2\mathrm{G})\ ^3\mathrm{G}^\circ$
		4	*82 009.93*	66		17	$(^4\mathrm{F})\ ^5\mathrm{F}^\circ$
		5	*83 147.76*	55		29	$(^4\mathrm{F})\ ^5\mathrm{F}^\circ$
$4d^3(^4\mathrm{F})5p$	$^3\mathrm{F}^\circ$	2	*82 540.09*	75		8	$(^2\mathrm{D}2)\ ^3\mathrm{F}^\circ$
		3	*83 584.49*	79		7	
		4	*84 544.49*	81		6	
$4d^3(^4\mathrm{P})5p$	$^5\mathrm{P}^\circ$	1	*85 308.94*	78		6	$(^2\mathrm{P})\ ^3\mathrm{P}^\circ$
		2	*86 426.76*	82		10	$(^4\mathrm{P})\ ^5\mathrm{D}^\circ$
		3	*87 391.73*	93		3	$(^4\mathrm{P})\ ^5\mathrm{D}^\circ$
$4d^3(^4\mathrm{P})5p$	$^3\mathrm{P}^\circ$	2	*85 330.02*	44		19	$(^4\mathrm{P})\ ^5\mathrm{D}^\circ$
		1	*87 831.27*	49		19	
$4d^3(^4\mathrm{P})5p$	$^5\mathrm{D}^\circ$	1	*85 683.20*	50		29	$(^4\mathrm{P})\ ^3\mathrm{P}^\circ$
		2	*87 473.40*	55		17	$(^4\mathrm{P})\ ^3\mathrm{P}^\circ$
		3	*87 810.62*	80		7	$(^4\mathrm{F})\ ^5\mathrm{D}^\circ$
		4	*89 100.21*	48		17	$(^2\mathrm{G})\ ^1\mathrm{G}^\circ$
$4d^3(^2\mathrm{G})5p$	$^3\mathrm{H}^\circ$	4	*85 896.16*	73		20	$(^2\mathrm{H})\ ^3\mathrm{H}^\circ$
		5	*86 892.69*	61		23	
		6	*88 441.64*	65		28	
$4d^35p$		3	*88 499.21*	37	$(^2\mathrm{G})\ ^3\mathrm{G}^\circ$	23	$(^2\mathrm{G})\ ^1\mathrm{F}^\circ$
$4d^35p$		2	*88 592.04*	21	$(^2\mathrm{P})\ ^1\mathrm{D}^\circ$	15	$(^2\mathrm{D}2)\ ^3\mathrm{F}^\circ$
$4d^35p$		4	*89 503.85*	45	$(^4\mathrm{P})\ ^5\mathrm{D}^\circ$	19	$(^2\mathrm{G})\ ^1\mathrm{G}^\circ$
$4d^3(^2\mathrm{G})5p$	$^1\mathrm{H}^\circ$	5	*89 689.96*	41		25	$(^2\mathrm{H})\ ^1\mathrm{H}^\circ$
$4d^3(^2\mathrm{G})5p$	$^3\mathrm{G}^\circ$	4	*90 255.09*	67		15	$(^2\mathrm{G})\ ^1\mathrm{G}^\circ$
		3	*90 588.48*	41		21	$(^2\mathrm{G})\ ^3\mathrm{F}^\circ$
		5	*91 006.93*	57		12	$(^2\mathrm{H})\ ^3\mathrm{I}^\circ$
$4d^35p$		2	*90 586.06*	25	$(^2\mathrm{G})\ ^3\mathrm{F}^\circ$	19	$(^2\mathrm{P})\ ^3\mathrm{P}^\circ$
$4d^35p$		2	*90 982.62*	23	$(^2\mathrm{P})\ ^3\mathrm{P}^\circ$	12	$(^2\mathrm{G})\ ^3\mathrm{F}^\circ$
$4d^3(^2\mathrm{G})5p$	$^1\mathrm{F}^\circ$	3	*91 050.26*	29		14	$(^2\mathrm{D}2)\ ^1\mathrm{F}^\circ$
$4d^35p$		4	*91 387.50*	39	$(^2\mathrm{G})\ ^3\mathrm{F}^\circ$	36	$(^2\mathrm{H})\ ^3\mathrm{H}^\circ$
$4d^3(^2\mathrm{P})5p$	$^3\mathrm{D}^\circ$	2	*91 674.52*	63		13	$(^2\mathrm{G})\ ^3\mathrm{F}^\circ$

Mo III — Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages			
$4d^3(^4P)5p$	$^5S^\circ$	2	*92 099.59*	79		6	$(^4P)\ ^3P^\circ$
$4d^3(^2H)5p$	$^3H^\circ$	5	*92 254.60*	53		22	$(^2G)\ ^3H^\circ$
		6	*92 728.91*	58		29	
$4d^3(^2H)5p$	$^3I^\circ$	5	*92 884.18*	54		18	$(^2G)\ ^1H^\circ$
		6	*93 306.10*	89		9	$(^2H)\ ^3H^\circ$
		7	*94 423.96*	100			
$4d^3(^2G)5p$	$^1G^\circ$	4	*93 102.01*	45		20	$(^2H)\ ^3H^\circ$
$4d^3(^2D2)5p$	$^3F^\circ$	4	*94 098.26*	41		26	$(^2H)\ ^1G^\circ$
$4d^35p$		3	*94 117.62*	23	$(^2D2)\ ^3F^\circ$	21	$(^2D2)\ ^3D^\circ$
$4d^3(^4P)5p$	$^3D^\circ$	2	*94 387.65*	31		29	$(^2D2)\ ^3D^\circ$
		3	*94 676.78*	40		26	$(^2D2)\ ^3D^\circ$
		1	*95 016.35*	72		7	$(^2P)\ ^3D^\circ$
$4d^3(^4P)5p$	$^3D^\circ$	3	*95 856.29*	28		22	$(^2D2)\ ^3D^\circ$
$4d^3(^2H)5p$	$^1H^\circ$	5	*96 285.38*	45		26	$(^2H)\ ^3G^\circ$
$4d^35p$		3	*96 838.34*	32	$(^2H)\ ^3G^\circ$	20	$(^2D2)\ ^1F^\circ$
$4d^3(^2H)5p$	$^1I^\circ$	6	*96 907.94*	90		4	$(^2H)\ ^3H^\circ$
$4d^3(^2H)5p$	$^3G^\circ$	5	*97 709.08*	56		22	$(^2H)\ ^1H^\circ$
Mo IV ($^4F_{3/2}$)	*Limit*		218 800				

Mo IV

$Z=42$

Y I isoelectronic sequence

Ground state $1s^22s^22p^63s^23p^63d^{10}4s^24p^64d^3\ ^4F_{3/2}$

Ionization energy 374 000 ± 2000 cm^{-1} (46.4 ± 0.2 eV)

An early analysis of this spectrum was carried out by Eliason [1933] who found the $4d^3\ ^4$F ground term, the lowest term of $4d^25s$, and three quartet terms of $4d^25p$.

New observations led to a great extension of the level structure by Fernandez *et al.* [1987]. They report all the levels of the $4d^3$ and $4d^25s$ configurations, and 45 levels of $4d^55p$. They also calculated the percentage composition of these levels. Their range of observations was 600–3200 Å, and about 500 lines were classified. The wavelength uncertainty was estimated to be ±0.005 Å.

The value for the ionization energy was obtained by Eliason by extrapolation along the isoelectronic sequence.

References

Eliason, A. Y. [1933], Phys. Rev. **43**, 745.

Fernandez, M. T., Cabeza, I., Iglesias, L., Garcia-Riquelme, O., Rico, F. R., and Kaufman, V. [1987], Phys. Scr. **35**, 819.

Mo IV

Configuration	Term	J	Level (cm^{-1})	Leading percentages		
$4d^3$	^{4}F	3/2	0.00	99		
		5/2	778.02	100		
		7/2	1 759.76	100		
		9/2	2 864.58	98		
$4d^3$	^{4}P	3/2	10 330.59	83	14	^{2}P
		1/2	10 337.77	93		
		5/2	11 611.99	99		
$4d^3$	^{2}G	7/2	11 580.50	99		
		9/2	12 310.80	83	15	^{2}H
$4d^3$	^{2}P	3/2	14 175.62	45	31	^{2}D2
		1/2	14 347.72	93		
$4d^3$	^{2}H	9/2	15 995.13	85	15	^{2}G
		11/2	16 357.48	100		
$4d^3$	^{2}D2	5/2	16 809.32	81	17	^{2}D1
		3/2	17 107.35	43	41	^{2}P
$4d^3$	^{2}F	7/2	24 787.03	99		
		5/2	25 100.40	99		
$4d^3$	^{2}D1	5/2	38 922.29	81	18	^{2}D2
		3/2	39 230.53	77	23	^{2}D2
$4d^2(^3$F$)5s$	^{4}F	3/2	60 896.28	99		
		5/2	61 626.19	98		
		7/2	62 708.50	99		
		9/2	64 046.46	100		
$4d^2(^3$F$)5s$	^{2}F	5/2	69 178.07	94		
		7/2	71 358.31	98		

Mo IV — Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages			
$4d^2(^3P)5s$	^4P	1/2	71 750.36	100			
		3/2	72 162.82	93			
		5/2	72 236.20	70		27	$(^1D)\ ^2D$
$4d^2(^1D)5s$	^2D	3/2	74 008.77	89		7	$(^3P)\ ^4P$
		5/2	74 981.08	68		29	$(^3P)\ ^4P$
$4d^2(^1G)5s$	^2G	9/2	79 106.26	100			
		7/2	79 193.56	99			
$4d^2(^3P)5s$	^2P	1/2	79 898.80	99			
		3/2	81 052.21	96			
$4d^2(^1S)5s$	^2S	1/2	99 783.80	99			
$4d^2(^3F)5p$	$^4G^\circ$	5/2	*109 415.25*	82		12	$(^3F)\ ^2F^\circ$
		7/2	*111 339.53*	90			
		9/2	*113 443.02*	92			
		11/2	*115 881.12*	100			
$4d^2(^3F)5p$	$^4F^\circ$	3/2	*111 760.03*	75		19	$(^3F)\ ^2D^\circ$
		5/2	*112 925.24*	73		12	$(^3F)\ ^2D^\circ$
		7/2	*114 624.49*	90			
		9/2	*115 961.91*	82		8	$(^3F)\ ^4G^\circ$
$4d^2(^3F)5p$	$^2F^\circ$	5/2	*113 984.98*	41		19	$(^3F)\ ^4F^\circ$
		7/2	*115 762.16*	61		25	$(^3F)\ ^4D^\circ$
$4d^2(^3F)5p$	$^2D^\circ$	3/2	*114 708.24*	42		23	$(^3F)\ ^4F^\circ$
		5/2	*117 604.08*	32		26	$(^3F)\ ^4D^\circ$
$4d^2(^3F)5p$	$^4D^\circ$	1/2	*115 789.36*	79		17	$(^3P)\ ^4D^\circ$
		5/2	*116 583.82*	47		19	$(^3F)\ ^2F^\circ$
		3/2	*116 586.00*	60		17	$(^3P)\ ^4D^\circ$
		7/2	*118 080.17*	55		19	$(^3F)\ ^2F^\circ$
$4d^2(^3P)5p$	$^2S^\circ$	1/2	*117 922.63*	92			
$4d^2(^3F)5p$	$^2G^\circ$	7/2	*119 002.33*	78		12	$(^1G)\ ^2G^\circ$
		9/2	*120 645.02*	73		14	$(^1G)\ ^2G^\circ$
$4d^2(^3P)5p$	$^4S^\circ$	3/2	*120 823.46*	65		25	$(^1D)\ ^2P^\circ$
$4d^2(^3P)5p$	$^4D^\circ$	1/2	*122 419.26*	80		18	$(^3F)\ ^4D^\circ$
		3/2	*123 432.84*	49		27	$(^1D)\ ^2P^\circ$
		5/2	*124 789.75*	69		15	$(^1D)\ ^2F^\circ$
		7/2	*126 416.33*	54		31	$(^1G)\ ^2G^\circ$
$4d^25p$		3/2	*122 808.84*	31	$(^3P)\ ^4D^\circ$	19	$(^1D)\ ^2P^\circ$
$4d^2(^1D)5p$	$^2F^\circ$	5/2	*123 534.18*	61		13	$(^3F)\ ^2F^\circ$
		7/2	*124 947.54*	45		18	$(^1G)\ ^2G^\circ$
$4d^2(^1D)5p$	$^2P^\circ$	1/2	*124 741.62*	79		16	$(^3P)\ ^4P^\circ$
$4d^2(^1D)5p$	$^2D^\circ$	3/2	*126 243.19*	40		21	$(^3P)\ ^4P^\circ$
		5/2	*126 716.64*	46		35	$(^3P)\ ^4P^\circ$

Mo IV — Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages			
$4d^2(^3P)5p$	$^4P^\circ$	1/2	*126 760.46*	79		13	$(^1D)\ ^2P^\circ$
		3/2	*127 181.20*	75		19	$(^1D)\ ^2D^\circ$
		5/2	*128 897.78*	59		38	$(^1D)\ ^2D^\circ$
$4d^2(^1G)5p$	$^2G^\circ$	9/2	*126 999.09*	71		18	$(^3F)\ ^2G^\circ$
$4d^25p$		7/2	*127 728.82*	35	$(^1G)\ ^2G^\circ$	33	$(^1D)\ ^2F^\circ$
$4d^2(^1G)5p$	$^2H^\circ$	9/2	*130 149.35*	87		13	$(^1G)\ ^2G^\circ$
		11/2	*132 012.37*	100			
$4d^2(^3P)5p$	$^2D^\circ$	3/2	*131 699.83*	62		17	$(^3P)\ ^2P^\circ$
		5/2	*132 219.07*	72		19	$(^3F)\ ^2D^\circ$
$4d^2(^3P)5p$	$^2P^\circ$	1/2	*133 362.00*	94			
		3/2	*134 242.50*	77		11	$(^3P)\ ^2D^\circ$
$4d^2(^1G)5p$	$^2F^\circ$	7/2	*134 951.06*	91			
		5/2	*136 324.44*	95			
$4d^2(^1S)5p$	$^2P^\circ$	1/2	*150 069.22*	94			
		3/2	*152 757.31*	97			
Mo V ($^3F_2$)	***Limit***		374 000				

Mo v

$Z=42$

Sr i isoelectronic sequence

Ground state $1s^22s^22p^63s^23p^63d^{10}4s^24p^64d^2\ {}^3\mathrm{F}_2$

Ionization energy 439 450 ± 200 cm^{-1} (54.49 ± 0.02 eV)

The analysis of this spectrum was first undertaken by Trawick [1935] who classified 90 lines in the range of 410–2159 Å. He reported 36 levels of the configurations $4d^2$, $4d5s$, $4d5p$, $4d5d$ and $4d4f$. With a new set of observations in the range of 319–2384 Å measured with an accuracy of ±0.015 Å, Tauheed, Chaghtai, and Rahimullah [1985] increased the number of classified lines to 535 and reported 141 levels, including 11 additional configurations.

Independently Cabeza, Meijer, and Iglesias [1986] observed the spectrum from 250–6000 Å and reported wavelengths with an estimated uncertainty of ±0.005 Å. They made a new extension of the analysis of Trawick and compared their results with those of Tauheed *et al.*

Cabeza *et al.* found that the singlets reported by Trawick were erroneous. Their analysis agrees for the most part with that of Tauheed *et al.* for the configurations they have so far analyzed, including all levels through $4d6p\ {}^1\mathrm{P}^\circ$ at 285 619 cm^{-1}. Below this energy they found that 15 levels of Tauheed *et al.* were incorrect. Levels above this energy, they assert, are derived from lines of which many belong to other ionization stages.

All the level values reported here are from Cabeza *et al.* The $4d4f\ {}^3\mathrm{H}^\circ_6$ level given in brackets is the calculated value. Eigenvectors were derived from a parametric analysis including extensive configuration interaction in each parity. The leading percentages are taken from this work.

Cabeza *et al.* derived the value for the ionization energy from $4dns$ and $4pnd$ series with estimated change of quantum defect between $5s$–$6s$ and $5d$–$6d$.

References

Cabeza, M. I., Meijer, F. G., and Iglesias, L. [1986], Phys. Scr. **34**, 223.

Tauheed, A., Chaghtai, M. S. Z., and Rahimullah, K. [1985], Phys. Scr. **31**, 369.

Trawick, M. W. [1935], Phys. Rev. **34**, 223.

Mo v

Configuration	Term	J	Level (cm^{-1})	Leading percentages		
$4d^2$	^{3}F	2	0.00	98		
		3	1577.87	100		
		4	3357.34	99		
$4d^2$	^{1}D	2	10 190.29	77	21	^{3}P
$4d^2$	^{3}P	0	11 161.49	99		
		1	11 806.85	100		
		2	13 408.20	79	21	^{1}D
$4d^2$	^{1}G	4	16 353.91	99		
$4d^2$	^{1}S	0	37 738.34	99		
$4d5s$	^{3}D	1	92 381.00	100		
		2	93 111.92	96		
		3	94 835.84	100		
$4d5s$	^{1}D	2	99 381.13	95		
$4d5p$	^{1}D°	2	*146 976.93*	54	41	^{3}F°
$4d5p$	^{3}D°	1	*148 949.24*	94		
		2	*150 346.35*	60	22	^{1}D°
		3	*153 040.28*	61	36	^{3}F°

Mo v — Continued

Configuration	Term	*J*	Level (cm^{-1})	Leading percentages		
4*d*5*p*	^{3}F°	3	*151 195.74*	63	34	^{3}D°
		2	*151 213.95*	46	35	
		4	*155 032.90*	100		
4*d*5*p*	^{3}P°	1	*156 617.07*	85	11	^{1}P°
		0	*157 059.70*	100		
		2	*157 852.16*	93	5	^{1}D°
4*d*5*p*	^{1}F°	3	*159 857.34*	96		
4*d*5*p*	^{1}P°	1	*162 257.70*	84	13	^{3}P°
4*d*5*d*	^{1}F	3	232 561.5	78	12	^{3}G
4*d*5*d*	^{3}D	1	233 190.7	82	18	^{1}P
		2	234 253.2	98		
		3	235 635.8	80	15	^{1}F
4*d*5*d*	^{3}G	3	234 491.3	82	10	^{3}D
		4	235 496.4	98		
		5	237 205.0	100		
4*d*5*d*	^{1}P	1	236 002.8	74	17	^{3}D
4*d*4*f*	^{1}G°	4	*237 483.3*	85	9	^{3}H°
4*d*5*d*	^{3}F	2	237 760.0	93	5	^{1}D
		3	239 069.3	96		
		4	240 110.1	97		
4*d*5*d*	^{3}S	1	239 189.6	88	8	^{1}P
4*d*4*f*	^{3}F°	2	*239 393.5*	86	14	^{1}D°
		3	*240 004.7*	96		
		4	*240 878.7*	89	8	^{1}G°
4*d*4*f*	^{3}H°	4	*239 950.4*	88	6	^{1}G°
		5	*240 726.6*	98		
		6	[*241 300*]	100		
4*d*4*f*	^{1}D°	2	*241 752.0*	85	13	^{3}F°
4*d*5*d*	^{1}D	2	241 965.9	71	24	^{3}P
4*d*5*d*	^{3}P	0	242 162.7	97		
		1	242 972.3	96		
		2	243 955.1	76	24	^{1}D
4*d*4*f*	^{3}G°	3	*243 408.6*	96		
		4	*244 627.7*	95		
		5	*245 601.3*	99		
4*d*5*d*	^{1}G	4	244 170.6	97		
5*s*5*p*	^{3}P°	0	*246 619.0*	78	22	4*d*4*f* ^{3}P°
		1	*246 800.0*	47	29	
		2	*254 210.0*	66	33	

Mo V — Continued

Configuration	Term	*J*	Level (cm^{-1})	Leading percentages			
4*d*4*f*	^{3}D°	2	*247 091.5*	66		25	^{3}P°
		3	*247 688.3*	93		5	^{1}F°
		1	*247 933.0*	74		21	5*s*5*p* ^{3}P°
4*d*4*f*	^{3}P°	2	*248 745.0*	41		32	^{3}D°
		0	*252 464.3*	78		22	5*s*5*p* ^{3}P°
		1	*252 649.0*	64		28	5*s*5*p* ^{3}P°
4*d*4*f*	^{1}F°	3	*250 992.0*	93		5	^{3}D°
4*d*5*d*	^{1}S	0	251 093.7?	97			
4*d*6*s*	^{3}D	1	254 126.2	100			
		2	254 465.3	77		23	^{1}D
		3	256 676.6	100			
4*d*4*f*	^{1}P°	1	*255 941.0*	74		19	5*s*5*p* ^{1}P°
4*d*6*s*	^{1}D	2	257 443.3	77		23	^{3}D
4*d*4*f*	^{1}H°	5	*259 256.7*	100			
5*s*5*p*	^{1}P°	1	*273 199.0*	68		16	4*d*4*f* ^{1}P°
4*d*6*p*	^{1}D°	2	*276 471.0*	51		28	^{3}F°
4*d*6*p*	^{3}D°	1	*277 188.7*	97			
		2	*278 005.6*	57		43	^{3}F°
		3	*278 999.7*	56		34	^{3}F°
4*d*6*p*		2	*279 061.0*	43	^{1}D°	30	^{3}F°
4*d*6*p*	^{3}F°	3	*279 478.6*	63		37	^{3}D°
		4	*281 268.7*	100			
4*d*6*p*	^{3}P°	0	*280 451.5*	100			
		1	*280 506.5*	92		5	^{1}P°
		2	*282 057.8*	94		6	^{1}D°
4*d*6*p*	^{1}F°	3	*281 996.8*	89		7	^{3}D°
4*d*6*p*	^{1}P°	1	*285 619.0*	80		7	^{3}P°
....	....	....	....				
Mo VI (^{2}D$_{3/2}$)	*Limit*		439 450				

Mo VI

$Z=42$

Rb I isoelectronic sequence

Ground state $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 4d$ $^2D_{3/2}$

Ionization energy 555 132 ± 2 cm^{-1} (68.8276 ± 0.0002 eV)

The earliest work on this spectrum was carried out by Trawick [1934] who reported the six lowest doublets. Later Charles [1950] corrected the $4f$ ^{2}F term and added the $6p$ ^{2}P°. Long wavelength observations in the range of 2193–6336 Å by Romanov and Striganov [1969] permitted them to locate the $6p$, $6d$, $7p$ and $7d$ terms and transitions among ng, nh and ni terms which they were unable to join to the rest of the level system. The $6p$ term of Charles proved to be incorrect.

New observations of the spectrum from 232–2540 Å were reported by Edlén, Rahimullah, Tauheed, and Chaghtai [1985]. With these data they were able to unite the high angular momentum doublet terms with the rest of the system and to add $7s$, $8s$, $8p$, $8d$, $8g$, $8k$, $9k$, and a tentative $9i$. They note that the nf series is greatly perturbed by the $4s^2 4p^5 4d^2$ configuration, according to a calculation by Cowan. The uncertainty in these level values is ±4 cm^{-1}. Edlén *et al.* derived a value for the ionization energy from the $6h$, $7i$, and $8k$ terms by means of a polarization formula. They found that the ng series behaves anomalously and attributed this to interaction with the $4s4p^6 4d^2$ configuration.

An analysis of the $4p^6 4d - 4p^5 4d^2$ array in the range of 238–1476 Å was given by Tauheed, Rahimullah, and Chaghtai [1985]. Subsequently Kancerevicius, Ramonas, and Ryabtsev [1987], on the basis of new observations in the range of 190–350 Å, rejected the levels of $4p^5 4d^2$ and gave the new ones quoted here. They also found the levels of the $4p^5 4d5s$ configuration as well as the Rydberg series terms $4p^6 6f - 9f$ and $4p^6 8p - 11p$. Their wavelength uncertainty is ±0.005 Å.

Mushtaq, Chaghtai, and Rahimullah [1979] analyzed the $4p^6 4d - 4p^5 4d5s$ array in the isoelectronic sequence Y III, Zr IV, Nb V, and Mo VI. In a later analysis of Zr IV, Acquista and Reader [1980] pointed out that most of the $4p^5 4d5s$ levels of Zr IV by Mushtaq *et al.* are above the ionization limit and the lines are due mostly to Zr VII. We have therefore not compiled these authors' results for Mo VI.

References

Acquista, N., and Reader, J. [1980], J. Opt. Soc. Am. **70,** 789.

Charles, G. W. [1950], Phys. Rev. **77,** 120.

Edlén, B., Rahimullah, K., Tauheed, A., and Chaghtai, M. S. Z. [1985] Phys. Scr. **32,** 215.

Kancerevicius, A., Ramonas, A. A., and Ryabtsev, A. N. [1987], private communication.

Mushtaq, A., Chaghtai, M. S. Z., and Rahimullah, K. [1979], J. Phys. B **12,** 19.

Romanov, N. P., and Striganov, A. R. [1969], Opt. Spectrosc. (USSR), **27,** 8.

Tauheed, A., Rahimullah, K., and Chaghtai, M. S. Z. [1985], Phys. Rev. A **32,** 237.

Trawick, M. W. [1934], Phys. Rev. **46,** 63.

Mo VI

Configuration	Term	J	Level (cm^{-1})	Leading percentages
$4p^6(^1S)4d$	^{2}D	3/2	0.0	
		5/2	2 584.3	
$4p^6(^1S)5s$	^{2}S	1/2	119 727.3	
$4p^6(^1S)5p$	^{2}P°	1/2	*182 405.5*	
		3/2	*187 332.8*	
$4p^6(^1S)4f$	^{2}F°	5/2	*267 048.8*	
		7/2	*267 458.4*	
$4p^6(^1S)5d$	^{2}D	3/2	282 827.1	
		5/2	283 612.5	
$4p^6(^1S)6s$	^{2}S	1/2	313 809.1	
$4p^5(^2P°)4d^2$		5/2	*315 151*	34 $(^2P°)(^3F)$ ^{4}F° 21 $(^2P°)(^1G)$ ^{2}F°

Mo VI — Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages			
$4p^5(^2P^\circ)4d^2$		7/2	*316 472*	25	$(^2P^\circ)(^1D)\ ^2F^\circ$	19	$(^2P^\circ)(^3F)\ ^2F^\circ$
$4p^5(^2P^\circ)4d^2(^1D)$	$^2F^\circ$	7/2	*320 084*	64		10	$(^2P^\circ)(^3P)\ ^4D^\circ$
		5/2	*337 067*	81			
$4p^5(^2P^\circ)4d^2(^3P)$	$^4D^\circ$	5/2	*329 869*	45		23	$(^2P^\circ)(^3F)\ ^4D^\circ$
		7/2	*331 203*	42		37	$(^2P^\circ)(^3F)\ ^4D^\circ$
		3/2	*331 690*	53		24	$(^2P^\circ)(^3P)\ ^2D^\circ$
$4p^6(^1S)6p$	$^2P^\circ$	1/2	*340 572.9*				
		3/2	*342 564.6*				
$4p^6(^1S)5f$	$^2F^\circ$	5/2	*365 106.6*				
		7/2	*368 206.3*				
$4p^6(^1S)6d$	^2D	3/2	386 167.3				
		5/2	386 553.8				
$4p^6(^1S)5g$	^2G	7/2	395 184.6				
		9/2	395 186.7				
$4p^5(^2P^\circ)4d^2(^3F)$	$^2F^\circ$	5/2	*394 060*	52		48	$(^2P^\circ)(^1G)\ ^2F^\circ$
$4p^5(^2P^\circ)4d^2(^1G)$	$^2F^\circ$	7/2	*398 948*	55		44	$(^2P^\circ)(^3F)\ ^2F^\circ$
$4p^6(^1S)7s$	^2S	1/2	400 769.5				
$4p^5(^2P^\circ)4d^2(^3P)$	$^2P^\circ$	1/2	*403 129*	66		23	$(^2P^\circ)(^1S)\ ^2P^\circ$
		3/2	*407 909*	74		17	$(^2P^\circ)(^1D)\ ^2P^\circ$
$4p^5(^2P^\circ)4d^2(^3F)$	$^2D^\circ$	5/2	*412 803*	70		18	$(^2P^\circ)(^1D)\ ^2D^\circ$
		3/2	*413 282*	72		18	
$4p^6(^1S)7p$	$^2P^\circ$	1/2	*414 855.4*				
		3/2	*416 070.2*				
$4p^5(^2P^\circ)4d(^3P)5s$	$^4P^\circ$	1/2	*417 692*	96			
		3/2	*420 670*	92			
		5/2	*426 490*	88			
$4p^5(^2P^\circ)4d(^3P)5s$	$^2P^\circ$	1/2	*427 000*	94			
		3/2	*433 174*	81			
$4p^5(^2P^\circ)4d(^3F)5s$	$^4F^\circ$	7/2	*431 553*	86			
		5/2	*434 199*	72		9	$(^2P^\circ)(^3F)\ ^2F^\circ$
		3/2	*437 885*	67		20	$(^2P^\circ)(^1D)\ ^2D^\circ$
$4p^6(^1S)6f$	$^2F^\circ$	5/2	*436 174*				
		7/2	*436 541*				
$4p^5(^2P^\circ)4d(^3F)5s$	$^2F^\circ$	7/2	*437 970*	88			
		5/2	*441 558*	52		21	$(^2P^\circ)(^1D)\ ^2D^\circ$
$4p^6(^1S)7d$	^2D	3/2	439 466.6				
		5/2	439 692.8				
$4p^6(^1S)6g$	^2G	7/2	443 941.0				
		9/2	443 943.7				

Mo VI — Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages			
$4p^6(^1S)6h$	$^2H^\circ$		*445 107.3*				
$4p^6(^1S)8s$	^2S	1/2	447 738.6				
$4p^5(^2P^\circ)4d(^3D)5s$	$^4D^\circ$	7/2	*448 050*	67		30	$(^2P^\circ)(^1F)\ ^2F^\circ$
		1/2	*454 863*	94			
		3/2	*455 807*	66		18	$(^2P^\circ)(^3F)\ ^4F^\circ$
$4p^5(^2P^\circ)4d(^3D)5s$	$^2D^\circ$	5/2	*451 835*	42		29	$(^2P^\circ)(^1F)\ ^2F^\circ$
		3/2	*466 399*	59		23	$(^2P^\circ)(^1D)\ ^2D^\circ$
$4p^6(^1S)8p$	$^2P^\circ$	1/2	*456 491*				
		3/2	*456 712*				
$4p^5(^2P^\circ)4d(^1D)5s$	$^2D^\circ$	3/2	*458 214*	45		28	$(^2P^\circ)(^3D)\ ^2D^\circ$
		5/2	*462 574*	45		30	$(^2P^\circ)(^3D)\ ^4D^\circ$
$4p^5(^2P^\circ)4d5s$		5/2	*458 943*	28	$(^2P^\circ)(^1D)\ ^2D^\circ$	19	$(^2P^\circ)(^3D)\ ^4D^\circ$
$4p^5(^2P^\circ)4d(^1F)5s$	$^2F^\circ$	7/2	*466 405*	62		21	$(^2P^\circ)(^3D)\ ^4D^\circ$
		5/2	*469 446*	45		35	$(^2P^\circ)(^3D)\ ^2D^\circ$
$4p^6(^1S)7f$	$^2F^\circ$	5/2	*467 823*				
		7/2	*467 934*				
$4p^6(^1S)8d$	^2D	3/2	470 850.0				
		5/2	470 991.4				
$4p^6(^1S)7g$	^2G	7/2	473 424.6				
		9/2	473 427.7				
$4p^6(^1S)7h$	$^2H^\circ$		*474 299.7*				
$4p^6(^1S)7i$	^2H		474 436.4				
$4p^6(^1S)9p$	$^2P^\circ$	1/2	*481 363*				
		3/2	*481 765*				
$4p^6(^1S)8f$	$^2F^\circ$	5/2	*488 710*				
		7/2	*488 750*				
$4p^6(^1S)8g$	^2G	7/2	492 545				
		9/2	492 548				
$4p^6(^1S)8h$	$^2H^\circ$		*493 249.5*				
$4p^6(^1S)8i$	^2I		493 351.3				
$4p^6(^1S)8k$	$^2K^\circ$		*493 381.8*				
$4p^6(^1S)10p$	$^2P^\circ$	1/2	*498 024*				
		3/2	*498 293*				
$4p^6(^1S)9f$	$^2F^\circ$	5/2	*502 976*				
		7/2	*502 996*				
$4p^6(^1S)9i$	^2I		506 316.7?				

Mo VI — Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages
$4p^6(^1S)9k$	$^2K°$		*506 342.2*	
$4p^6(^1S)11p$	$^2P°$	$1/2$	*509 597*	
		$3/2$	*509 779*	
Mo VII ($^1S_0$)	***Limit***		555 132	

Mo VII

$Z=42$

Kr I isoelectronic sequence

Ground state $1s^{2}2s^{2}2p^{6}3s^{2}3p^{6}3d^{10}4s^{2}4p^{6}$ $^{1}\mathrm{S}_{0}$

Ionization energy 1 013 550 ± 150 cm^{-1} (125.66 ± 0.02 eV)

Charles [1950] proposed classifications of $4p^{5}4d$, $5s$, and $5d$ transitions to the ground state, but only the two $5s$ lines have been confirmed in an extensive isoelectronic study of resonance lines by Reader, Epstein, and Ekberg [1972]. The identification of the two lines from $4p^{5}4d$ $^{3}\mathrm{P}^{\circ}_{1}$ and $^{3}\mathrm{D}^{\circ}_{1}$ by Chaghtai [1970] were also confirmed by their observations, which include resonance lines from $4p^{5}ns$ ($n=5-10$), $4p^{5}nd$ ($n=4-6$), and the $^{3}\mathrm{P}_{1}$ and $^{1}\mathrm{P}_{1}$ levels of $4s4p^{6}5p$. Their wavelength uncertainty is ±0.002 Å.

The analysis was extended to other J-values by Tauheed and Chaghtai [1984] using new observations from 400–2540 Å with an accuracy of ±0.015 Å. Their results have been questioned by Feldman and Reader [1988] who have begun a new analysis of this spectrum. We omit the levels of Tauheed and Chaghtai [1984] pending the outcome of the new analysis.

Reader *et al.* derived the value for the ionization energy from the $4p^{5}ns$ series.

References

Chaghtai, M. S. Z. [1970], Phys. Scr. **1**, 31.

Charles, G. W. [1950], Phys. Rev. **77**, 120.

Feldman, U., and Reader, J. [1988], private communication.

Reader, J., Epstein, G. L., and Ekberg, J. O. [1972], J. Opt. Soc. Am. **62**, 273.

Tauheed, A., and Chaghtai, M. S. Z. [1984], J. Phys. B **17**, 179.

Mo VII

Configuration	Term	J	Level (cm^{-1})	Leading percentages
$4p^{6}$	$^{1}\mathrm{S}$	0	0	
$4p^{5}4d$	$^{3}\mathrm{P}^{\circ}$	1	*305 563*	
$4p^{5}4d$	$^{3}\mathrm{D}^{\circ}$	1	*341 711*	
$4p^{5}4d$	$^{1}\mathrm{P}^{\circ}$	1	*417 538*	
$4p^{5}(^{2}\mathrm{P}^{\circ}_{3/2})5s$	$(^{3}/_{2},^{1}/_{2})^{\circ}$	1	*481 294*	
$4p^{5}(^{2}\mathrm{P}^{\circ}_{1/2})5s$	$(^{1}/_{2},^{1}/_{2})^{\circ}$	1	*502 930*	
$4p^{5}5d$	$^{3}\mathrm{P}^{\circ}$	1	*658 992*	
$4p^{5}5d$	$^{3}\mathrm{D}^{\circ}$	1	*669 066*	
$4p^{5}5d$	$^{1}\mathrm{P}^{\circ}$	1	*689 779*	
$4p^{5}(^{2}\mathrm{P}^{\circ}_{3/2})6s$	$(^{3}/_{2},^{1}/_{2})^{\circ}$	1	*710 061*	
$4p^{5}(^{2}\mathrm{P}^{\circ}_{1/2})6s$	$(^{1}/_{2},^{1}/_{2})^{\circ}$	1	*732 563*	
$4s4p^{6}5p$	$^{3}\mathrm{P}^{\circ}$	1	*780 390*	
$4s4p^{6}5p$	$^{1}\mathrm{P}^{\circ}$	1	*789 696*	
$4p^{5}6d$	$^{3}\mathrm{D}^{\circ}$	1	*795 520*	
$4p^{5}(^{2}\mathrm{P}^{\circ}_{3/2})7s$	$(^{3}/_{2},^{1}/_{2})^{\circ}$	1	*816 413*	
$4p^{5}(^{2}\mathrm{P}^{\circ}_{1/2})7s$	$(^{1}/_{2},^{1}/_{2})^{\circ}$	1	*839 342*	
$4p^{5}(^{2}\mathrm{P}^{\circ}_{3/2})8s$	$(^{3}/_{2},^{1}/_{2})^{\circ}$	1	*874* 998	
$4p^{5}(^{2}\mathrm{P}^{\circ}_{1/2})8s$	$(^{1}/_{2},^{1}/_{2})^{\circ}$	1	*898 093*	
$4p^{5}(^{2}\mathrm{P}^{\circ}_{3/2})9s$	$(^{3}/_{2},^{1}/_{2})^{\circ}$	1	*910 830*	
$4p^{5}(^{2}\mathrm{P}^{\circ}_{3/2})10s$	$(^{3}/_{2},^{1}/_{2})^{\circ}$	1	*934 536*	
Mo VIII ($^{2}\mathrm{P}^{\circ}_{3/2}$)	***Limit***		***1 013 550***	

Mo VIII

$Z=42$

Br I isoelectronic sequence

Ground state $1s^22s^22p^63s^23p^63d^{10}4s^24p^5\ ^2P^\circ_{3/2}$

Ionization energy 1 157 900 ± 8000 cm^{-1} (143.56 ± 1.00 eV)

Early work on this spectrum was reported by Charles [1950] who established the $4p^5$ ground term interval, the $4s4p^6\ ^2S_{1/2}$ level and several levels of $4p^44d$ and $5s$. Revisions and additions were made by Chaghtai [1969, 1970]. The spectrum was reobserved in the region of 100–450 Å by Ekberg, Hansen, and Reader [1972] who completed the configuration $4p^45s$, replaced two of the earlier levels, and found all but one level of $4p^44d$, confirming five of Chaghtai's levels. We quote their level values for these configurations, which are accurate to ±10 cm^{-1} or better. They have also reported the percentage compositions.

Further observations by Chaghtai, Singh, and Khatoon [1975] enabled them to extend the analysis to the $4p^46s$, $7s$, $5d$, and $6d$ configurations by isoelectronic extrapolation and calculations provided by Cowan. They derived the value for the ionization energy from an average over 20 *ns* and *nd* level series. It agrees within their uncertainty with a value given by Ekberg *et al.*

Two levels of $4p^46s$ at 825 687 cm^{-1} and 825 714 cm^{-1} were revised by Khan, Chaghtai, and Rahimullah [1981] to the values 825 900 cm^{-1} and 826 096 cm^{-1}.

References

Charles, G. W. [1950], Phys. Rev. **77**, 120.

Chaghtai, M. S. Z. [1969], J. Opt. Soc. Am. **59**, 969.

Chaghtai, M. S. Z. [1970], Phys. Scr. **1**, 109.

Chaghtai, M. S. Z., Singh, S. P., and Khatoon, S. [1975], J. Phys. B **8**, 1831.

Ekberg, J. O., Hansen, J. E., and Reader, J. [1972], J. Opt. Soc. Am. **62**, 1143.

Khan, Z. A., Chaghtai, M. S. Z., and Rahimullah, K. [1981], Phys. Scr. **23**, 837.

Mo VIII

Configuration	Term	J	Level (cm^{-1})	Leading percentages			
$4s^24p^5$	$^2P^\circ$	3/2	*0*				
		1/2	*23 274*				
$4s4p^6$	^2S	1/2	233 830	79		21	$4s^24p^4(^1D)4d\ ^2S$
$4s^24p^4(^3P)4d$	^4D	5/2	308 699	85			
		3/2	309 938	80		6	$(^3P)\ ^4P$
$4s^24p^4(^1D)4d$	^2P	1/2	330 800?	40		34	$(^3P)\ ^2P$
$4s^24p^44d$		3/2	335 663	30	$(^3P)\ ^4F$	20	$(^3P)\ ^4P$
$4s^24p^4(^3P)4d$	^4P	1/2	336 936	88		6	$(^3P)\ ^2P$
		5/2	346 215	89		11	$(^1S)\ ^2D$
$4s^24p^4(^3P)4d$	^4F	5/2	337 941	90			
$4s^24p^44d$		3/2	339 525	34	$(^3P)\ ^4F$	33	$(^3P)\ ^4P$
$4s^24p^44d$		3/2	341 362	31	$(^1D)\ ^2D$	26	$(^3P)\ ^4F$
$4s^24p^44d$		3/2	348 832	39	$(^3P)\ ^4P$	25	$(^1D)\ ^2P$
$4s^24p^44d$		5/2	353 148	38	$(^1D)\ ^2D$	25	$(^3P)\ ^4P$
$4s^24p^4(^3P)4d$	^2F	5/2	357 811	61		24	$(^1D)\ ^2F$
$4s^24p^4(^1D)4d$	^2F	5/2	371 341	71		12	$(^1D)\ ^2D$

Mo VIII — Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages		
$4s^24p^4(^1S)4d$	^2D	3/2	394 545	60	25	$(^1D)\ ^2D$
		5/2	404 903	72	11	
$4s^24p^4(^1D)4d$	^2S	1/2	411 512	72	19	$4s4p^6\ ^2S$
$4s^24p^4(^3P)4d$	^2P	3/2	421 559	50	35	$(^1D)\ ^2P$
		1/2	430 969	50	42	
$4s^24p^4(^3P)4d$	^2D	5/2	426 778	67	23	$(^1D)\ ^2D$
		3/2	447 876	58	18	$(^1S)\ ^2D$
$4s^24p^4(^3P_2)5s$	(2,1/2)	5/2	521 461	90	10	$(^1D_2)$ (2,1/2)
		3/2	527 389	82	14	
$4s^24p^4(^3P_0)5s$	(0,1/2)	1/2	538 732	67	17	$(^1S_0)$ (0,1/2)
$4s^24p^4(^3P_1)5s$	(1,1/2)	3/2	543 336	95		
		1/2	548 923	83	12	$(^3P_0)$ (0,1/2)
$4s^24p^4(^1D_2)5s$	(2,1/2)	5/2	558 812	90	10	$(^3P_2)$ (2,1/2)
		3/2	559 813	84	15	
$4s^24p^4(^1S_0)5s$	(0,1/2)	1/2	595 829	78	22	$(^3P_0)$ (0,1/2)
$4s^24p^4(^3P)5d$	^4P	1/2	730 472			
		3/2	745 165			
		5/2	748 161			
$4s^24p^4(^3P)5d$	^2D	3/2	731 073			
		5/2	733 372			
$4s^24p^4(^3P)5d$	^4F	3/2	741 552			
		5/2	744 258			
$4s^24p^4(^3P)5d$	^2F	5/2	749 531			
$4s^24p^4(^3P)5d$	^2P	3/2	750 937			
$4s^24p^4(^1D)5d$	^2S	1/2	759 112			
$4s^24p^4(^1D)5d$	^2P	3/2	761 941			
		1/2	770 370			
$4s^24p^4(^1D)5d$	^2D	5/2	763 015			
		3/2	767 167			
$4s^24p^4(^1D)5d$	^2F	5/2	764 770			
$4s^24p^4(^3P_2)6s$	(2,1/2)	5/2	789 754			
		3/2	791 823			
$4s^24p^4(^1S)5d$	^2D	5/2	798 781			
		3/2	800 351			
$4s^24p^4(^3P_0)6s$	(0,1/2)	1/2	806 614			
$4s^24p^4(^3P_1)6s$	(1,1/2)	3/2	810 363			
		1/2	812 274			

Mo VIII — Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages
$4s^24p^4(^1D_2)6s$	$(2,1/2)$	$5/2$ $3/2$	825 900 826 096	
$4s^24p^4(^1S_0)6s$	$(0,1/2)$	$1/2$	862 803	
$4s^24p^4(^3P)6d$	^2D	$5/2$ $3/2$	890 834 891 999	
$4s^24p^4(^3P)6d$	^4P	$3/2$ $5/2$	906 608 907 534	
$4s^24p^4(^3P)6d$	^2F	$5/2$	909 889	
$4s^24p^4(^3P)6d$	^2P	$3/2$	910 220	
$4s^24p^4(^3P_2)7s$	$(2,1/2)$	$5/2$ $3/2$	916 634 919 154	
$4s^24p^4(^1D)6d$	^2S	$1/2$	920 428	
$4s^24p^4(^1D)6d$	^2P	$3/2$ $1/2$	921 068 924 105	
$4s^24p^4(^1D)6d$	^2D	$5/2$ $3/2$	923 747 927 660	
$4s^24p^4(^3P_0)7s$	$(0,1/2)$	$1/2$	928 921	
$4s^24p^4(^3P_1)7s$	$(1,1/2)$	$3/2$ $1/2$	932 812 934 364	
$4s^24p^4(^1D_2)7s$	$(2,1/2)$	$5/2$ $3/2$	948 129 948 153	
$4s^24p^4(^1S)6d$	^2D	$3/2$	964 373	
$4s^24p^4(^1S_0)7s$	$(0,1/2)$	$1/2$	982 044	
Mo IX $(^3P_2)$	***Limit***		**1 157 900**	

Mo IX

$Z=42$

Se I isoelectronic sequence

Ground state $1s^22s^22p^63s^23p^63d^{10}4s^24p^4$ $^3P_2$

Ionization energy 1 323 700 ± 700 cm^{-1} (164.12 ± 0.09 eV)

The first attempt to analyze this spectrum was made by Chaghtai [1970]. His levels for the ground configuration $4s^24p^4$, and consequently the excited configurations $4p^34d$ and $5s$, were found to be false by Reader and Acquista [1976]. These authors reported an interpretation of the $4s^24p^4-4s4p^5$ transition array. They derived all the levels of these configurations with a level uncertainty of ±1 cm^{-1} for $4s^24p^4$ and ±2 cm^{-1} for $4s4p^5$. They give percentage compositions for the levels of the ground configuration. Reader has provided us with an unpublished calculation of eigenvectors for the $4s4p^5$ and $4s^24p^34d$ configurations calculated with configuration interaction.

A new analysis of the $4s^24p^4-4s^24p^35s$ array was published by Chaghtai, Rahimullah, and Khatoon [1976], in which their levels derived for the $4s^24p^4$ configuration are within ±50 cm^{-1} of those of Reader and Acquista. We have used the level values of the latter authors and the line classifications of the former to rederive the levels of the $4s^24p^35s$ configuration.

In a new analysis of the $4s^24p^4-4s^24p^34d$ array Rahimullah, Chaghtai, and Khatoon [1978] obtained values for the levels of $4s^24p^4$ in agreement with those of Reader and Acquista. Their level values of $4s^24p^34d$ are reported here.

The energy level scheme was considerably augmented by Khatoon, Chaghtai, and Rahimullah [1979] who reported levels of the $4p^35d$, $6d$, $6s$, and $7s$ configurations. From these ns series data they derived the value for the ionization energy.

References

Chaghtai, M. S. Z. [1970], Phys. Scr. **1**, 104.

Chaghtai, M. S. Z., Rahimullah, K., and Khatoon, S. [1976], Phys. Scr. **14**, 281.

Khatoon, S., Chaghtai, M. S. Z., and Rahimullah, K. [1979], Phys. Scr. **19**, 22.

Rahimullah, K., Chaghtai, M. S. Z., and Khatoon, S. [1978], Phys. Scr. **18**, 96.

Reader, J., and Acquista, N. [1976], J. Opt. Soc. Am. **66**, 896.

Mo IX

Configuration	Term	J	Level (cm^{-1})	Leading percentages		
$4s^24p^4$	^3P	2	0.0			
		0	16 588.8			
		1	20 576.3			
$4s^24p^4$	^1D	2	35 674.5			
$4s^24p^4$	^1S	0	72 884.6			
$4s4p^5$	$^3P^\circ$	2	*233 122.9*	86	10	$4s^24p^3(^2D^\circ)4d$ $^3P^\circ$
		1	*246 113.0*	81	10	
		0	*256 536.7*	85	11	
$4s4p^5$	$^1P^\circ$	1	*295 624.1*	61	29	$4s^24p^3(^2D^\circ)4d$ $^1P^\circ$
$4s^24p^3(^2D^\circ)4d$	$^3D^\circ$	1	*347 777*	46	46	$(^4S^\circ)$ $^3D^\circ$
$4s^24p^3(^2D^\circ)4d$	$^3F^\circ$	2	*350 444*	51	22	$(^4S^\circ)$ $^3D^\circ$
		3	*353 696*	60	18	$(^2D^\circ)$ $^3D^\circ$
$4s^24p^3(^2D^\circ)4d$	$^3G^\circ$	3	*362 277*	78	7	$(^2D^\circ)$ $^3F^\circ$
$4s^24p^3(^2P^\circ)4d$	$^3D^\circ$	1	*380 383*	49	35	$(^2D^\circ)$ $^3D^\circ$
		2	*392 634*	52	19	
		3	*402 590*	29	28	

Mo IX — Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages			
$4s^24p^3(^2P^\circ)4d$	$^1D^\circ$	2	*381 528*	49		21	$(^2D^\circ)\ ^1D^\circ$
$4s^24p^3(^2P^\circ)4d$	$^3P^\circ$	1	*388 801*	62		17	$(^2D^\circ)\ ^3P^\circ$
		2	*405 684*	65		8	$(^2P^\circ)\ ^1D^\circ$
$4s^24p^3(^2P^\circ)4d$	$^3F^\circ$	3	*395 360*	67		12	$(^2P^\circ)\ ^3D^\circ$
		2	*396 711*	54		21	$(^2D^\circ)\ ^3F^\circ$
$4s^24p^3(^2D^\circ)4d$	$^3S^\circ$	1	*416 746*	84		11	$(^2D^\circ)\ ^3P^\circ$
$4s^24p^3(^2P^\circ)4d$	$^3P^\circ$	2	*419 123*	82		10	$3s3p^5\ ^3P^\circ$
$4s^24p^3(^2D^\circ)4d$	$^1P^\circ$	1	*420 947*	41		28	$(^2D^\circ)\ ^3P^\circ$
$4s^24p^3(^2P^\circ)4d$	$^1F^\circ$	3	*424 009*	45		32	$(^2P^\circ)\ ^3D^\circ$
$4s^24p^3(^4S^\circ)4d$	$^3D^\circ$	3	*431 498*	44		21	$(^2D^\circ)\ ^1F^\circ$
		2	*441 012*	27		23	$(^2P^\circ)\ ^3D^\circ$
$4s^24p^34d$		1	*433 445*	28	$(^2D^\circ)\ ^3P^\circ$	24	$(^2D^\circ)\ ^1P^\circ$
$4s^24p^34d$		1	*447 509*	40	$(^2P^\circ)\ ^3D^\circ$	31	$(^4S^\circ)\ ^3D^\circ$
$4s^24p^3(^2D^\circ)4d$	$^1D^\circ$	2	*456 111*	46		17	$(^2P^\circ)\ ^1D^\circ$
$4s^24p^3(^2D^\circ)4d$	$^1F^\circ$	3	*466 718*	56		33	$(^2P^\circ)\ ^1F^\circ$
$4s^24p^3(^2P^\circ)4d$	$^1P^\circ$	1	*487 905*	80		7	$(^4S^\circ)\ ^3D^\circ$
$4s^24p^3(^4S^\circ_{3/2})5s$	$(^3/_2,^1/_2)^\circ$	2	*571 798*				
		1	*582 356*				
$4s^24p^3(^2D^\circ_{3/2})5s$	$(^3/_2,^1/_2)^\circ$	2	*601 678*				
		1	*602 468*				
$4s^24p^3(^2D^\circ_{5/2})5s$	$(^5/_2,^1/_2)^\circ$	3	*609 234*				
		2	*613 394*				
$4s^24p^3(^2P^\circ_{1/2})5s$	$(^1/_2,^1/_2)^\circ$	0	*628 649*				
		1	*630 384*				
$4s^24p^3(^2P^\circ_{3/2})5s$	$(^3/_2,^1/_2)^\circ$	2	*644 114*				
		1	*647 535*				
$4s^24p^3(^2D^\circ)5d$	$^3D^\circ$	1	*797 355*				
$4s^24p^3(^2D^\circ)5d$	$^3F^\circ$	2	*800 579*				
$4s^24p^3(^2D^\circ)5d$	$^3G^\circ$	3	*822 534*				
$4s^24p^3(^2P^\circ)5d$	$^3D^\circ$	1	*825 266*				
		3	*839 507*				
$4s^24p^3(^2P^\circ)5d$	$^1D^\circ$	2	*828 728*				
$4s^24p^3(^2P^\circ)5d$	$^3P^\circ$	1	*830 015*				
		2	*839 713*				
$4s^24p^3(^2D^\circ)5d$	$^3P^\circ$	2	*840 654*				
		1	*848 809*				
$4s^24p^3(^2D^\circ)5d$	$^1P^\circ$	1	*843 565*				
$4s^24p^3(^2P^\circ)5d$	$^1F^\circ$	3	*845 474*				

Mo IX — Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages
$4s^24p^3(^4S^\circ)5d$	$^3D^\circ$	3	*847 507*	
		1	*865 366*	
$4s^24p^3(^2D^\circ)5d$	$^1D^\circ$	2	*869 633*	
$4s^24p^3(^4S^\circ_{3/2})6s$	$(^3/_2,^1/_2)^\circ$	2	*875 565*	
		1	*880 843*	
$4s^24p^3(^2P^\circ)5d$	$^1P^\circ$	1	*886 605*	
$4s^24p^3(^2D^\circ_{3/2})6s$	$(^3/_2,^1/_2)^\circ$	2	*905 858*	
		1	*906 239*	
$4s^24p^3(^2D^\circ_{5/2})6s$	$(^5/_2,^1/_2)^\circ$	3	*912 477*	
		2	*915 504*	
$4s^24p^3(^2P^\circ_{1/2})6s$	$(^1/_2,^1/_2)^\circ$	0	*933 385*	
		1	*934 288*	
$4s^24p^3(^2P^\circ_{3/2})6s$	$(^3/_2,^1/_2)^\circ$	2	*947 617*	
		1	*950 649*	
$4s^24p^3(^2D^\circ)6d$	$^3D^\circ$	1	*987 579*	
$4s^24p^3(^2D^\circ)6d$	$^3F^\circ$	2	*990 382*	
$4s^24p^3(^2D^\circ)6d$	$^3G^\circ$	3	*1 014 603*	
$4s^24p^3(^2P^\circ)6d$	$^3D^\circ$	1	*1 015 585*	
		3	*1 024 196*	
$4s^24p^3(^2P^\circ)6d$	$^1D^\circ$	2	*1 016 860*	
$4s^24p^3(^2P^\circ)6d$	$^3P^\circ$	1	*1 018 148*	
		2	*1 025 122*	
$4s^24p^3(^4S^\circ_{3/2})7s$	$(^3/_2,^1/_2)^\circ$	2	*1 025 704*	
		1	*1 028 743*	
$4s^24p^3(^2P^\circ)6d$	$^1F^\circ$	3	*1 031 317*	
$4s^24p^3(^2D^\circ)6d$	$^3P^\circ$	2	*1 033 227*	
		1	*1 040 059*	
$4s^24p^3(^2D^\circ_{3/2})7s$	$(^3/_2,^1/_2)^\circ$	1	*1 055 089*	
		2	*1 055 312*	
$4s^24p^3(^4S^\circ)6d$	$^3D^\circ$	1	*1 056 382*	
$4s^24p^3(^2D^\circ)6d$	$^1D^\circ$	2	*1 057 289*	
$4s^24p^3(^2D^\circ_{5/2})7s$	$(^5/_2,^1/_2)^\circ$	3	*1 062 162*	
		2	*1 064 357*	
$4s^24p^3(^2P^\circ)6d$	$^1P^\circ$	1	*1 065 491*	
$4s^24p^3(^2P^\circ_{1/2})7s$	$(^1/_2,^1/_2)^\circ$	0	*1 082 463*	
		1	*1 083 142*	

Mo IX — Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages
$4s^24p^3(^2P^\circ_{3/2})7s$	$(^3/_2,^1/_2)^\circ$	2 1	*1 097 040* *1 099 412*	
Mo X ($^4S^\circ_{3/2}$)	***Limit***		***1 323 700***	

Mo X

$Z=42$

As I isoelectronic sequence

Ground state $1s^22s^22p^63s^23p^63d^{10}4s^24p^3\ {}^4S^\circ_{3/2}$

Ionization energy 1 503 000 ± 10 000 cm^{-1} (186.4 ± 1.2 eV)

The $4s^24p^3-4s^24p^25s$ and $4d$ transition arrays in the range of 149–165 Å, and 220–326 Å respectively, were interpreted by Rahimullah, Chaghtai, and Khatoon [1976, 1978]. Reader and Acquista [1981] analyzed the array $4s^24p^3-4s4p^4$ in the wavelength range 314–473 Å, redetermining the levels of the $4s^24p^3$ ground configuration as well as those of $4s^24p^25s$. Since their longer wavelengths produce more accurate values for the levels of $4s^24p^3$ we have adopted their values for this configuration and for $4s^24p^25s$, and have reevaluated the levels of $4s^24p^24d$. Ateqad, Chaghtai, and Rahimullah [1984] added the terms (^{3}P) ^{2}F, (^{3}P) ^{4}F and (^{3}P) ^{4}D to $4s^24p^2$4d. The accuracy of the levels of the ground configuration and $4s4p^4$ is ±5 cm^{-1}, while that of $4s^24p^25s$ is ±15 cm^{-1} and $4s^24p^24d$ is ±30 cm^{-1}.

Reader and Acquista provided the percentage compositions of the $4s^24p^3$ and $4s^24p^25s$ configurations. They determined the value for the ionization energy by combining isoelectronic data and Hartree-Fock calculations to determine $n^*(5s)$ and $n^*(6s)$.

References

Ateqad, N., Chaghtai, M. S. Z., and Rahimullah, R. [1984], J. Phys. B **17**, 4617.

Rahimullah, K., Chaghtai, M. S. Z., and Khatoon, S. [1976], Phys. Scr. **14**, 221; [1978], Phys. Scr. **18**, 96.

Reader, J., and Acquista, N. [1981], J. Opt. Soc. Am. **71**, 434.

Mo X

Configuration	Term	J	Level (cm^{-1})	Leading percentages		
$4s^24p^3$	^{4}S°	3/2	*0*	84	12	^{2}P°
	^{2}D°	3/2	*26 886*	74	15	^{2}P°
		5/2	*35 522*	100		
	^{2}P°	1/2	*55 313*	100		
		3/2	*70 544*	73	22	^{2}D°
$4s4p^4$	^{4}P	5/2	224 939			
		3/2	239 891			
		1/2	244 457			
	^{2}D	3/2	276 573			
		5/2	281 535			
	^{2}S	1/2	314 504			
	^{2}P	3/2	318 423			
		1/2	341 642			
$4s^24p^2(^3\mathrm{P})4d$	^{4}F	3/2	356 732			
		5/2	360 764			
		7/2	368 028			
$4s^24p^2(^3\mathrm{P})4d$	^{2}F	5/2	369 830			
		7/2	375 345			

Mo X — Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages		
$4s^24p^2(^3P)4d$	^4D	$^1/_2$	372 595			
		$^3/_2$	377 099			
		$^5/_2$	383 440			
		$^7/_2$	395 762			
$4s^24p^2(^3P)4d$	^2P	$^3/_2$	404 950			
		$^1/_2$	419 322			
$4s^24p^2(^1D)4d$	^2G	$^7/_2$	408 801			
$4s^24p^2(^3P)4d$	^4P	$^5/_2$	416 017			
		$^3/_2$	420 260			
		$^1/_2$	427 397			
$4s^24p^2(^3P)4d$	^2D	$^3/_2$	429 661			
		$^5/_2$	439 671			
$4s^24p^2(^1D)4d$	^2D	$^3/_2$	446 930			
		$^5/_2$	448 779			
$4s^24p^2(^1D)4d$	^2P	$^1/_2$	452 877			
		$^3/_2$	462 467			
$4s^24p^2(^1D)4d$	^2F	$^5/_2$	458 371			
		$^7/_2$	468 216			
$4s^24p^2(^1D)4d$	^2S	$^1/_2$	463 532			
$4s^24p^2(^1S)4d$	^2D	$^5/_2$	488 950			
		$^3/_2$	487 241			
$4s^24p^2(^3P)5s$	^4P	$^1/_2$	638 999	76	14	$(^3P)\ ^2P$
		$^3/_2$	654 947	93	6	$(^3P)\ ^2P$
		$^5/_2$	664 258	73	27	$(^1D)\ ^2D$
$4s^24p^2(^3P)5s$	^2P	$^1/_2$	660 981	81	18	$(^3P)\ ^4P$
		$^3/_2$	669 948	59	39	$(^1D)\ ^2D$
$4s^24p^2(^1D)5s$	^2D	$^5/_2$	692 660	73	27	$(^3P)\ ^4P$
		$^3/_2$	695 263	60	36	$(^3P)\ ^2P$
$4s^24p^2(^1S)5s$	^2S	$^1/_2$	723 115	90	6	$(^3P)\ ^4P$
Mo XI $(^3P_0)$	***Limit***		**1 503 000**			

Mo XI

$Z=42$

Ge I isoelectronic sequence

Ground state $1s^22s^22p^63s^23p^63d^{10}4s^24p^2$ $^3\mathrm{P}_0$

Ionization energy 1 688 000 ± 10 000 cm^{-1} (209.3 ± 1.2 eV)

Rahimullah, Chaghtai, and Khatoon [1978] have determined all the energy levels of $4s^24p^2$, $4s^24p5s$, and all but the $^3\mathrm{F}_4$ level of $4s^24p4d$, as well as the $^3\mathrm{S}^\circ_1$ and $^1\mathrm{P}^\circ_1$ levels of $4s4p^3$. These are determined from observations in the range of 207–360 Å. Their estimated wavelength uncertainty is ±0.005 Å, and level uncertainty is ±15 cm^{-1}.

The ionization energy was calculated by Cowan [1968] by the Hartree-Fock method.

References

Cowan, R. D. [1968], J. Opt. Soc. Am. **58**, 924.

Rahimullah, K., Chaghtai, M. S. Z., and Khatoon, S. [1978], Phys. Scr. **18**, 96.

Mo XI

Configuration	Term	J	Level (cm^{-1})	Leading percentages
$4s^24p^2$	^{3}P	0	0	
		1	17 590	
		2	27 136	
$4s^24p^2$	^{1}D	2	54 719	
$4s^24p^2$	^{1}S	0	84 808	
$4s4p^3$	^{3}S°	1	*335 178*	
$4s4p^3$	^{1}P°	1	*362 196*	
$4s^24p4d$	^{3}F°	2	*380 832*	
		3	*390 018*	
		4		
$4s^24p4d$	^{1}D°	2	*415 602*	
$4s^24p4d$	^{3}P°	1	*424 400*	
		2	*430 145*	
		0	*435 558*	
$4s^24p4d$	^{3}D°	1	*441 686*	
		3	*444 196*	
		2	*445 333*	
$4s^24p4d$	^{1}F°	3	*475 300*	
$4s^24p4d$	^{1}P°	1	*482 661*	
$4s^24p5s$	($^1/_2$,$^1/_2$)°	0	*707 202*	
		1	*709 077*	
$4s^24p5s$	($^3/_2$,$^1/_2$)°	2	*735 196*	
		1	*739 589*	
Mo XII ($^2\mathrm{P}^\circ_{1/2}$)	***Limit***		***1 688 000***	

Mo XII

$Z=42$

Ga I isoelectronic sequence

Ground state $1s^22s^22p^63s^23p^63d^{10}4s^24p\ \ ^2\mathrm{P}^\circ_{1/2}$

Ionization energy 1 857 300 ± 500 cm^{-1} (230.28 ± 0.06 eV)

The ground term ^{2}P° splitting was determined from a magnetic dipole (M1) transition observed in a tokamak discharge and by observations of the $4s^24p\ ^2\mathrm{P}^\circ - 4s4p^2\ ^2\mathrm{P}$ lines with a spark discharge by Curtis *et al.* [1984]. These authors showed that the $4s^24p - 4s^25d$ doublet reported by Alexander *et al.* [1971] is incorrect. The M1 value is 28 463(2) cm^{-1}.

New observations of this spectrum were reported by Reader, Acquista and Goldsmith [1986] who derived new values for the $4s^24p\ ^2\mathrm{P}^\circ$, $4s4p^2\ ^2\mathrm{P}$, and $4s^25s$ levels and calculated their percentage composition. They obtained the value 28 467(4) cm^{-1} for the ground state ^{2}P° splitting. We use a weighted average of this and the M1-derived value to obtain 28 464(2) cm^{-1}. The upper levels were rederived from this value with an uncertainty of ±10 cm^{-1} for the ^{2}P level and ±60 cm^{-1} for the ^{2}S level.

The ionization energy was calculated by Reader *et al.*

References

Alexander, E., Even-Zohar, M., Fraenkel, B. S., and Goldsmith, S. [1971], J. Opt. Soc. Am. **61**, 508.

Curtis, L. J., Reader, J., Goldsmith, S., Denne, B., and Hinnov, E. [1984], Phys. Rev. A **29**, 2248.

Reader, J., Acquista, N., and Goldsmith, S. [1986], J. Opt. Soc. Am. B **3**, 874.

Mo XII

Configuration	Term	J	Level (cm^{-1})	Leading percentages	
$4s^24p$	^{2}P°	1/2	*0*		
		3/2	*28 464*		
$4s4p^2$	^{2}P	1/2	325 518	56	43 ^{2}S
		3/2	332 035	96	3 ^{2}D
$4s^25s$	^{2}S	1/2	761 070	100	
Mo XIII (^{1}S$_0$)	***Limit***		**1 857 300**		

Mo XIII

$Z=42$

Zn I isoelectronic sequence

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

Ionization energy 2 251 000 ± 4 000 cm^{-1} (279.1 ± 0.5 eV)

The resonance line $4s^2\ {}^1S_0-4s4p\ {}^1P^\circ_1$ was identified by Hinnov *et al.* [1972] in a tokamak plasma and measured more accurately by Reader and Acquista [1977] at 340.909(10) Å in a laser-excited spectrum. Finkenthal *et al.* [1981] observed the spin-forbidden resonance line $4s^2\ {}^1S_0-4s4p\ {}^3P^\circ_1$ at 481.02 Å in a tokamak plasma.

From a study of the isoelectronic sequence of transitions between levels of the $n=4$ shell, Litzén and Ando [1984] have identified the lines of the $4s4p-4p^2$ transition array including intersystem lines in a laser-heated plasma. They also observed the spin-forbidden resonance line of Finkenthal *et al.* at 480.820 Å. Their wavelength measurements have an uncertainty of ±0.010 Å. The resulting energy levels of $4s4p$ show that the multiplet $4s4p\ {}^3P^\circ-4s5s\ {}^3S$ identified by Alexander *et al.* [1971] is incorrect. They also verify the identification of the $4s4p\ {}^3P^\circ_2-4p^2\ {}^3P_2$ line by Finkenthal *et al.*, but apart from the spin-forbidden resonance line mentioned above, the rest of the identifications by Finkenthal *et al.* are incorrect.

In an isoelectronic study of $n=5$ to $n=4$ transitions Wyart *et al.* [1987] found the levels of the $4s5s$ and $4s5d$ configurations. They also give a corrected value for the $4s4p\ {}^3P^\circ_0$ level reported by Litzén and Ando. New measurements are given for the $4s^2-4s5p$ transitions first identified by Alexander *et al.*, whose paper contains a misprint for the ${}^1S-{}^1P$ transition.

An improved set of measurements with a wavelength uncertainty of ±0.005 Å, except for a few lines of uncertainty ±0.02 Å, was used by Litzén and Reader [1987] to reevaluate the known levels. In addition, they found the complete $4s4d$ and $4p5s$ configurations and the $4p^2\ {}^1S_0$ level. The $4s4f-4s5g$ array was also reported but was not connected to the level scheme. They gave percentage compositions for the even configurations with configuration interaction included in their calculation. We quote their results for these levels.

The inner shell excitation $3d^{10}4s^2-3d^94s^24p$ was observed by Wyart, Reader, and Ryabtsev [1981], who reported the two resonance lines from the ${}^3D^\circ_1$ and ${}^1P^\circ_1$ levels. Their wavelength uncertainty is ±0.005 Å.

The value of the ionization energy was determined by Litzén and Reader from two-member series combined with Hartree-Fock calculations of the change in the effective quantum number between the series members.

References

Alexander, E., Even-Zohar, M., Fraenkel, B. S., and Goldsmith, S. [1971], J. Opt. Soc. Am. **61**, 508.

Finkenthal, M., Bell, R. E., Moos, H. W., Bhatia, A. K., Marmar, E. S., Terry, J. L., and Rice, J. E. [1981], Phys. Lett. A **82**, 123.

Hinnov, E., Johnson, L. C., Meservey, E. B., and Dimock, D. L. [1972], Plasma Phys. **14**, 755.

Litzén, U., and Ando, K. [1984], Phys. Lett. A **100**, 411.

Litzén, U., and Reader, J. [1987], Phys. Rev. A **36**, 5159.

Reader, J., and Acquista, N. [1977], Phys. Rev. Lett. **39**, 184.

Wyart, J. -F., Mandelbaum, P., Klapisch, M., Schwob, J. -L., and Schweitzer, N. [1987], Phys. Scr. **36**, 224.

Wyart, J. -F., Reader, J., and Ryabtsev, A. [1981], J. Opt. Soc. Am. **71**, 692.

Mo XIII

Configuration	Term	J	Level (cm^{-1})	Leading percentages		
$4s^2$	${}^1S$	0	0	98	2	$4p^2\ {}^1S$
$4s4p$	${}^3P^\circ$	0	*200 259*	100		
		1	*207 982*	97	3	${}^1P^\circ$
		2	*230 642*	100		
$4s4p$	${}^1P^\circ$	1	*293 333*	97	3	${}^3P^\circ$
$4p^2$	${}^3P$	0	464 439	90	9	${}^1S$
		1	483 549	100		
		2	514 034	62	38	${}^1D$
$4p^2$	${}^1D$	2	486 036	57	38	${}^3P$

Mo XIII — Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages		
$4p^2$	$^1\mathrm{S}$	0	559 827	89	9	$^3\mathrm{P}$
$4s4d$	$^3\mathrm{D}$	1	626 853	100		
		2	628 707	100		
		3	631 755	100		
$4s4d$	$^1\mathrm{D}$	2	676 590	91	9	$4p^2\ ^1\mathrm{D}$
$4s5s$	$^3\mathrm{S}$	1	1 022 664			
$4s5s$	$^1\mathrm{S}$	0	1 037 226			
$4s5p$	$^3\mathrm{P}^\circ$	1	*1 126 684*			
$4s5p$	$^1\mathrm{P}^\circ$	1	*1 139 342*			
$4p5s$	$(^1/_2,^1/_2)^\circ$	0	*1 264 629*			
		1	*1 267 402*			
$4p5s$	$(^3/_2,^1/_2)^\circ$	2	*1 295 364*			
		1	*1 301 864*			
$4s5d$	$^3\mathrm{D}$	1	1 296 905			
		2	1 297 901			
		3	1 300 240			
$3d^94s^24p$	$^1\mathrm{P}^\circ$	1	*1 848 400*			
$3d^94s^24p$	$^3\mathrm{D}^\circ$	1	*1 867 400*			
Mo XIV ($^2\mathrm{S}_{1/2}$)	***Limit***		**2 251 000**			

Mo XIV

$Z=42$

Cu I isoelectronic sequence

Ground state $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s$ $^2S_{1/2}$

Ionization energy 2 440 600 ± 300 cm^{-1} (302.60 ± 0.04 eV)

Alexander, Even-Zohar, Fraenkel, and Goldsmith [1971] identified $4s$–$5p$ and $6p$, $4p$–$5s$ and $5d$, and $4d$–$5f$ transitions in a spark discharge. The $4s$–$4p$ transitions were first identified by Hinnov, Johnson, Meservey, and Dimock [1972] from tokamak observations. A comprehensive analysis of the one-electron spectrum was given by Reader, Luther, and Acquista [1979], which extended the number of observed levels and improved the accuracy of measurement to ±0.005 Å. They used both a spark discharge and a laser-generated plasma to excite the spectrum. They determined the ionization energy from the ng series ($n=5,6,7$). In a later paper [1981], they revised the measurements of the $4s$–$6p$ doublet given by Alexander *et al.* and corrected their identification of the $4d$–$6p$ doublet. A new value for the $6p$ $^2P^\circ_{1/2}$ level was given.

Using a low-inductance spark discharge Wyart, Reader, and Ryabtsev [1981] investigated the $3d^{10}4s$–$3d^9 4s4p$ array in the isoelectronic sequence Y XI to Mo XIV. They improved the measurements in the earlier study of this array in Mo XIV by Burkhalter, Reader, and Cowan (1980) and identified the overlapping transition arrays $3d^{10}4p$–$3d^9 4p^2$ and $3d^{10}4s$–$3d^{10}7p$. Three more revisions were proposed by Wyart *et al.* [1984] in a new isoelectronic treatment of these arrays. The level values and percentage compositions are taken from this paper. Their measurement uncertainty of ±0.005 Å gives a level uncertainty of ±200 cm^{-1}.

References

Alexander, E., Even-Zohar, M., Fraenkel, B. S., and Goldsmith, S. [1971], J. Opt. Soc. Am. **61**, 508.

Burkhalter, P. G., Reader, J., and Cowan, R. D. [1980], J. Opt. Soc. Am. **70**, 912.

Hinnov, E., Johnson, L. C., Meservey, E. B., and Dimock, D. L. [1972], Plasma Phys. **14**, 755.

Reader, J., Luther, G., and Acquista, N. [1979], J. Opt. Soc. Am. **69**, 144.

Reader, J., Luther, G., and Acquista, N. [1981], J. Opt. Soc. Am. **71**, 204.

Wyart, J. F., Reader, J., and Ryabtsev, A. [1981], J. Opt. Soc. Am. **71**, 692.

Wyart, J. F., van Kleef, T. A. M., Ryabtsev, A. N., and Joshi, Y. N. [1984], Phys. Scr. **29**, 319.

Mo XIV

Configuration	Term	J	Level (cm^{-1})	Leading percentages
$3d^{10}(^1S)4s$	^2S	1/2	0	
$3d^{10}(^1S)4p$	$^2P^\circ$	1/2	*236 085*	
		3/2	*267 632*	
$3d^{10}(^1S)4d$	^2D	3/2	649 976	
		5/2	655 242	
$3d^{10}(^1S)4f$	$^2F^\circ$	5/2	*1 033 850*	
		7/2	*1 033 968*	
$3d^{10}(^1S)5s$	^2S	1/2	1 089 691	
$3d^{10}(^1S)5p$	$^2P^\circ$	1/2	*1 192 036*	
		3/2	*1 205 254*	
$3d^{10}(^1S)5d$	^2D	3/2	1 372 413	
		5/2	1 374 830	
$3d^{10}(^1S)5f$	$^2F^\circ$	5/2	*1 540 440*	
		7/2	*1 540 574*	

Mo XIV — Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages
$3d^{10}(^1S)5g$	^2G	7/2,9/2	1 577 546	
$3d^{10}(^1S)6s$	^2S	1/2	1 579 705	
$3d^{10}(^1S)6p$	$^2P^\circ$	1/2	*1 633 270*	
		3/2	*1 640 046*	
$3d^{10}(^1S)6f$	$^2F^\circ$	5/2	*1 818 244*	
		7/2	*1 818 317*	
$3d^{10}(^1S)6g$	^2G	7/2,9/2	1 841 006	
$3d^9(^2D)4s4p(^3P^\circ)$	$^4P^\circ$	3/2	*1 861 190*	47
		1/2	*1 883 240*	68
$3d^9(^2D)4s4p(^3P^\circ)$	$^4F^\circ$	3/2	*1 874 730*	84
$3d^{10}(^1S)7p$	$^2P^\circ$	1/2	*1 874 730*	
		3/2	*1 878 710*	
$3d^9(^2D)4s4p(^3P^\circ)$	$^2D^\circ$	3/2	*1 885 090*	51
$3d^9(^2D)4s4p(^3P^\circ)$	$^2P^\circ$	3/2	*1 895 630*	58
		1/2	*1 897 890*	80
$3d^9(^2D)4s4p(^3P^\circ)$	$^4D^\circ$	1/2	*1 905 630*	56
		3/2	*1 914 680*	51
$3d^9(^2D)4s4p(^1P^\circ)$	$^2P^\circ$	3/2	*1 945 600*	89
		1/2	*1 968 970*	96
$3d^{10}(^1S)7g$	^2G	7/2,9/2	2 000 101	
$3d^9(^2D)4p^2(^1D)$	^2P	3/2	2 143 750	61
$3d^9(^2D)4p^2(^3P)$	^2D	3/2	2 158 460	51
		5/2	2 190 210	49
$3d^9(^2D)4p^2(^3P)$	^4F	3/2	2 171 600	46
$3d^9(^2D)4p^2(^1D)$	^2D	3/2	2 180 320	52
$3d^9(^2D)4p^2(^3P)$	^2P	1/2	2 190 700	89
		3/2	2 194 630	62
$3d^9(^2D)4p^2(^1D)$	^2F	5/2	2 208 270	48
$3d^9(^2D)4p^2(^1S)$	^2D	5/2	2 230 110	81
…………	…………	……	…………	
Mo XV ($^1S_0$)	***Limit***		**2 440 600**	

Mo XV

$Z=42$

Ni I isoelectronic sequence

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

Ionization energy 4 388 000 ± 4000 cm^{-1} (544.0 ± 0.5 eV)

The three resonance lines $3d^{10}$ $^1S_0$–$3d^94p$ $^3P^\circ_1$, $^1P^\circ_1$, and $^3D^\circ_1$ were reported by Alexander *et al.* [1971] at 50.920 Å, 50.437 Å, and 49.904 Å respectively, with an uncertainty of ±0.02 Å. Improved measurements with an uncertainty of ±0.005 Å were given by Wyart, Reader, and Ryabtsev [1981] who found the values 50.956 Å, 50.448 Å, and 49.914 Å. Wyart *et al.* [1984], in a new investigation of the spectrum of Mo XIV concluded that the line at 50.956 Å really belongs to this spectrum and proposed a new line at 50.928 Å to take its place in Mo XV.

Ryabtsev *et al.* [1987] succeeded in identifying the $3d^94s$–$3d^94p$ and $3d^94p$–$3d^94d$ arrays for Rb X to Mo XV, obtaining all the levels of the $3d^94s$ and $3d^94p$ configurations. Their wavelength error is estimated to be ±0.015 Å. Because of "severe blending of $4p$–$4d$ transitions" only the $^3G_5$ level of $3d^94d$ was found. The accuracy of the energy level values is given as ±10 cm^{-1}. We quote their level values. Practically identical results for the $4s$ and $4p$ levels were obtained by Brage and Litzén [1987], except for a shift of about −50 cm^{-1} in their levels. This arises from the choice of wavelengths for the resonance lines reported in the literature. Brage and Litzén also give percentage compositions for these levels.

The resonance line $3d^{10}$ $^1S_0$–$3d^94f$ $^1P^\circ_1$ was reported by Schwob *et al.* [1977] at 35.362 Å. Burkhalter, Reader, and Cowan [1980] gave the value 35.368 Å and observed the resonance line $3d^{10}$ $^1S_0$–$3d^94f$ $^3D^\circ_1$ at 36.059 Å. Practically identical values (within 0.001 Å) were reported by Schweitzer *et al.* [1981] with a measurement uncertainty of ±0.005 Å, but with the addition of $^1S_0$–$^3P^\circ_1$ at 36.376 Å.

Two electric quadrupole transitions were observed in a tokamak discharge at 57.927 Å and 58.832 Å by Klapisch *et al.* [1978] and classified as $3d^{10}$ $^1S_0$–$3d^94s$ $(\frac{3}{2},\frac{1}{2})_2$ and $(\frac{5}{2},\frac{1}{2})_2$, or $^1D_2$ and $^3D_2$, respectively. Their measurement uncertainty is ±0.005 Å. These lines were also reported by Mansfield *et al.* [1978].

Schweitzer *et al.* identified the doublet $3d^{10}$ $^1S_0$–$3d^95f$ $(\frac{5}{2},\frac{7}{2})^\circ$, and $(\frac{3}{2},\frac{5}{2})^\circ$, at 29.774 Å and 29.458 Å. These, along with the $4f$ levels, allow a value for the ionization energy to be derived if one assumes a value for the difference of effective quantum numbers between them. We have taken the value of 0.97809 from Mo XIV.

References

Alexander, E., Even-Zohar, M., Fraenkel, B. S., and Goldsmith, S. [1971], J. Opt. Soc. Am. **61**, 508.

Brage, T., and Litzén, U. [1987], Phys. Scr. **35**, 662.

Burkhalter, P. G., Reader, J., and Cowan, R. D. [1980], J. Opt. Soc. Am. **70**, 912.

Klapisch, M., Schwob, J. L., Finkenthal, M., Fraenkel, B. S., Egert, S., Bar-Shalom, A., Breton, C., De Michelis, C., and Mattioli, M. [1978], Phys. Rev. Lett. **41**, 403.

Mansfield, M. W. D., Peacock, N. J., Smith, C. C., Hobby, M. G., and Cowan, R. D. [1978], J. Phys. B **11**, 1521.

Ryabstev, A. N., Churilov, S. S., and Wyart, J. F. [1987], Opt. Spektrosk. **62**, 258.

Schweitzer, N., Klapsich, M., Schwob, J. L., Finkenthal, M., Bar-Shalom, A., Mandelbaum, P., and Fraenkel, B. S. [1981], J. Opt. Soc. Am. **71**, 219.

Schwob, J. L., Klapisch, M., Schweitzer, N., Finkenthal, M., Breton, C., De Michelis, C., and Mattioli, M. [1977], Phys. Lett. A **62**, 85.

Wyart, J. F., Reader, J., and Ryabtsev, A. [1981], J. Opt. Soc. Am. **71**, 692.

Wyart, J. F., van Kleef, T. A. M., Ryabtsev, A., and Joshi, Y. N. [1984], Phys. Scr. **29**, 319.

Mo XV

Configuration	Term	J	Level (cm^{-1})	Leading percentages	
$3d^{10}$	^1S	0	0		
$3d^9(^2D_{5/2})4s$	$({}^5/_2,{}^1/_2)$	3	1 694 910	100	
		2	1 699 860	97	
$3d^9(^2D_{3/2})4s$	$({}^3/_2,{}^1/_2)$	1	1 721 770	100	
		2	1 726 410	97	
$3d^9(^2D_{5/2})4p$	$({}^5/_2,{}^1/_2)^\circ$	2	*1 932 860*	91	8 $({}^5/_2,{}^3/_2)^\circ$
		3	*1 939 450*	98	

Mo XV — Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages		
$3d^9(^2D_{3/2})4p$	$(^3/_2,^1/_2)^\circ$	2	*1 962 160*	88	9	$(^5/_2,^3/_2)^\circ$
		1	*1 963 620*	47	40	$(^5/_2,^3/_2)^\circ$
$3d^9(^2D_{5/2})4p$	$(^5/_2,^3/_2)^\circ$	4	*1 968 200*	100		
		2	*1 978 020*	81	10	$(^3/_2,^1/_2)^\circ$
		1	*1 982 270*	50	47	$(^5/_2,^3/_2)^\circ$
		3	*1 982 810*	98		
$3d^9(^2D_{3/2})4p$	$(^3/_2,^3/_2)^\circ$	0	*1 984 950*	100		
		3	*1 999 880*	98		
		1	*2 003 420*	85	13	$(^5/_2,^3/_2)^\circ$
		2	*2 008 190*	97		
$3d^94d$	^3G	5	2 364 270			
$3d^94f$	$^3P^\circ$	1	*2 749 060*			
$3d^94f$	$^3D^\circ$	1	*2 773 230*			
$3d^94f$	$^1P^\circ$	1	*2 827 410*			
$3d^95f$	$^3D^\circ$	1	*3 358 600*			
$3d^95f$	$^1P^\circ$	1	*3 394 700*			
Mo XVI ($^2D_{5/2}$)	***Limit***		4 388 000			

Mo XVI

$Z = 42$

Co I isoelectronic sequence

Ground state $1s^22s^22p^63s^23p^63d^9\ ^2D_{5/2}$

Ionization energy 4 600 000 ± 180 000 cm^{-1} (570 ± 22 eV)

The $3p^63d^9$–$3p^53d^{10}$ doublet was first observed by Edlén [1947], but no wavelengths were reported. Measurements of these lines were given by Alexander *et al.* [1971] and finally by Ryabtsev and Reader [1982] with an uncertainty of ±0.005 Å, giving a level uncertainty of ±100 cm^{-1}. The ground state $3d^9\ ^2D$ splitting was observed directly by means of a magnetic dipole line observed at 3708.1(2) Å in a tokamak discharge by Suckewer *et al.* [1982]. This gives a splitting of 26 960(1) cm^{-1}.

Classifications of lines of the $3d^9$–$3d^84p$ array were first given by Mansfield *et al.* [1978] and revised and extended by Burkhalter *et al.* [1980]. From new observations Ryabtsev and Reader [1982] revised identifications in the earlier work and classified additional lines. Their derived energy levels have an uncertainty of ±200 cm^{-1} relative to the ground state. Their analysis is confirmed by calculated energy level positions and line intensities. The percentage compositions of the $3d^84p$ levels are given in their paper. An independent analysis appeared a short time later by Wyart, Klapisch, Schwob, and Schweitzer [1982] giving essentially the same results, but missing some of the weaker lines. Their wavelengths are systematically shifted from those of Ryabtsev and Reader by 0.009 Å.

Five lines of the transition array $3d^9$–$3d^84s$, forbidden by electric dipole radiation, were observed as electric quadrupole transitions in a tokamak discharge by Mansfield *et al.* [1978]. New measurements of these lines with an uncertainty of ±0.02 Å were communicated to us by J. F. Wyart [1986]. From a study of the isoelectronic sequence he made several changes in the classifications by Mansfield. The levels are derived from the assignments of Wyart.

Mansfield *et al.* also give classifications of six lines of the $3d^9$–$3d^84f$ array. These are extended to 19 by Burkhalter *et al.* [1980], and revised and extended to 29 lines by Ando and Ishii [1985].

The ionization energy was calculated by Carlson *et al.* [1970].

References

Alexander, E., Even-Zohar, M., Fraenkel, B. S., and Goldsmith, S. [1971], J. Opt. Soc. Am. **61**, 508.

Ando, K., and Ishii, K. [1985], J. Phys. Soc. Japan **54**, 3297.

Burkhalter, P. G., Reader, J., and Cowan, R. D. [1980], J. Opt. Soc. Am. **70**, 912.

Carlson, T. A., Nestor, C. W., Jr., Wasserman, N., and McDowell, J. D. [1970], At. Data Nucl. Data Tables **2**, 63.

Edlén, B. [1947], Physica **13**, 545.

Mansfield, M. W. D., Peacock, N. J., Smith, C. C., Hobby, M. G., and Cowan, R. D. [1978], J. Phys. B **11**, 1521.

Ryabtsev, A. N., and Reader, J. [1982], J. Opt. Soc. Am. **72**, 710.

Suckewer, S., Hinnov, E., Cohen, S., Finkenthal, M., and Sato, K. [1982], Phys. Rev. A **26**, 1161.

Wyart, J. F. [1986], private communication.

Wyart, J. F., Klapisch, M., Schwob, J. L., and Schweitzer, N. [1982], Phys. Scr. **26**, 141.

Mo XVI

Configuration	Term	J	Level (cm^{-1})	Leading percentages		
$3p^63d^9$	^{2}D	$5/2$	0			
		$3/2$	26 960			
$3p^53d^{10}$	^{2}P°	$3/2$	*1 318 040*			
		$1/2$	*1 463 860*			
$3p^63d^8(^3F_4)4s$	$(4,1/2)$	$9/2$	1 840 940			
		$7/2$	1 849 230			
$3p^63d^8(^3F_3)4s$	$(3,1/2)$	$7/2$	1 870 910			
$3p^63d^8(^1G_4)4s$	$(4,1/2)$	$9/2$	1 927 380			
		$7/2$	1 927 670			
$3p^63d^8(^3F)4p$	^{4}D°	$7/2$	*2 085 110*	69	16	(^{3}F) ^{4}F°
		$5/2$	*2 110 510*	60	18	

Mo XVI — Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages			
$3p^63d^8(^3F)4p$	$^4G^\circ$	$7/2$	*2 114 080*	65		15	$(^3F)\ ^2G^\circ$
		$5/2$	*2 115 860*	46		19	$(^1D)\ ^2F^\circ$
$3p^63d^84p$		$3/2$	*2 115 910*	20	$(^3F)\ ^4F^\circ$	6	$(^3F)\ ^4D^\circ$
$3p^63d^8(^3F)4p$	$^2F^\circ$	$7/2$	*2 134 060*	59		15	$(^3F)\ ^4F^\circ$
		$5/2$	*2 160 220*	36		15	$(^1D)\ ^2F^\circ$
$3p^63d^8(^3F)4p$	$^2D^\circ$	$5/2$	*2 134 880*	41		26	$(^3F)\ ^4G^\circ$
		$3/2$	*2 178 520*	36		21	$(^1D)\ ^2D^\circ$
$3p^63d^84p$		$3/2$	*2 146 260*	33	$(^3P)\ ^4P^\circ$	19	$(^3F)\ ^4F^\circ$
$3p^63d^84p$		$5/2$	*2 147 170*	32	$(^3F)\ ^2D^\circ$	20	$(^3P)\ ^4P^\circ$
$3p^63d^84p$		$5/2$	*2 151 550*	33	$(^3F)\ ^4F^\circ$	16	$(^3F)\ ^2F^\circ$
$3p^63d^8(^3F)4p$	$^4F^\circ$	$7/2$	*2 156 190*	53		22	$(^3F)\ ^2F^\circ$
		$3/2$	*2 164 610*	40		16	$(^3F)\ ^2D^\circ$
$3p^63d^84p$		$7/2$	*2 157 400*	37	$(^1D)\ ^2F^\circ$	36	$(^3F)\ ^2G^\circ$
$3p^63d^84p$		$5/2$	*2 167 740*	28	$(^3P)\ ^4P^\circ$	22	$(^1D)\ ^2F^\circ$
$3p^63d^84p$		$3/2$	*2 171 850*	15	$(^3F)\ ^2D^\circ$	11	$(^1D)\ ^2D^\circ$
$3p^63d^8(^1G)4p$	$^2F^\circ$	$7/2$	*2 172 780*	64		14	$(^3F)\ ^2G^\circ$
		$5/2$	*2 212 460*	43		16	$(^1D)\ ^2D^\circ$
$3p^63d^8(^3P)4p$	$^4D^\circ$	$1/2$	*2 174 130*	50		26	$(^3F)\ ^4D^\circ$
		$7/2$	*2 182 980*	56		14	$(^3F)\ ^2G^\circ$
		$5/2$	*2 203 810*	40		36	$(^3P)\ ^2D^\circ$
$3p^63d^84p$		$5/2$	*2 179 240*	26	$(^3F)\ ^2F$	24	$(^3P)\ ^2D^\circ$
$3p^63d^8(^1D)4p$	$^2P^\circ$	$3/2$	*2 190 130*	38		17	$(^3P)\ ^2P^\circ$
		$1/2$	*2 222 200*	32		31	
$3p^63d^84p$		$5/2$	*2 195 590*	30	$(^1G)\ ^2F^\circ$	24	$(^1D)\ ^2D^\circ$
$3p^63d^84p$		$3/2$	*2 198 620*	37	$(^3P)\ ^2P^\circ$	17	$(^1D)\ ^2D^\circ$
$3p^63d^8(^3P)4p$	$^2S^\circ$	$1/2$	*2 207 180*	61		19	$(^3P)\ ^2P^\circ$
$3p^63d^8(^3P)4p$	$^2D^\circ$	$3/2$	*2 207 920*	69		9	$(^3P)\ ^4D^\circ$
$3p^63d^8(^1D)4p$	$^2F^\circ$	$7/2$	*2 209 940*	48		30	$(^3P)\ ^4D^\circ$
$3p^63d^8(^1G)4p$	$^2G^\circ$	$7/2$	*2 222 220*	77		17	$(^1G)\ ^2F^\circ$
$3p^63d^8(^1S)4p$	$^2P^\circ$	$1/2$	*2 273 700*	88		4	$(^1D)\ ^2P^\circ$
		$3/2$	*2 308 160*	91		2	
$3p^63d^84f$		$5/2$	*2 942 700*	34	$(^3F_4)\ ^2[3]^\circ$	23	$(^3F_3)\ ^2[2]^\circ$
$3p^63d^8(^3F_3)4f$	$^2[4]^\circ$	$7/2$	*2 957 500*	54		15	$(^3F_3)\ ^2[3]^\circ$

Mo XVI — Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages			
$3p^63d^8(^3F_3)4f$	$^2[3]^\circ$	7/2	*2 962 100*	43		26	$(^3F_2)\ ^2[4]^\circ$
$3p^63d^8(^3F_3)4f$	$^2[1]^\circ$	3/2	*2 963 800*	50		12	$(^3F_4)\ ^2[2]^\circ$
$3p^63d^84f$		3/2	*2 968 800*	27	$(^3F_2)\ ^2[1]^\circ$	25	$(^1D_2)\ ^2[2]^\circ$
$3p^63d^8(^3F_3)4f$	$^2[2]^\circ$	5/2	*2 969 100*	47		14	$(^3F_4)\ ^2[3]^\circ$
$3p^63d^84f$		7/2	*2 977 000*	26	$(^3P_2)\ ^2[4]^\circ$	21	$(^3F_3)\ ^2[4]^\circ$
$3p^63d^84f$		5/2	*2 981 100*	26	$(^3F_2)\ ^2[2]^\circ$	16	$(^3P_2)\ ^2[3]^\circ$
$3p^63d^84f$		3/2	*2 985 500*	37	$(^3P_2)\ ^2[2]^\circ$	24	$(^3P_1)\ ^2[2]^\circ$
$3p^63d^8(^3F_2)4f$	$^2[3]^\circ$	7/2	*2 986 900*	50		32	$(^3P_2)\ ^2[3]^\circ$
$3p^63d^84f$		5/2	*2 991 400*	25	$(^3P_2)\ ^2[3]^\circ$	21	$(^3F_2)\ ^2[3]^\circ$
$3p^63d^84f$		7/2	*2 998 800*	31	$(^3P_2)\ ^2[3]^\circ$	15	$(^3F_2)\ ^2[4]^\circ$
$3p^63d^84f$		7/2	*3 003 600*	35	$(^3P_0)\ ^2[3]^\circ$	24	$(^1D_2)\ ^2[3]^\circ$
$3p^63d^8(^3P_1)4f$	$^2[2]^\circ$	5/2	*3 006 200*	39		31	$(^3P_0)\ ^2[3]^\circ$
$3p^63d^8(^3P_1)4f$	$^2[4]^\circ$	7/2	*3 008 900*	50		19	$(^3P_0)\ ^2[3]^\circ$
$3p^63d^8(^3P_1)4f$	$^2[3]^\circ$	5/2	*3 013 400*	58		15	$(^1G_4)\ ^2[2]^\circ$
$3p^63d^8(^1G_4)4f$	$^2[3]^\circ$	7/2	*3 019 300*	43		26	$(^1D_2)\ ^2[3]^\circ$
$3p^63d^8(^1D_2)4f$	$^2[1]^\circ$	3/2	*3 024 200*	45		40	$(^3P_2)\ ^2[1]^\circ$
$3p^63d^8(^1G_4)4f$	$^2[1]^\circ$	3/2	*3 038 000*	77		8	$(^3F_4)\ ^2[2]^\circ$
		1/2	*3 048 100*	68		11	$(^3F_2)\ ^2[1]^\circ$
$3p^63d^8(^1G_4)4f$	$^2[2]^\circ$	5/2	*3 042 600*	51		9	$(^3F_4)\ ^2[3]^\circ$
$3p^63d^84f$		7/2	*3 043 200*	30	$(^1G_4)\ ^2[3]^\circ$	17	$(^3P_2)\ ^2[4]^\circ$
$3p^63d^84f$		3/2	*3 058 900*	33	$(^1G_4)\ ^2[2]^\circ$	18	$(^1D_2)\ ^2[2]^\circ$
$3p^63d^8(^1S_0)4f$	$^2[3]^\circ$	7/2	*3 117 400*	94		4	$(^3P_0)\ ^2[3]^\circ$
		5/2	*3 120 700*	90		7	
Mo XVII $(^3F_4)$	***Limit***		**4 600 000**				

Mo XVII

$Z=42$

Fe I isoelectronic sequence

Ground state $1s^22s^22p^63s^23p^63d^8$ ^{3}F$_4$

Ionization energy 5 130 000 ± 480 000 cm^{-1} (636 ± 60 eV)

Analyses of the $3p^63d^8$–$3p^53d^9$ array appeared in print nearly simultaneously by Burkhalter, Reader, and Cowan [1980] and by Bogdanovichene *et al.* [1980]. In the first paper 14 lines are classified and in the second 21. In the latter, all levels of the $3p^53d^9$ configuration and all but the ^{3}P$_0$ and ^{1}S$_0$ of $3p^63d^8$ were reported. The spectrum was reobserved by Reader and Ryabtsev [1981], who extended the number of classified lines in this array to 42 with wavelengths observed in the range of 65–83 Å, found the missing levels of $3d^8$, corrected the ^{1}G$_4$, and replaced the levels ^{3}P$^\circ_0$ and ^{1}F$^\circ_3$ of $3p^53d^9$. Their measurement uncertainty is ±0.005 Å, giving a level uncertainty of ±100 cm^{-1}. Reader and Ryabtsev [1983] later reported a slightly revised value for the ^{1}S$_0$ level of $3p^63d^8$. They give the percentage composition for these levels.

An analysis of the $3d^8$–$3d^74p$ array was carried out by Wyart *et al.* [1983]. They observed this isolated array in the range of 41–44 Å and classified 47 lines. Their measurement uncertainty, reported in an earlier paper by Klapisch *et al.* [1981], is ±0.005 Å giving a level uncertainty of ±300 cm^{-1}. Only the final J quantum number and a serial number N for the order in which the level occurs in that J are given to designate each level. In the case of $3d^74p$ the average purity in LS-coupling is only 34% so, clearly, naming the levels in this scheme is inappropriate.

An accurate value for the lowest energy interval of this ion was obtained by Suckewer *et al.* [1982] from their observation of the magnetic dipole transition $3d^8$ ^{3}F$_4$–^{3}F$_3$ at 4123.5(3) Å in a tokamak plasma.

The ionization energy is a calculated value by Carlson *et al.* [1970].

References

Bogdanovichene, M. I., Kononov, E. Ya., Merkelis, G. V., Ramonas, A. A., Ryabtsev, A. N., and Churlov, S. S. [1981], Opt. Spectrosc. (USSR) **49**, 244.

Burkhalter, P. G., Reader, J., Cowan, R. D. [1980], J. Opt. Soc. Am. **70**, 912.

Carlson, T. A., Nestor, C. W., Jr., Wasserman, N., and McDowell, J. D. [1970], At. Data Nucl. Data Tables **2**, 63.

Klapisch, M., Mandelbaum, P., Schwob, J. L., Bar-Shalom, A., and Schweitzer, N. [1981], Phys. Lett. A **84**, 177.

Reader, J., and Ryabtsev, A. [1981], J. Opt. Soc. Am. **71**, 231.

Reader, J., and Ryabtsev, A. [1983], J. Opt. Soc. Am. **73**, 1207.

Suckewer, S., Hinnov, E., Cohen, S., Finkenthal, M., and Sato, K. [1982], Phys. Rev. A **26**, 1161.

Wyart, J. F., Klapisch, M., Schwob, J. L., Schweitzer, N., and Mandelbaum, P. [1983], Phys. Scr. **27**, 275.

Mo XVII

Configuration	Term	J	Level (cm^{-1})	Leading percentages		
$3p^63d^8$	^{3}F	4	0	98	2	^{1}G
		3	24 250	100		
		2	27 030	57	34	^{1}D
$3p^63d^8$	^{3}P	2	51 000	55	12	^{1}D
		0	68 350	93	7	^{1}S
		1	70 310	100		
$3p^63d^8$	^{1}D	2	77 960	52	37	^{3}P
$3p^63d^8$	^{1}G	4	82 420	98	2	^{3}F
$3p^63d^8$	^{1}S	0	176 680	93	7	^{3}P
$3p^53d^9$	^{3}F$^\circ$	4	*1 262 860*	100		
		3	*1 311 160*	65	34	^{3}D$^\circ$
		2	*1 445 570*	66	20	^{1}D$^\circ$
$3p^53d^9$	^{1}D$^\circ$	2	*1 281 600*	73	14	^{3}F$^\circ$

Mo XVII — Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages		
$3p^53d^9$	^{3}D°	2	*1 342 800*	51	31	^{3}P°
		3	*1 370 010*	57	28	^{3}F°
		1	*1 391 470*	63	32	^{1}P°
$3p^53d^9$	^{3}P°	1	*1 352 050*	86	12	^{3}D°
		0	*1 356 860*	100		
		2	*1 471 690*	51	41	^{3}D°
$3p^53d^9$	^{1}F°	3	*1 544 660*	84	9	^{3}D°
$3p^53d^9$	^{1}P°	1	*1 563 830*	66	25	^{3}D°
$3p^63d^74p$	1	4	*2 270 430*			
$3p^63d^74p$	2	4	*2 297 320*			
$3p^63d^74p$	2	5	*2 311 790*			
$3p^63d^74p$	3	4	*2 319 900*			
$3p^63d^74p$	3	3	*2 324 090*			
$3p^63d^74p$	4	3	*2 334 250*			
$3p^63d^74p$	4	5	*2 338 250*			
$3p^63d^74p$	5	4	*2 341 690*			
$3p^63d^74p$	6	3	*2 349 350*			
$3p^63d^74p$	4	1	*2 353 690*			
$3p^63d^74p$	5	5	*2 358 500*			
$3p^63d^74p$	8	3	*2 360 950*			
$3p^63d^74p$	9	2	*2 366 360*			
$3p^63d^74p$	10	3	*2 374 600*			
$3p^63d^74p$	10	2	*2 376 490*			
$3p^63d^74p$	11	3	*2 377 580*			
$3p^63d^74p$	10	4	*2 383 490*			
$3p^63d^74p$	8	1	*2 383 830*			
$3p^63d^74p$	7	5	*2 383 840*			
$3p^63d^74p$	12	3	*2 386 200*			
$3p^63d^74p$	9	1	*2 388 150*			
$3p^63d^74p$	10	1	*2 398 220*			
$3p^63d^74p$	9	5	*2 411 280*			
$3p^63d^74p$	16	3	*2 413 480*			

Mo XVII — Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages
$3p^63d^74p$	13	4	*2 413 910*	
$3p^63d^74p$	12	1	*2 414 300*	
$3p^63d^74p$	18	2	*2 425 180*	
$3p^63d^74p$	18	3	*2 426 890*	
$3p^63d^74p$	19	2	*2 434 930*	
$3p^63d^74p$	10	5	*2 436 880*	
$3p^63d^74p$	15	1	*2 444 680*	
$3p^63d^74p$	21	3	*2 472 230*	
$3p^63d^74p$	23	2	*2 483 140*	
$3p^63d^74p$	23	3	*2 519 060*	
$3p^63d^74p$	19	1	*2 530 230*	
Mo XVIII ($^4F_{9/2}$)	***Limit***		5 130 000	

Mo XVIII

$Z=42$

Mn I isoelectronic sequence

Ground state $1s^22s^22p^63s^23p^63d^7$ ^{4}F$_{9/2}$

Ionization energy 5 660 000 ± 560 000 cm^{-1} (702 ± 69 eV)

Four lines of the $3p^63d^7$–$3p^53d^8$ transition array were classified by Burkhalter *et al.* [1980]. Wyart *et al.* [1983] extended the number of classified lines to 53 with measurements in the range of 66–83 Å, and a measurement uncertainty of ±0.005 Å that gives a level uncertainty of ±100 cm^{-1} . With the resulting levels they predict a magnetic dipole transition between the lowest two levels of $3p^63d^7$ at 4574±15 Å. Only the J value and serial number N assigned in the order of energy for each J are given by them. We obtained designations and percentage composition from diagonalizations of the energy matrices using the radial parameters given by Wyart *et al.*

A value for the ionization energy was calculated by Carlson *et al.* [1970].

References

Burkhalter, P. G., Reader, J., and Cowan, R. D. [1980], J. Opt. Soc. Am. **70**, 912.

Carlson, T. A., Nestor, C. W., Jr., Wasserman, N., and McDowell, J. D. [1970], At. Data Nucl. Data Tables **2**, 63.

Wyart, J. F., Klapisch, M., Schwob, J. L., and Mandelbaum, P. [1983], Phys. Scr. **28**, 381.

Mo XVIII

Configuration	Term	J	Level (cm^{-1})	Leading percentages			
$3p^63d^7$	^{4}F	$9/2$	0	92		8	^{2}G
		$7/2$	21 850	98		2	^{2}G
		$5/2$	31 440	89		6	^{2}D2
$3p^63d^7$	^{4}P	$5/2$	60 740	91		4	^{2}D1
$3p^63d^7$	^{2}G	$9/2$	62 500	71		22	^{2}H
		$7/2$	81 500	94		4	^{2}F
$3p^63d^7$	^{2}H	$11/2$	84 900	100			
		$9/2$	107 650	78		21	^{2}G
$3p^63d^7$	^{2}D2	$5/2$	94 000	65		20	^{2}D1
$3p^63d^7$	^{2}F	$7/2$	141 650	95		4	^{2}G
$3p^63d^7$	^{2}D1	$5/2$	210 770	71		24	^{2}D2
$3p^53d^8$(^{3}F°)	^{4}G°	$11/2$	*1 198 630*	99			
		$9/2$	*1 242 360*	86		12	(^{3}F°) ^{4}F°
$3p^53d^8$		$7/2$	*1 280 420*	36	(^{3}P°) ^{4}D°	31	(^{3}F°) ^{4}G°
$3p^53d^8$(^{3}F°)	^{4}F°	$9/2$	*1 284 110*	46		26	(^{1}G°) ^{2}G°
		$5/2$	*1 322 740*	45		22	(^{3}P°) ^{4}P°
$3p^53d^8$(^{3}P°)	^{4}D°	$7/2$	*1 306 770*	54		13	(^{3}F°) ^{4}G°
$3p^53d^8$(^{3}P°)	^{4}P°	$5/2$	*1 307 600*	47		30	(^{3}P°) ^{4}D°
		$3/2$	*1 336 120*	40		17	
$3p^53d^8$		$7/2$	*1 320 790*	30	(^{3}F°) ^{4}F°	27	(^{1}G°) ^{2}G°

Mo XVIII — Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages			
$3p^53d^8$		$^9/_2$	*1 354 790*	38	$(^1\mathrm{G}^\circ)\ ^2\mathrm{G}^\circ$	35	$(^3\mathrm{F}^\circ)\ ^4\mathrm{F}^\circ$
$3p^53d^8(^1\mathrm{G}^\circ)$	$^2\mathrm{H}^\circ$	$^{11}/_2$	*1 355 000*	99			
		$^9/_2$	*1 494 810*	71		15	$(^3\mathrm{F}^\circ)\ ^2\mathrm{G}^\circ$
$3p^53d^8$		$^7/_2$	*1 362 690*	26	$(^1\mathrm{G}^\circ)\ ^2\mathrm{G}^\circ$	22	$(^1\mathrm{D}^\circ)\ ^2\mathrm{F}^\circ$
$3p^53d^8$		$^5/_2$	*1 377 840*	31	$(^3\mathrm{P}^\circ)\ ^4\mathrm{D}^\circ$	22	$(^3\mathrm{F}^\circ)\ ^4\mathrm{G}^\circ$
$3p^53d^8$		$^5/_2$	*1 383 380*	27	$(^3\mathrm{F}^\circ)\ ^4\mathrm{D}^\circ$	20	$(^3\mathrm{F}^\circ)\ ^2\mathrm{D}^\circ$
$3p^53d^8$		$^7/_2$	*1 406 680*	35	$(^3\mathrm{F}^\circ)\ ^4\mathrm{D}^\circ$	26	$(^3\mathrm{F}^\circ)\ ^4\mathrm{F}^\circ$
$3p^53d^8$		$^5/_2$	*1 479 650*	23	$(^1\mathrm{G}^\circ)\ ^2\mathrm{F}^\circ$	21	$(^1\mathrm{D}^\circ)\ ^2\mathrm{D}^\circ$
$3p^53d^8$		$^7/_2$	*1 492 600*	40	$(^3\mathrm{F}^\circ)\ ^2\mathrm{F}^\circ$	24	$(^3\mathrm{F}^\circ)\ ^4\mathrm{D}^\circ$
$3p^53d^8(^3\mathrm{F}^\circ)$	$^2\mathrm{G}^\circ$	$^7/_2$	*1 517 570*	52		34	$(^1\mathrm{G}^\circ)\ ^2\mathrm{F}^\circ$
		$^9/_2$	*1 574 310*	63		27	$(^1\mathrm{G}^\circ)\ ^2\mathrm{G}^\circ$
$3p^53d^8(^1\mathrm{D}^\circ)$	$^2\mathrm{F}^\circ$	$^5/_2$	*1 559 730*	39		32	$(^3\mathrm{F}^\circ)\ ^2\mathrm{F}^\circ$
$3p^53d^8(^1\mathrm{G}^\circ)$	$^2\mathrm{F}^\circ$	$^7/_2$	*1 610 200*	41		24	$(^1\mathrm{G}^\circ)\ ^2\mathrm{G}^\circ$
$3p^53d^8(^3\mathrm{P}^\circ)$	$^2\mathrm{D}^\circ$	$^5/_2$	*1 615 600*	58		23	$(^3\mathrm{F}^\circ)\ ^2\mathrm{D}^\circ$
$3p^53d^8(^3\mathrm{P}^\circ)$	$^2\mathrm{P}^\circ$	$^3/_2$	*1 646 000*	61		12	$(^3\mathrm{P}^\circ)\ ^2\mathrm{D}^\circ$
....	....	....	....				
Mo xix ($^5\mathrm{D}_4$)	*Limit*		5 660 000				

Mo XIX

$Z = 42$

Cr I isoelectronic sequence

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

Ionization energy 6 190 000 ± 240 000 cm^{-1} (767 ± 30 eV)

No energy levels have been reported for this ion. Schwob *et al.* [1977] observed the unresolved $3d^6$–$3d^54p$ array in the range of 36.0–36.9 Å.

The ionization energy was calculated by Carlson *et al.* [1970].

References

Carlson, T. A., Nestor, C. W., Jr., Wasserman, N., and McDowell, J. D. [1970], At. Data Nucl. Data Tables **2**, 63.

Schwob, J. L., Klapisch, M., Schweitzer, N., Finkenthal, M., Breton, C., DeMichelis, C., and Mattioli, M. [1977], Phys. Lett. A **62**, 85.

Mo XX

$Z = 42$

V I isoelectronic sequence

Ground state $1s^22s^22p^63s^23p^63d^5\ {}^6S_{5/2}$

Ionization energy 6 720 000 ± 270 000 cm^{-1} (833 ± 33 eV)

No energy levels have been reported for this ion. Schwob *et al.* [1977] observed the unresolved $3d^5$–$3d^44f$ array in the range of 25.8–26.6 Å.

The ionization energy was calculated by Carlson *et al.* [1970].

References

Carlson, T. A., Nestor, C. W., Jr., Wasserman, N., and McDowell, J. D. [1970], At. Data Nucl. Data Tables **2**, 63.

Schwob, J. L., Klapisch, M., Schweitzer, N., Finkenthal, M., Breton, C., DeMichelis, C., and Mattioli, M. [1977], Phys. Lett. A **62**, 85.

Mo XXI

$Z = 42$

Ti I isoelectronic sequence

Ground state $1s^22s^22p^63s^23p^63d^4\ {}^5D_0$

Ionization energy 7 280 000 ± 290 000 cm^{-1} (902 ± 36 eV)

No energy levels have been reported for this ion. Schwob *et al.* [1977] observed the unresolved $3d^4$–$3d^34f$ array in the range of 24.5–25.2 Å.

The ionization energy was calculated by Carlson *et al.* [1970].

References

Carlson, T. A., Nestor, C. W., Jr., Wasserman, N., and McDowell, J. D. [1970], At. Data Nucl. Data Tables **2**, 63.

Schwob, J. L., Klapisch, M., Schweitzer, N., Finkenthal, M., Breton, C., DeMichelis, C., and Mattioli, M. [1977], Phys. Lett. A **62**, 85.

Mo XXII

$Z=42$

Sc I isoelectronic sequence

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

Ionization energy 7 810 000 ± 310 000 cm^{-1} (968 ± 38 eV)

No energy levels have been reported for this ion. Schwob *et al.* [1977] observed the unresolved $3d^3$–$3d^24f$ array in the range of 23.5–24.1 Å.

The ionization energy was calculated by Carlson *et al.* [1970].

References

Carlson, T. A., Nestor, C. W., Jr., Wasserman, N., and McDowell, J. D. [1970], At. Data Nucl. Data Tables **2**, 63.

Schwob, J. L., Klapisch, M., Schweitzer, N., Finkenthal, M., Breton, C., DeMichelis, C., and Mattioli, M. [1977], Phys. Lett. A **62**, 85.

Mo XXIII

$Z=42$

Ca I isoelectronic sequence

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

Ionization energy 8 230 000 ± 80 000 cm^{-1} (1020 ± 10 eV)

The first energy interval $3d^2$ $^3F_2-{}^3F_3$ was measured by means of a magnetic dipole transition observed in a tokamak plasma at 3553.3(3) Å by Suckewer *et al.* [1982]. They tentatively identified a second line at 3319.8(3) Å as the magnetic dipole transition between the second and third levels ($3d^2$ $^3F_3$–$^3F_4$). This assignment was found to be incorrect by Wyart *et al.* [1985], on the basis of a theoretical isoelectronic study.

Schwob *et al.* [1977] reported the unresolved $3d^2$–$3d4f$ array at 22.4-22.9 Å.

The value for the ionization energy was calculated by Cowan [981].

References

Cowan, R. D. [1981], *The Theory of Atomic Structure and Spectra*, (Univ. California Press, Berkeley).

Schwob, J. L., Klapisch, M., Schweitzer, N., Finkenthal, M., Breton, C., DeMichelis, C., and Mattioli, M. [1977], Phys. Lett. A **62**, 85.

Suckewer, S., Hinnov, E., Cohen, S., Finkenthal, M., and Sato, K. [1982], Phys. Rev. A **26**, 1161.

Wyart, J. F., Raassen, A. J. J., and Uylings, P. H. M. [1985], Phys. Scr. **32**, 169.

Mo XXIV

$Z = 42$

K I isoelectronic sequence

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

Ionization energy 8 730 000 ± 90 000 cm^{-1} (1082 ± 11 eV)

The ground term $^2D_{3/2}$–$^2D_{5/2}$ splitting is given by the magnetic dipole transition observed at 2686.5(3) Å (in air) by Suckewer *et al.* [1982] in a tokamak discharge. Schwob *et al.* [1977] identified the $3d\ ^2D$–$4f\ ^2F^\circ$ lines at 21 Å in a tokamak spectrum and reported them with a measurement uncertainty of ±0.005 Å.

The levels of $3p^5 3d^2$ were derived by Kaufman, Sugar, and Rowan [1987] from observations of a tokamak plasma in the range of 70–79 Å. Their measurement uncertainty is ±0.01 Å, giving a level uncertainty of ±200 cm^{-1}.

The ionization energy was calculated by Cowan [1981].

References

Cowan, R. D. [1981], *The Theory of Atomic Structure and Spectra*, (Univ. California Press, Berkeley).

Kaufman, V., Sugar, J., and Rowan, W. L. [1987], private communication.

Schwob, J. L., Klapisch, M., Schweitzer, N., Finkenthal, M., Breton, C., DeMichelis, C., and Mattioli, M. [1977], Phys. Lett. A **62**, 85.

Suckewer, S., Hinnov, E., Cohen, S., Finkenthal, M., and Sato, K. [1982], Phys. Rev. A **26**, 1161.

Mo XXIV

Configuration	Term	*J*	Level (cm^{-1})	Leading percentages
$3p^6 3d$	^2D	3/2	0	
		5/2	37 212	
$3p^5(^2P^\circ)3d^2(^3F)$	$^2F^\circ$	5/2	*1 256 070*	
$3p^5(^2P^\circ)3d^2(^1G)$	$^2F^\circ$	7/2	*1 368 040*	
$3p^5(^2P^\circ)3d^2(^3P)$	$^2P^\circ$	1/2	*1 403 130*	
		3/2	*1 442 200*	
$3p^5(^2P^\circ)3d^2(^3F)$	$^2D^\circ$	3/2	*1 413 940*	
		5/2	*1 425 140*	
$3p^6 4f$	$^2F^\circ$	5/2	*4 611 700*	
		7/2	*4 613 000*	
Mo XXV ($^1S_0$)	*Limit*		8 730 000	

Mo XXV

$Z = 42$

Ar I isoelectronic sequence

Ground state $1s^22s^22p^63s^23p^6\ {}^1S_0$

Ionization energy 10 190 000 ± 100 000 cm^{-1} (1263 ± 12 eV)

The $3p^6\ {}^1S_0$–$3p^53d\ {}^3D^\circ_1$, ${}^1P^\circ_1$ resonance lines were observed by Sugar, Kaufman, and Rowan [1987] with a wavelength uncertainty of ±0.01 Å. Schwob *et al.* [1977] reported the two resonance lines $3p^6$–$3p^54d\ {}^3D^\circ_1$, ${}^1P^\circ_1$. Both observations were obtained from tokamak plasmas.

The ionization energy was calculated by Cowan [1981].

References

Cowan, R. D. [1981], *The Theory of Atomic Structure and Spectra*, (Univ. California Press, Berkeley).

Schwob, J. L., Klapisch, M., Schweitzer, N., Finkenthal, M., Breton, C., DeMichelis, C., and Mattioli, M. [1977], Phys. Lett. A **62**, 85.

Sugar, J., Kaufman, V., and Rowan, W. L. [1987], J. Opt. Soc. Am. B **4**, 1927.

Mo XXV

Configuration	Term	J	Level (cm^{-1})	Leading percentages
$3s^23p^6$	${}^1S$	0	0	
$3s^23p^53d$	${}^3D$	1	1 094 950	
$3s^23p^53d$	${}^1P^\circ$	1	*1 348 250*	
$3s^23p^54d$	${}^1P^\circ$	1	*5 405 400*	
$3s^23p^54d$	${}^3D^\circ$	1	*5 562 000*	
Mo XXVI (${}^2P^\circ_{3/2}$)	***Limit***		***10 190 000***	

Mo XXVI

$Z=42$

Cl I isoelectronic sequence

Ground state $1s^22s^22p^63s^23p^5\ ^2P^\circ_{3/2}$

Ionization energy 10 670 000 ± 100 000 cm^{-1} (1323 ± 12 eV)

The magnetic dipole transition $3p^5\ ^2P^\circ_{3/2}$–$^2P^\circ_{1/2}$ was observed at 534.9(3) Å by Denne *et al.* [1983] in a tokamak plasma, giving a level uncertainty of ±100 cm^{-1} for $^2P^\circ_{1/2}$.

Kaufman, Sugar, and Rowan [1987] identified three levels of $3p^43d$ from observations in a tokamak plasma. Their level uncertainty is ±200 cm^{-1}.

The value for the ionization energy was calculated by Cowan [1981].

References

Cowan, R. D. [1981], *The Theory of Atomic Structure and Spectra*, (Univ. California Press, Berkeley).

Denne, B., Hinnov, E., Suckewer, S., and Cohen, S. [1983], Phys. Rev. A **28**, 206.

Kaufman, V., Sugar, J., and Rowan, W. L. [1987], private communication.

Mo XXVI

Configuration	Term	J	Level (cm^{-1})	Leading percentages
$3s^23p^5$	$^2P^\circ$	3/2	*0*	
		1/2	*186 950*	
$3s^23p^4(^3P)3d$	^2D	5/2	1 305 110	
		3/2	1 479 440	
$3s^23p^4(^3P)3d$	^2P	3/2	1 321 060	
Mo XXVII ($^3P_2$)	***Limit***		**10 670 000**	

Mo XXVII

$Z=42$

S I isoelectronic sequence

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

Ionization energy 11 190 000 ± 110 000 cm^{-1} (1387 ± 14 eV)

The following magnetic dipole transitions were observed in tokamak plasmas:

$3s^23p^4$	$^3P_2$–$^3P_1$	569.8(1) Å	Denne *et al.* [1983]
	$^3P_1$–$^1D_2$	2350.8(3) Å (in air)	Hinnov [1985]
	$^3P_2$–$^1D_2$	458.6(2) Å	Denne *et al.* [1983]
	$^3P_1$–$^1S_0$	397.2(3) Å	Hinnov [1985]

The $^3P_1$–$^3P_0$ transition was calculated by Sugar and Kaufman [1984] at 909.8 ± 5.0 Å. All the levels of the $3s^23p^4$ configuration are derived from these lines with a level uncertainty of ±100 cm^{-1}.

The three levels of $3s^23p^33d$ were obtained by Kaufman, Sugar, and Rowan [1987] from observations of a tokamak discharge. The level uncertainty is ±200 cm^{-1}.

The value for the ionization energy was calculated by Cowan [1981].

References

Cowan, R. D. [1981], *The Theory of Atomic Structure and Spectra*, (Univ. California Press, Berkeley).

Denne, B., Hinnov, E., Suckewer, S., and Cohen, S. [1983], Phys. Rev. A **28**, 206.

Hinnov, E. [1985], private communication.

Kaufman, V., Sugar, J., and Rowan, W. L. [1987], private communication.

Sugar, J., and Kaufman, V. [1984], J. Opt. Soc. Am. B **1**, 218.

Mo XXVII

Configuration	Term	J	Level (cm^{-1})	Leading percentages
$3s^23p^4$	^3P	2	0	
		0	[65 580]	
		1	175 500	
$3s^23p^4$	^1D	2	218 040	
$3s^23p^4$	^1S	0	427 260	
$3s^23p^3(^2D^\circ)3d$	$^3P^\circ$	2	*1 277 660*	
$3s^23p^3(^4S^\circ)3d$	$^3D^\circ$	3	*1 281 140*	
$3s^23p^3(^2D^\circ)3d$	$^1D^\circ$	2	*1 442 010*	
Mo XXVIII ($^4S^\circ_{3/2}$)	*Limit*		*11 190 000*	

Mo XXVIII

$Z = 42$

P I isoelectronic sequence

Ground state $1s^2 2s^2 2p^6 3s^2 3p^3\ {}^4S^\circ_{3/2}$

Ionization energy 11 690 000 ± 110 000 cm^{-1} (1449 ± 14 eV)

The following magnetic dipole transitions were observed in tokamak plasmas:

$3s^2 3p^3$	${}^4S^\circ_{3/2}$–${}^2P^\circ_{1/2}$	387.7(3) Å	Denne *et al.* [1984]
	${}^4S^\circ_{3/2}$–${}^2D^\circ_{5/2}$	498.2(2) Å	Denne *et al.* [1983]
	${}^4S^\circ_{3/2}$–${}^2D^\circ_{3/2}$	637.1(2) Å	Denne *et al.* [1984]
	${}^2D^\circ_{3/2}$–${}^2P^\circ_{3/2}$	389.9(2) Å	Denne *et al.* [1984]
	${}^2D^\circ_{3/2}$–${}^2D^\circ_{5/2}$	2285.4(1) Å (air)	Denne *et al.* [1983]
	${}^2D^\circ_{5/2}$–${}^2P^\circ_{3/2}$	470.0(2) Å	Denne *et al.* [1984]
	${}^2P^\circ_{1/2}$–${}^2P^\circ_{3/2}$	643.0(5) Å	Denne *et al.* [1984]

Levels of this configuration are derived from these data with an uncertainty of ±100 cm^{-1}.

The value for the ionization energy was calculated by Cowan [1981].

References

Cowan, R. D. [1981], *The Theory of Atomic Structure and Spectra,* (Univ. California Press, Berkeley).

Denne, B., Hinnov, E., Suckewer, S., and Cohen, S. [1983], Phys. Rev. A **28**, 206.

Denne, B., Hinnov, E., Suckewer, S., and Timberlake, J. [1984], J. Opt. Soc. Am. B **1**, 296.

Mo XXVIII

Configuration	Term	J	Level (cm^{-1})	Leading percentages
$3s^2 3p^3$	${}^4S^\circ$	3/2	*0*	
$3s^2 3p^3$	${}^2D^\circ$	3/2	*156 960*	
		5/2	*200 702*	
$3s^2 3p^3$	${}^2P^\circ$	1/2	*257 930*	
		3/2	*413 450*	
Mo XXIX (${}^3P_0$)	*Limit*		11 690 000	

Mo XXIX

$Z = 42$

Si I isoelectronic sequence

Ground state $1s^2 2s^2 2p^6 3s^2 3p^2\ {}^3P_0$

Ionization energy 12 380 000 ± 130 000 cm^{-1} (1535 ± 16 eV)

The following magnetic dipole transitions were observed in tokamak plasmas:

$3s^2 3p^2$	$^3P_0$–$^3P_1$	618.5(3) Å	Denne *et al.* [1983]
	$^3P_1$–$^3P_2$	2841.1(2) Å (air)	Denne *et al.* [1983]
	$^3P_2$–$^1D_2$	530.3(3) Å	Hinnov [1985]
	$^3P_1$–$^1D_2$	446.9(2) Å	Hinnov [1985]
	$^3P_1$–$^1S_0$	325.3(3) Å	Denne *et al.* [1983]

The $^3P_1$–$^1S_0$ line is a tentative identification. The uncertainty of the level values derived from these data is ±100 cm^{-1}.

The value for the ionization energy was calculated by Cowan [1981].

References

Cowan, R. D. [1981], *The Theory of Atomic Structure and Spectra,* (Univ. California Press, Berkeley).

Denne, B., Hinnov, E., Suckewer, S., and Cohen, S. [1983], Phys. Rev. A **28**, 206.

Hinnov, E. [1985], private communication.

Mo XXIX

Configuration	Term	J	Level (cm^{-1})	Leading percentages
$3s^2 3p^2$	^3P	0	0	
		1	161 680	
		2	196 870	
$3s^2 3p^2$	^1D	2	385 440	
$3s^2 3p^2$	^1S	0	469 100?	
Mo XXX ($^2P^\circ_{1/2}$)	***Limit***		***12 380 000***	

Mo XXX

$Z = 42$

Al I isoelectronic sequence

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

Ionization energy 12 910 000 ± 130 000 cm^{-1} (1601 ± 16 eV)

The magnetic dipole transition $^2\mathrm{P}^\circ_{1/2}$–$^2\mathrm{P}^\circ_{3/2}$ within the ground configuration $3s^23p$ was observed by Denne *et al.* [1983] in a tokamak plasma at 490.1(3) Å.

Burkhalter, Reader, and Cowan [1977] tentatively identified the $3p$–$3d$ doublet, the three lines of $3p$–$4d$, the $3p$–$4s$ doublet, and the two stronger lines of $3d$–$4f$ in spectra of a laser-produced plasma. Their results are based on comparison of their laser-generated spectra with predicted wavelengths obtained with relativistic Hartree-Fock calculations. Their wavelength uncertainty is ±0.010 Å. Hinnov *et al.* [1986] reported observations of the $3s^23p$–$3s3p^2$ and $3s^23p$–$3s^23d$ arrays in a tokamak plasma for Zn, Ge, Se, Zr, Mo, and Ag. The regularities of these transitions led them to select different lines for $3p$–$3d$ than Burkhalter *et al.* We use the classifications of Hinnov *et al.* and the improved wavelengths (±0.01Å) of Sugar, Kaufman, and Rowan [1987]. The percentage composition of the $3s3p^2$ configuration mixed with $3s^23d$ was obtained by Sugar *et al.* The predicted value for $3s3p^2$ $^4\mathrm{P}_{1/2}$ results from a least-squares fit to the known levels.

The ionization energy was calculated by Cowan [1981].

References

Burkhalter, P. G., Reader, J., and Cowan, R. D. [1977], J. Opt. Soc. Am. **67**, 1521.

Cowan, R. D. [1981], *The Theory of Atomic Structure and Spectra*, (Univ. California Press, Berkeley).

Denne, B., Hinnov, E., Suckewer, S., and Cohen, S. [1983], Phys. Rev. A **28**, 206.

Hinnov, E., Boody, F., Cohen, S., Feldman, U., Hosea, J., Sato, K., Schwob, J. L., Suckewer, S., and Wouters, A. [1986], J. Opt. Soc. Am. B **3**, 1288.

Sugar, J., Kaufman, V., and Rowan, W. L. [1988], J. Opt. Soc. Am. B, in press.

Mo XXX

Configuration	Term	J	Level (cm^{-1})	Leading percentages		
$3s^23p$	$^2\mathrm{P}^\circ$	1/2	*0*			
		3/2	*204 020*			
$3s3p^2$	$^4\mathrm{P}$	1/2	[528 400]	82	14	$^2\mathrm{S}$
$3s3p^2$	$^2\mathrm{D}$	3/2	816 860	76	12	$3s^23d$ $^2\mathrm{D}$
		5/2	914 330	54	34	$3s3p^2$ $^4\mathrm{P}$
$3s3p^2$	$^2\mathrm{P}$	1/2	891 280	67	21	$^2\mathrm{S}$
		3/2	1 150 820	45	32	$3s^23d$ $^2\mathrm{D}$
$3s^23d$	$^2\mathrm{D}$	3/2	1 080 540	56	43	$3s3p^2$ $^2\mathrm{P}$
		5/2	1 162 130	86	13	$3s3p^2$ $^2\mathrm{D}$
$3s3p^2$	$^2\mathrm{S}$	1/2	1 095 240	65	30	$^2\mathrm{P}$
$3s^24s$	$^2\mathrm{S}$	1/2	5 760 000			
$3s^24d$	$^2\mathrm{D}$	3/2	6 405 000			
		5/2	6 426 000			
$3s^24f$	$^2\mathrm{F}^\circ$	7/2	*6 701 000*			
		5/2	*6 718 000*			
Mo XXXI ($^1\mathrm{S}_0$)	***Limit***		**12 910 000**			

Mo XXXI

$Z=42$

Mg I isoelectronic sequence

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

Ionization energy 13 920 000 ± 140 000 cm^{-1} (1726 ± 17 eV)

Levels of the $3s3p$ configuration are determined with an uncertainty of ± 500 cm^{-1} from tokamak and laser plasma observations. The spin-forbidden transition $3s^2\ {}^1S_0$–$3s3p\ {}^3P_1^\circ$ was identified by Finkenthal *et al.* [1982] at 190.5(2) Å in a tokamak discharge. A more accurate value of 190.466 Å was measured by Sugar, Kaufman, and Rowan [1987] in the same type source. From the same type plasma Hinnov [1976] observed the $3s^2\ {}^1S_0$–$3s3p\ {}^1P_1^\circ$ line and Denne *et al.* [1983] observed the magnetic dipole transition ${}^3P_1^\circ$–${}^3P_2^\circ$ within the $3s3p$ configuration at 577.5(3) Å. The latter paper gave a line at 609.8(3) Å classified in the P sequence as $3p^3\ {}^4S_{3/2}^\circ$–${}^2D_{3/2}^\circ$, but a new line at 637.1 Å was later assigned to this transition by Denne *et al.* [1984]. The line at 609.8 Å was proposed as the $3s3p\ {}^3P_2^\circ$–${}^1P_1^\circ$ transition by Kaufman and Sugar [1986]. It provided a value for the $3s3p\ {}^1P_1^\circ$ term in agreement within 40 cm^{-1} with the resonance transition from this level remeasured by Reader [1983] at 115.991(15) Å.

Two lines of the $3s3p$–$3s3d$ array, the ${}^3P_2^\circ$–${}^3D_3$ at 112.654(15) Å and ${}^1P_1^\circ$–${}^1D_2$ at 113.896(15) Å, were given by Reader and also given earlier by Burkhalter *et al.* [1977] and Mansfield *et al.* [1978]. The Mansfield paper gave several other lines of this array but on the basis of known or estimated level intervals of $3s3p$ only the ${}^3P_1^\circ$–${}^3D_2$ line at 96.52(2) Å is adopted. The improved measured value of 96.513 Å by Kaufman *et al.* [1987] is used here.

Both resonance lines from the $3s4p$ configuration, ${}^3P_1^\circ$ and ${}^1P_1^\circ$ to $3s^2\ {}^1S_0$, were reported by Burkhalter *et al.* The latter was given earlier by Schwob *et al.* [1977] and by Mansfield *et al.* Five lines of the $3s3d$–$3s4f$ array were reported by Burkhalter *et al.* at ~17 Å with an uncertainty of ±0.010 Å.

Many more lines of this ion are classified by Mansfield *et al.* that require further confirmation.

The ionization energy was calculated by Cowan [1981].

References

Burkhalter, P. G., Reader, J., and Cowan, R. D. [1977], J. Opt. Soc. Am. **67**, 1521.

Cowan, R. D. [1981], *The Theory of Atomic Structure and Spectra,* (Univ. California Press, Berkeley).

Denne, B., Hinnov, E., Suckewer, S., and Cohen, S. [1983], Phys. Rev. A **28**, 206.

Denne, B., Hinnov, E., Suckewer, S., and Timberlake, J. [1984], J. Opt. Soc. Am. B **1**, 296.

Finkenthal, M., Hinnov, E., Cohen, S., and Suckewer, S. [1982], Phys. Lett. A **91**, 284.

Hinnov, E. [1976], Phys. Rev. A **14**, 1533.

Kaufman, V., and Sugar, J. [1986], J. Phys. Chem. Ref. Data **15**, 321.

Kaufman, V., Sugar, J., and Rowan, W. L. [1987], private communication.

Mansfield, M. W. D., Peacock, N. J., Smith, C. C., Hobby, M. G., and Cowan, R. D. [1978], J. Phys. B **11**, 1521.

Reader, J. [1983], J. Opt. Soc. Am. **73**, 796.

Schwob, J. L., Klapisch, M., Schweitzer, N., Finkenthal, M., Breton, C., DeMichelis, C., and Mattioli, M. [1977], Phys. Lett. A **62**, 85.

Sugar, J., Kaufman, V., and Rowan, W. L. [1987], J. Opt. Soc. Am. B **4**, 1927.

Mo XXXI

Configuration	Term	J	Level (cm^{-1})	Leading percentages
$3s^2$	^{1}S	0	0	
$3s3p$	^{3}P°	0		
		1	*525 028*	
		2	*698 188*	
$3s3p$	^{1}P°	1	*862 140*	
$3s3d$	^{3}D	1		
		2	1 561 160	
		3	1 585 860	
$3s3d$	^{1}D	2	1 740 130	

Mo XXXI — Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages
$3s4p$	$^3P^\circ$	0		
		1	*6 698 800*	
		2		
$3s4p$	$^1P^\circ$	1	*6 782 000*	
$3s4f$	$^3F^\circ$	2		
		3	*7 275 000*	
		4	*7 281 800*	
$3s4f$	$^1F^\circ$	3	*7 335 800*	
....	....	......	....	
Mo XXXII ($^2S_{1/2}$)	***Limit***		**13 920 000**	

Mo XXXII

$Z=42$

Na I isoelectronic sequence

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

Ionization energy 14 448 000 ± 5 000 cm^{-1} (1791.3 ± 0.6 eV)

Hinnov [1976] observed two lines of this spectrum at 129(1) Å and 177(1) Å in a tokamak plasma, and identified them as the $3s$–$3p$ doublet. Burkhalter *et al.* [1977] and Mansfield *et al.* [1978] found two lines in the vicinity of the line at 129 Å and identified them as $3s$ $^2S_{1/2}$–$3p$ $^2P^\circ_{3/2}$ and $3p$ $^2P^\circ_{3/2}$–$3d$ $^2D_{5/2}$. Burkhalter's measurement for the $3s$–$3p$ line is 127.814(10) Å and for $3p$-$3d$ 126.937(10) Å. These tentative identifications were confirmed by Reader [1985] who established the corresponding identifications for other neighboring members of the isoelectronic sequence. More accurate values for the $3s-3p$, $3p-3d$, and $3d-4f$ doublets are given in a study of the wavelengths for these sequences by Reader *et al.* [1987]. A new set of measurements by Reader *et al.* [1988] enabled them to improve level values for the $n=4$, 5, and 6 terms and to find the $5g$ ^2G term. They used the wavelengths given by Reader *et al.* [1987] to derive the $3p$, $3d$, and $4f$ terms. The uncertainty of the $n=3$ levels is ±50 cm^{-1}, of the $n=4$ levels ±3000 cm^{-1}, and of the $n=5$ levels ±5000 cm^{-1}.

The ionization energy was derived by Edlén from a polarization treatment of the nf levels.

References

Burkhalter, P. G., Reader, J., and Cowan, R. D. [1977], J. Opt. Soc. Am. **67**, 1521.

Edlén, B. [1978], Phys. Scr. **17**, 565.

Hinnov, E. [1976], Phys. Rev. A **14**, 1533.

Mansfield, M. W. D., Peacock, N. J., Smith, C. C., Hobby, M. G., and Cowan, R. D. [1978], J. Phys. B **11**, 1521.

Reader, J. [1985], private communication.

Reader, J., Ekberg, J. O., Feldman, U., Brown, C. M., and Seely, J. F. [1988], private communication.

Reader, J., Kaufman, V., Sugar, J., Ekberg, J. O., Feldman, U., Brown, C. M., Seely, J. F., and Rowan, W. L. [1987], J. Opt. Soc. Am. B **4**, 1821.

Mo XXXII

Configuration	Term	J	Level (cm^{-1})	Leading percentages
$3s$	^2S	1/2	0	
$3p$	$^2P^\circ$	1/2	*566 098*	
		3/2	*782 056*	
$3d$	^2D	3/2	1 524 931	
		5/2	1 569 588	
$4s$	^2S	1/2	*6 630 700*	
$4p$	$^2P^\circ$	1/2	*6 865 500*	
		3/2	*6 951 500*	
$4d$	^2D	3/2	7 231 500	
		5/2	7 251 600	
$4f$	$^2F^\circ$	5/2	*7 392 800*	
		7/2	*7 400 800*	
$5p$	$^2P^\circ$	1/2	*9 687 100*	
		3/2	*9 735 200*	
$5d$	^2D	3/2	9 853 700	
		5/2	9 863 900	
$5f$	$^2F^\circ$	5/2	*9 933 300*	
		7/2	*9 937 000*	

Mo XXXII — Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages
5g	^{2}G	$^7/_2$	9 944 900	
		$^9/_2$	9 947 200	
6f	^{2}F°	$^5/_2$	*11 331 700*	
		$^7/_2$	*11 334 300*	
Mo XXXIII (^{1}S$_0$)	***Limit***		**14 448 000**	

Mo XXXIII

$Z=42$

Ne I isoelectronic sequence

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

Ionization energy 34 340 000 ± 340 000 cm^{-1} (4257 ± 42 eV)

Identifications of resonance lines from the $n=3$ shell $2p^6$–$2p^53s$, $3d$, and $2s2p^63p$, were reported by Aglitskii *et al.* [1975] from spectra of a laser plasma. Improved values for four of the six lines were obtained by Aglitskii *et al.* [1979] using a low-inductance spark, and the transition from $2p^53d\ ^3P_1^\circ$ was added. The accuracy of these data is ±0.001 Å.

By means of exploding wires Burkhalter *et al.* [1977] observed the above transitions and resonance lines from the $2p^54s$ and $4d$ configurations with an uncertainty of ±0.02 Å, or 120 000 cm^{-1}. With probably the same wavelength uncertainty Burkhalter *et al.* [1978] identified resonance lines from the $2p^55d$, $6d$, and $7d$ configurations. The uncertainty in levels with a $n=3$ outer electron is ±30 000 cm^{-1}, with $n=4$ is ±120 000 cm^{-1}, and with $n=5$, 6 is ±300 000 cm^{-1}.

The ionization energy was calculated by Cowan [1981].

References

Aglitskii, E. V., Boiko, V. A. Krokhin, O. N., Pikuz, S. A., and Faenov, A. Ya. [1975], Sov. J. Quant. Electron. **4**, 1152.

Aglitskii, E. V., Golts, E. Ya., Levykin, Yu. A., Livshits, A. M., Mandelstam, S. L., and Safronova, A. S. [1979], Opt. Spectrosc. (USSR) **46**, 590.

Burkhalter, P. G., Dozier, C. M., and Nagel, D. J. [1977], Phys. Rev. A **15**, 700.

Burkhalter, P. G., Schneider, R., Dozier, C. M., and Cowan, R. D. [1978], Phys. Rev. A **18**, 718.

Cowan, R. D. [1981], *The Theory of Atomic Structure and Spectra*, (Univ. California Press, Berkeley).

Mo XXXIII

Configuration	Term	J	Level (cm^{-1})	Leading percentages
$2s^22p^6$	^1S	0	0	
$2s^22p^53s$	$^3P^\circ$	1	*19 220 000*	
$2s^22p^53s$	$^1P^\circ$	1	*20 080 000*	
$2s^22p^53d$	$^3P^\circ$	1	*20 612 000*	
$2s^22p^53d$	$^3D^\circ$	1	*20 814 000*	
$2s^22p^53d$	$^1P^\circ$	1	*21 593 000*	
$2s2p^63p$	$^3P^\circ$	1	*22 398 000*	
$2s2p^63p$	$^1P^\circ$	1	*22 634 000*	
$2s^22p^54s$	$^3P^\circ$	1	*26 250 000*	
$2s^22p^54s$	$^1P^\circ$	1	*26 570 000*	
$2s^22p^54d$	$^3D^\circ$	1	*27 140 000*	
$2s^22p^54d$	$^1P^\circ$	1	*27 500 000*	
$2s^22p^55d$	$^3D^\circ$	1	*29 200 000*	
$2s^22p^55d$	$^1P^\circ$	1	*30 100 000*	

Mo XXXIII — Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages
$2s^22p^56d$	$^3D^\circ$	1	*30 700 000*	
$2s^22p^56d$	$^1P^\circ$	1	*31 400 000*	
$2s^22p^57d$	$^1P^\circ$	1	*32 400 000*	
Mo XXXIV ($^2P^\circ_{3/2}$)	***Limit***		***34 340 000***	

Mo XXXIV

$Z=42$

F I isoelectronic sequence

Ground state $1s^22s^22p^5\ {}^2\mathrm{P}^\circ_{3/2}$

Ionization energy 35 730 000 ± 350 000 cm^{-1} (4430 ± 43 eV)

Reader *et al.* [1986] have identified the $2s^22p^5$–$2s2p^6$ transitions at 37.661(15) Å and 56.257(15) Å. Their measurements determined the $2p^5\ {}^2\mathrm{P}^\circ$ ground term splitting.

The transition array $2p^5$–$2p^43d$ was observed by Boiko *et al.* [1978] in a laser generated plasma. Classifications of the lines relied on predictions of the spectrum provided privately to them by Rudzikas and isoelectronic data available from Fe XVIII to Se XXVI. The Mo array falls at ~4.5 Å, and was measured in the third order of diffraction of a crystal spectrometer with an uncertainty of ±0.002 Å.

The ionization energy was calculated by Cowan [1981].

References

Boiko, V. A., Pikuz, S. A., Safronova, A. S., and Faenov, A. Ya. [1978], J. Phys. B **11**, L503.

Cowan, R. D. [1981], *The Theory of Atomic Structure and Spectra,* (Univ. California Press, Berkeley).

Reader, J., Brown, C. M., Ekberg, J. O., Feldman, U., Seely, J. F., and Behring, W. E. [1986], J. Opt. Soc. Am. B **3**, 1609.

Mo XXXIV

Configuration	Term	J	Level (cm^{-1})	Leading percentages
$2s^22p^5$	$^2\mathrm{P}^\circ$	3/2 1/2	*0* *886 200*	
$2s2p^6$	$^2\mathrm{S}$	1/2	2 655 300	
$2s^22p^4(^3\mathrm{P})3d$	$^2\mathrm{F}$	5/2	18 060 000	
$2s^22p^4(^3\mathrm{P})3d$	$^2\mathrm{D}$	3/2 5/2	21 978 000 22 119 000	
$2s^22p^4(^1\mathrm{D})3d$	$^2\mathrm{S}$	1/2	22 163 000	
$2s^22p^4(^1\mathrm{D})3d$	$^2\mathrm{P}$	3/2 1/2	22 193 000 22 361 000	
$2s^22p^4(^1\mathrm{D})3d$	$^2\mathrm{D}$	5/2 3/2	22 207 000 22 321 000	
$2s^22p^4(^1\mathrm{S})3d$	$^2\mathrm{D}$	3/2	23 143 000	
Mo XXXV ($^3\mathrm{P}_2$)	***Limit***		**35 730 000**	

Mo XXXV

$Z=42$

O I isoelectronic sequence

Ground state $1s^2 2s^2 2p^4$ $^3P_2$

Ionization energy 37 240 000 ± 370 000 cm^{-1} (4617 ± 46 eV)

No energy levels have been reported for this ion. The value for the ionization energy was calculated by Cowan [1981].

Reference

Cowan, R. D. [1981], *The Theory of Atomic Structure and Spectra*, (Univ. California Press, Berkeley).

Mo XXXVI

$Z=42$

N I isoelectronic sequence

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

Ionization energy 38 700 000 ± 390 000 cm^{-1} (4798 ± 48 eV)

No energy levels have been reported for this ion. The value for the ionization energy was calculated by Cowan [1981].

Reference

Cowan, R. D. [1981], *The Theory of Atomic Structure and Spectra*, (Univ. California Press, Berkeley).

Mo XXXVII

$Z=42$

C I isoelectronic sequence

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

Ionization energy 41 130 000 ± 410 000 cm^{-1} (5099 ± 51 eV)

No energy levels have been reported for this ion. The value for the ionization energy was calculated by Cowan [1981].

Reference

Cowan, R. D. [1981], *The Theory of Atomic Structure and Spectra*, (Univ. California Press, Berkeley).

Mo XXXVIII

$Z=42$

B I isoelectronic sequence

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

Ionization energy 42 720 000 ± 430 000 cm^{-1} (5296 ± 53 eV)

No energy levels have been reported for this ion. The value for the ionization energy was calculated by Cowan [1981].

Reference

Cowan, R. D. [1981], *The Theory of Atomic Structure and Spectra*, (Univ. California Press, Berkeley).

Mo XXXIX

$Z=42$

Be I isoelectronic sequence

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

Ionization energy 44 730 000 ± 440 000 cm^{-1} (5546 ± 55 eV)

No energy levels have been reported for this ion. The value for the ionization energy was calculated by Cowan [1981].

Reference

Cowan, R. D. [1981], *The Theory of Atomic Structure and Spectra*, (Univ. California Press, Berkeley).

Mo XL

$Z=42$

Li I isoelectronic sequence

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

Ionization energy 46 065 200 ± 5000 cm^{-1} (5711.36 ± 0.62 eV)

No experimental data are available for this ion. Vainshtein and Safronova [1985] have calculated the energy levels through $n=5$ and estimated the uncertainty to be 1 part in 10^4 relative to the ground state and 1 part in 10^3 for the fine structure splitting. We give their results in brackets, indicating theoretical values. The ionization energy was derived from these levels.

Reference

Vainshtein, L. A., and Safronova, U. I. [1985], Phys. Scr. **31**, 519.

Mo XL

Configuration	Term	J	Level (cm^{-1})	Leading percentages
$1s^22s$	^2S	1/2	0	
$1s^22p$	$^2P^\circ$	1/2	*[691 590]*	
		3/2	*[1 705 600]*	
$1s^23s$	^2S	1/2	[25 863 400]	
$1s^23p$	$^2P^\circ$	1/2	*[26 055 000]*	
		3/2	*[26 355 400]*	
$1s^23d$	^2D	3/2	[26 423 600]	
		5/2	[26 517 450]	
$1s^24s$	^2S	1/2	[34 790 700]	
$1s^24p$	$^2P^\circ$	1/2	*[34 870 800]*	
		3/2	*[34 997 400]*	
$1s^24d$	^2D	3/2	[35 025 900]	
		5/2	[35 065 560]	
$1s^25s$	^2S	1/2	[38 888 700]	
$1s^25p$	$^2P^\circ$	1/2	*[38 929 500]*	
		3/2	*[38 994 220]*	
$1s^25d$	^2D	3/2	[39 008 700]	
		5/2	[39 029 010]	
Mo XLI ($^1S_0$)	*Limit*		**[46 065 200]**	

Mo XLI

$Z=42$

He I isoelectronic sequence

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

Ionization energy 191 892 800 ± 800 cm^{-1} (23 791.67 ± 0.10 eV)

No reliable experimental data are available for this ion. Vainshtein and Safronova [1985] have calculated the energy levels through $n=5$ and estimated the uncertainty to be 1 part in 10^4 relative to the ground level.

An improved multiconfiguration Dirac-Fock calculation was provided by Indelicato [1987]. His QED corrections for $n=1,2$ were obtained as described by Indelicato, Gorceix, and Desclaux [1987]. For $n>2$ the one-electron correction is scaled as $1/n^3$, and the rest follows Indelicato *et al.* He estimates the uncertainty to be ±0.1 eV relative to the ground level and ±0.01 eV for $\Delta n=0$ intervals. His results are compiled here.

References

Indelicato, P. [1987], private communication.

Indelicato, P. J., Gorceix, O., and Desclaux, J. P. [1987], J. Phys. B **20**, 651.

Vainshtein, L. A., and Safronova, U. I. [1985], Phys. Scr. **31**, 519.

Mo XLI

Configuration	Term	J	Level (cm^{-1})	Leading percentages		
$1s^2$	^1S	0	0			
$1s2s$	^3S	1	[143 972 042]			
$1s2p$	$^3P^\circ$	0	*[144 418 218]*			
		1	*[144 429 731]*	77	23	$^1P^\circ$
		2	*[145 466 036]*			
$1s2s$	^1S	0	[144 441 297]			
$1s2p$	$^1P^\circ$	1	*[145 685 798]*	77	23	$^3P^\circ$
$1s3s$	^3S	1	[170 903 110]			
$1s3p$	$^3P^\circ$	0	*[171 025 507]*			
		1	*[171 028 623]*	76	24	$^1P^\circ$
		2	*[171 337 276]*			
$1s3s$	^1S	0	[171 027 461]			
$1s3p$	$^1P^\circ$	1	*[171 398 128]*	76	24	$^3P^\circ$
$1s4s$	^3S	1	[180 230 481]			
$1s4p$	$^3P^\circ$	0	*[180 280 592]*			
		1	*[180 281 884]*	76	24	$^1P^\circ$
		2	*[180 411 971]*			
$1s4s$	^1S	0	[180 280 817]			
$1s4p$	$^1P^\circ$	1	*[180 437 009]*	76	24	$^3P^\circ$
$1s5s$	^3S	1	[184 517 023]			
$1s5p$	$^3P^\circ$	0	[184 542 284]			
		1	[184 542 940]	76	24	$^1P^\circ$
		2	[184 609 428]			

Mo XLI — Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages
1*s*5*s*	^{1}S	0	[184 542 596]	
1*s*5*p*	^{1}P°	1	[*184 622 089*]	76 24 ^{3}P°
Mo XLII (^{2}S$_{1/2}$)	***Limit***		**[191 892 800]**	

Mo XLII

$Z=42$

H I isoelectronic sequence

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

Ionization energy 198 188 330 ± 200 cm^{-1} (24 572.22 ± 0.02 eV)

Turachek and Kunze [1975] measured the wavelength of the 1s $^2S_{1/2}$–2p $^2P^\circ_{3/2}$ transition as 0.6685(5) Å. We quote the results of Johnson and Soff [1985] who calculated the Dirac energies of the 1s, 2s, and 2p orbits including QED and extended-nucleus corrections. Their estimated accuracy is 1 part in 10^6 for the term energies and ±20 cm^{-1} for the term splittings.

For $n=3$ to 5 we give the Dirac-energy calculations of Kim [1987] who used $1/n^3$ scaling for the QED corrections. The accuracy is about the same as for lower n because the corrections are much smaller.

References

Johnson, W. R., and Soff, G. [1985], At. Data Nucl. Data Tables **33**, 405.

Kim, Y. K. [1987], private communication.

Turachek, J. J., and Kunze, H. J. [1975], Z. Phys. A **273**, 111.

Mo XLII

Configuration	Term	J	Level (cm^{-1})	Leading percentages
1s	^{2}S	$1/2$	0	
2p	^{2}P°	$1/2$	*[148 298 990]*	
		$3/2$	*[149 508 870]*	
2s	^{2}S	$1/2$	[148 322 640]	
3p	^{2}P°	$1/2$	*[176 150 820]*	
		$3/2$	*[176 509 990]*	
3s	^{2}S	$1/2$	[176 157 830]	
3d	^{2}D	$3/2$	[176 509 280]	
		$5/2$	[176 623 650]	
4p	^{2}P°	$1/2$	*[185 848 990]*	
		$3/2$	*[186 000 200]*	
4s	^{2}S	$1/2$	[185 851 950]	
4d	^{2}D	$3/2$	[185 999 910]	
		$5/2$	[186 048 250]	
4f	^{2}F°	$5/2$	*[186 048 170]*	
		$7/2$	*[186 072 080]*	
5p	^{2}P°	$1/2$	*[190 316 650]*	
		$3/2$	*[190 393 910]*	
5s	^{2}S	$1/2$	[190 318 170]	
5d	^{2}D	$3/2$	[190 393 760]	
		$5/2$	[190 418 520]	
5f	^{2}F°	$5/2$	*[190 418 470]*	
		$7/2$	*[190 430 730]*	

Mo XLII — Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages
5*g*	^{2}G	$^7/_2$	[190 430 710]	
		$^9/_2$	[190 438 030]	
	Limit		**[198 188 330]**	