Energy Levels of Manganese, Mn I through Mn XXV

Charles Corliss and Jack Sugar

Institute for Basic Standards, National Bureau of Standards, Washington, D.C. 20234

The energy levels of the manganese atom in all of its stages of ionization, as derived from the analyses of atomic spectra, have been compiled. In cases where only line classifications are given in the literature, level values have been derived. The percentages for the two leading components of the calculated eigenvectors of the levels are given where available. Ionization energies and g-values are also given.

Key words: Atomic energy levels; atomic spectra; manganese.

Contents

1. Introduction

New compilations of energy levels of atoms and ions of the iron period are being undertaken by the NBS Atomic Energy Levels Data Center of the Spectroscopy Section. Publication of chromium by Sugar and Corliss (1977) and iron by Reader and Sugar (1975) has been completed. The previous compilation of manganese energy levels, by Moore (1952), includes only fourteen of the twenty-five manganese spectra and many of those have since been significantly revised or corrected. A great amount of new experimental work has been carried out since then, particularly in the higher stages of ionization, as a result of the development of new and more energetic light sources and of interest in identification of lines in the ultra-violet solar spectrum now being observed from rockets and satellites. A new impetus to this type of research also arises from the need for spectroscopic data related to radiative energy losses encountered in hot laboratory plasmas generated to achieve controlled thermonuclear reactions.

The present compilation comprises the energy levels of the manganese atom and all of its ions, as derived from analyses of atomic spectra. These are primarily levels arising from outer-shell excitations. For the high stages of ionization, inner-shell excitations are included since the distinction in energy becomes less clear. For many of the ions the original papers do not give energy level values, but only classifications of observed lines. In these cases we have derived the level values. Although in most cases we used only published papers as sources of data, unpublished material was included when it constituted a considerable improvement.

We have also derived some of the ionization energies from the observed levels.[1] For a large number of ions, too few levels are known to permit the derivation of an experimental value of the ionization energy. In these cases we have quoted estimated values obtained by extrapolation along isoelectronic sequences. Although it is not possible to give a quantitative uncertainty for these extrapolated values, they are probably accurate to a few units of the last significant figure given. Edlén (1971) has recently published a set of semiempirical formulas that could be used to obtain new estimates for a number of the ionization energies.

[1] Values for ionization energies are usually derived in their equivalence in cm^{-1}. The conversion factor 8065.479 cm^{-1}/eV, as given by E. R. Cohen and B. N. Taylor, J. Phys. Chem. Ref. Data **2**, 663 (1973), was used to obtain values in eV.

Nearly all of the data are the results of observations of various types of laboratory light sources. However, they are sometimes supplemented by data obtained from solar observations. This is particularly true where spin-forbidden lines are required to establish the absolute energy of a system of excited levels and also where parity-forbidden transitions between levels of a ground configuration are used to obtain accurate relative energies for the low levels. Whenever both solar data and equivalent laboratory data were available for a given level system or part of a level system, preference was generally given to the laboratory data in order to avoid the problem of blended lines of various elements in the solar spectra. For Mn XXIV and XXV, which are isoelectronic with H I or He I, we give the theoretical level values since they are much more accurate than the experimental x-ray wavelengths. Our source of data was always the original literature. For a convenient source of wavelengths of manganese lines below 2000 Å we refer the reader to the compilation by Kelly and Palumbo (1973).

Almost every level in the present compilation is accompanied by a quantum mechanical designation (or name). The treatment of the level designations is sometimes a troublesome question. For a given configuration a certain number of terms of various types (^{5}H, ^{7}H, etc. in LS-coupling, for example) are theoretically expected, and spectroscopists have traditionally tried to give such definite names to terms, even though g-values, intensities, and arrangement of the levels may indicate that no such "pure" name is appropriate. It is of interest to know just how well the name of a level describes its quantum properties. To this end, we have included partial results of theoretical calculations which express the percentage composition of levels in terms of the basis states of a single configuration, or more than one configuration where configuration interaction is important.

The percentage compositions have the following meaning. Suppose that for a given configuration there is a set of n basis states, written symbolically as $\psi_1, \psi_2, \ldots, \psi_n$. Usually these basis states are taken to be the LS-states for a configuration but other coupling schemes are often used. Then the eigenvector ψ_A of an actual energy level A can be expressed as

$$\psi_A = \alpha_1\psi_1 + \alpha_2\psi_2 + \ldots \alpha_n\psi_n,$$

where $\alpha_1^2 + \alpha_2^2 + \ldots \alpha_n^2 = 1$. The squared quantities α_1^2, α_2^2, etc. represent the percentage composition of a given level. Generally, levels are given names corresponding to the basis state having the largest percentage. The percentage compositions are determined in the theoretical calculations by finding the eigenvalues and eigenvectors of the energy matrix.

In the columns of the present tables headed "Leading components" we give first the percentage of the basis state corresponding to the level's name; next the second largest (in a few cases the largest) percentage together with the related basis state. We have not listed any second component whose percentage is less than 4 percent. The percentages show that in many cases it is not possible to group the levels into meaningful terms. However, where levels have been arranged into terms in the original papers or in subsequent theoretical calculations, we have generally retained these groupings.

Of course, the percentage compositions cannot be considered to be as reliable as experimental quantities inasmuch as a new calculation using a different approximation, such as the introduction of configuration interaction where none had been used before, might yield a different set of percentages. For some levels the percentages may change drastically in a new calculation. Therefore the compositions given here should be considered only as a useful guide to the true quantum character of the levels.

It should be noted that the theoretical calculations involved in obtaining the percentage compositions are of two types. The semiempirical method treats the radial integrals appearing in the energy matrix as parameters whose values are determined by a least-squares fit to the observed levels. In the ab initio method, the radial integrations are carried out with wavefunctions found by solving the wave equation for a given atom, as in a Hartree-Fock calculation or variation thereof. In the present tables, the percentages are mostly taken from published least-squares level-fitting calculations. When only ab initio calculations are found in the literature, we have used them if there appears to be a reasonable correspondence with the experimental data. For higher ionization stages there have been fewer publications relating quantitatively the theoretical results to the observations by means of least-squares calculations.

For configurations of equivalent d electrons, repeating terms sometimes occur. These are generally distinguished by their seniority number. In the present compilation 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, respectively. These terms are denoted as ^{2}D1, ^{2}D2, and ^{2}D3 by Nielson and Koster.

The labeling of terms by lower case letters, a, b, c, etc. (for example $a\,^5$D, $z\,^5$G°, etc.) has been retained only for Mn I-IV, where their use in connection with various wavelength tables makes their retention desirable.

In assembling the data for each spectrum, we referred to the following bibliographies:

i. Papers cited by Moore (1952).
ii. C. E. Moore (1969)
iii. L. Hagan and W. C. Martin (1972)
iv. B. Edlén (1975)
v. L. Hagen (1977)
vi. Card file of publications since June 1975 maintained by the NBS Atomic Energy Levels Data Center.

A selection of data was made that, in our judgment, represents the most accurate and reliable available. A final check for new data was made on Dec. 30, 1976, at which time the compilations were considered completed. The text for each ion is not a complete review of the literature but is intended to credit the major contributions.

Acknowledgments

Throughout this work we have made extensive use of the bibliographical files and reprint collection maintained in the Atomic Energy Levels Data Center by Drs. Lucy Hagan and Romuald Zalubas. Our thanks are extended to them for their generous cooperation. The compilation has also benefited greatly from the preprints that were generously provided by many of our colleagues.

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2. Energy Level Tables

Mn I

Z=25

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

Ionization energy = 59 981 cm^{-1} (7.4368 eV)

The narrow term structure characteristic of manganese atoms and ions produces obvious repeated patterns in manganese spectra which were first interpreted by Catalan in 1922. He called them multiplets and his work led to the general recognition of multiplet structure in complex spectra.

The analysis of Mn I initiated by Catalan was carried on by him and his associates over a period of forty years. A final report of this effort was published by Catalan, Meggers, and Garcia-Riquelme (1964). The levels and g-values reported here are from that paper, which also summarizes the gradual advancement of the analysis over the intervening period.

The percentage compositions of the $3d^6 4s$ levels are quoted from an ab initio (Hartree-Fock) calculation by Vizbaraite, Kupliauskis, and Tutlys (1968). The compositions for the $3d^6 4p$ and $3d^5 4s4p$ configurations are taken from Roth (1970). His changes of designation for the experimental levels are adopted here. Roth distinguished repeating terms of the $3d^n$ core by the letters *a*, *b*, etc. rather than by seniority. His percentages include the sum of seniority states contributing to the term.

The alphabetic prefixing of terms with lower case letters for distinguishing repeating terms of the same type has been retained from Catalan et al. except where the levels were reinterpreted by Roth on the basis of his theoretical treatment.

The ionization energy given by Catalan et al. is the mean of two earlier determinations. The first value (59960 cm^{-1}) was obtained from a systematic study of the first three ionization potentials of elements in the iron group by Catalan and Velasco (1952). The second value (59979 cm^{-1}) was a previously unpublished result obtained from a four member series of $nf\ {}^6F^\circ$ terms by Garcia-Riquelme in 1962. We have recalculated the limit of the nf-series and obtain the value 59981 cm^{-1}, which is probably uncertain by ± 1 cm^{-1}. More than a third of the levels reported for this spectrum lie above the first limit.

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Mn I

Configuration	Term	J	Level (cm^{-1})	g	Leading components (%) First	Second
$3d^5 4s^2$	$a\ {}^6S$	5/2	0.00	1.999		
$3d^6(^5D)4s$	$a\ {}^6D$	9/2	17 052.29	1.559	100	
		7/2	17 282.00	1.584	100	
		5/2	17 451.52	1.657	100	
		3/2	17 568.48	1.866	100	
		1/2	17 637.15	3.327	100	
$3d^5(^6S)4s4p(^3P^\circ)$	$z\ {}^8P^\circ$	5/2	*18 402.46*	2.284	100	
		7/2	*18 531.64*	1.938	100	
		9/2	*18 705.37*	1.779	100	
$3d^6(^5D)4s$	$a\ {}^4D$	7/2	23 296.67	1.427	100	
		5/2	23 549.20	1.368	100	
		3/2	23 719.52	1.198	100	
		1/2	23 818.87	0.000	100	

Mn I—Continued

Configuration	Term	J	Level (cm^{-1})	g	Leading components (%)	
					First	Second
$3d^5(^6S)4s4p(^3P^\circ)$	$z\ ^6P^\circ$	3/2	*24 779.32*	2.364	97	
		5/2	*24 788.05*	1.875	97	
		7/2	*24 802.25*	1.714	97	
$3d^54s^2$	$a\ ^4G$	11/2	25 265.74	1.270		
		5/2	25 281.04			
		9/2	25 285.43	1.173		
		7/2	25 287.74			
$3d^54s^2$	$a\ ^4P$	5/2	27 201.54	1.597		
		3/2	27 248.00	1.730		
		1/2	27 281.85	2.666		
$3d^54s^2$	$b\ ^4D$	7/2	30 354.21	1.425		
		1/2	30 411.74	0.111		
		5/2	30 419.61	1.38		
		3/2	30 425.71			
$3d^5(^6S)4s4p(^3P^\circ)$	$z\ ^4P^\circ$	5/2	*31 001.15*	1.60	98	
		3/2	*31 076.42*	1.732	98	
		1/2	*31 124.95*	2.668	98	
$3d^6(^3P2)4s$	$b\ ^4P$	5/2	33 825.49	1.602	61	38 $(^3P1)\ ^4P$
		3/2	34 463.37	1.730	61	38
		1/2	34 845.26	2.655	61	38
$3d^6(^3H)4s$	$a\ ^4H$	13/2	34 138.88	1.231	100	
		11/2	34 250.52	1.135	98	
		9/2	34 343.90	0.971	98	
		7/2	34 423.27	0.665	98	
$3d^6(^3F2)4s$	$a\ ^4F$	9/2	34 938.70	1.328	67	18 $(^3F1)\ ^4F$
		7/2	35 041.37	1.238	67	18
		5/2	35 114.98	1.024	72	18
		3/2	35 165.05	0.430	79	20
$3d^5(^6S)4s4p(^1P^\circ)$	$y\ ^6P^\circ$	3/2	*35 689.98*	2.400	88	10 $3d^6(^5D)4p\ ^6P^\circ$
		5/2	*35 725.85*	1.886	88	10
		7/2	*35 769.97*	1.712	87	11
$3d^54s^2$	$a\ ^2I$	11/2	37 148.66	0.94		
		13/2	37 164.25			
$3d^6(^3G)4s$	$b\ ^4G$	11/2	37 420.24	1.263	98	
		9/2	37 630.62	1.163	83	11 $(^3F2)\ ^4F$
		7/2	37 737.22	0.989	85	11 $(^3F2)\ ^4F$
		5/2	37 789.93	0.59	90	8 $(^3F2)\ ^4F$
$3d^6(^3P2)4s$	$a\ ^2P$	3/2	37 586.03		61	38 $(^3P1)\ ^2P$
		1/2	38 351.78	0.675	62	38
$3d^6(^3H)4s$	$a\ ^2H$	11/2	38 008.70	1.098	100	
		9/2	38 120.18	0.914	96	

Mn I—Continued

Configuration	Term	J	Level (cm^{-1})	g	Leading components (%)	
					First	Second
$3d^6(^3F2)4s$	$a\ ^2F$	7/2	38 669.60	1.128	64	18 $(^3G)\ ^2G$
		5/2	38 934.94		79	20 $(^3F1)\ ^2F$
$3d^54s(^7S)5s$	$e\ ^8S$	7/2	39 431.31	2.000		
$3d^6(^3G)4s$	$a\ ^2G$	9/2	41 031.48	1.118	96	
		7/2	41 230.30	0.88	81	14 $(^3F2)\ ^2F$
$3d^54s(^7S)5s$	$e\ ^6S$	5/2	41 403.93	1.997		
$3d^6(^5D)4p$	$z\ ^6D^\circ$	9/2	*41 789.48*	1.556	95	4 $3d^5(^4D)4s4p(^3P^\circ)\ ^6D^\circ$
		7/2	*41 932.64*	1.587	94	4
		5/2	*42 053.73*	1.653	94	4
		3/2	*42 143.57*	1.867	95	4
		1/2	*42 198.56*	3.317	95	4
$3d^6(^1I)4s$	$b\ ^2I$	13/2	43 053.30	1.07		
		11/2	43 139.27	0.924		
$3d^6(^5D)4p$	$z\ ^6F^\circ$	11/2	*43 314.23*	1.464	83	15 $3d^5(^4G)4s4p(^3P^\circ)\ ^6F^\circ$
		9/2	*43 428.58*	1.431	80	15
		7/2	*43 524.08*	1.395	80	15
		5/2	*43 595.50*	1.310	80	16
		3/2	*43 644.45*	1.068	80	17
		1/2	*43 672.66*	−0.602	81	17
$3d^6(^5D)4p$	$z\ ^4F^\circ$	9/2	*44 288.76*	1.317	89	6 $3d^5(^4G)4s4p(^3P^\circ)\ ^4F^\circ$
		7/2	*44 523.45*	1.240	88	6
		5/2	*44 696.29*	1.030	89	6
		3/2	*44 814.73*	0.400	90	6
$3d^6(^5D)4p$	$x\ ^6P^\circ$	7/2	*44 993.92*	1.717	60	17 $3d^5(^4P)4s4p(^3P^\circ)\ ^6P^\circ$
		5/2	*45 156.11*	1.885	66	20
		3/2	*45 259.17*	2.399	67	21
$3d^6(^5D)4p$	$z\ ^4D^\circ$	7/2	*45 754.27*	1.427	82	8 $3d^6(^5D)4p\ ^6P^\circ$
		5/2	*45 940.93*	1.372	89	
		3/2	*46 083.89*	1.200	92	
		1/2	*46 169.93*	0.000	93	
$3d^54s(^7S)5p$	$y\ ^8P^\circ$	5/2	*45 981.44*			
		7/2	*46 000.77*			
		9/2	*46 026.75*			
$3d^54s(^7S)4d$	$e\ ^8D$	3/2	46 706.09			
		5/2	46 707.03			
		7/2	46 708.33			
		9/2	46 710.15			
		11/2	46 712.58			

Mn I—Continued

Configuration	Term	J	Level (cm^{-1})	g	Leading components (%)	
					First	Second
$3d^6(^5D)4p$	$y\ ^4P^\circ$	5/2	*46 901.13*	1.595	90	
		3/2	*47 154.51*	1.732	90	
		1/2	*47 299.29*	2.666	91	
$3d^54s(^7S)5p$	$w\ ^6P^\circ$	7/2	*47 387.62*	1.713		
		5/2	*47 659.52*	1.952		
		3/2	*47 782.43*	2.666		
$3d^54s(^7S)4d$	$e\ ^6D$	9/2	47 207.28	1.554		
		7/2	47 212.06	1.581		
		5/2	47 215.61	1.634		
		3/2	47 218.15	1.759		
		1/2	47 219.64	3.934		
$3d^5(^4P)4s4p(^3P^\circ)$	$y\ ^6D^\circ$	1/2	*47 452.16*	3.174	83	15 $3d^5(^4D)4s4p(^3P^\circ)\ ^6D^\circ$
		3/2	*47 466.66*		82	14 $3d^5(^4D)4s4p(^3P^\circ)\ ^6D^\circ$
		5/2	*47 753.99*	1.820	80	14 $3d^5(^4D)4s4p(^3P^\circ)\ ^6D^\circ$
		7/2	*47 774.52*	1.594	77	12 $3d^5(^4D)4s4p(^3P^\circ)\ ^6D^\circ$
		9/2	*47 903.80*	1.540	63	18 $3d^5(^4G)4s4p(^3P^\circ)\ ^6F^\circ$
$3d^5(^4G)4s4p(^3P^\circ)$	$y\ ^6F^\circ$	11/2	*48 021.43*	1.460	80	16 $3d^6(^5D)4p\ ^6F^\circ$
		9/2	*48 168.01*	1.432	60	23 $3d^5(^4P)4s4p(^3P^\circ)\ ^6D^\circ$
		7/2	*48 225.99*	1.043	73	16 $3d^6(^5D)4p\ ^6F^\circ$
		5/2	*48 270.91*	1.319	76	17 $3d^6(^5D)4p\ ^6F^\circ$
		3/2	*48 300.98*	1.068	76	18 $3d^6(^5D)4p\ ^6F^\circ$
		1/2	*48 318.12*	−0.496	76	19 $3d^6(^5D)4p\ ^6F^\circ$
$3d^54s(^5S)5s$	$f\ ^6S$	5/2	49 415.35	2.00		
$3d^54s(^5S)5s$	$e\ ^4S$	3/2	49 591.51	1.998		
$3d^5(^4P)4s4p(^3P^\circ)$	$v\ ^6P^\circ$	7/2	*49 888.08*	1.711	62	19 $3d^6(^5D)4p\ ^6P^\circ$
		5/2	*50 012.53*	1.888	65	20
		3/2	*50 099.16*	2.398	69	20
$3d^5(^4G)4s4p(^3P^\circ)$	$z\ ^4H^\circ$	7/2	*50 065.46*		97	
		9/2	*50 072.59*		96	
		11/2	*50 081.31*		96	
		13/2	*50 094.60*	1.22	96	
$3d^54s(^7S)6s$	$f\ ^8S$	7/2	50 157.63	1.995		
$3d^5(^4G)4s4p(^3P^\circ)$	$y\ ^4F^\circ$	9/2	*50 341.30*	1.318	92	
		7/2	*50 359.28*	1.242	92	
		5/2	*50 373.23*	1.03	92	
		3/2	*50 383.27*		92	
$3d^5(^4D)4s4p(^3P^\circ)$	$x\ ^6F^\circ$	1/2	*50 818.64*	−0.62	92	5 $3d^5(^4G)4s4p(^3P^\circ)\ ^6F^\circ$
		3/2	*50 863.05*	1.07	92	
		5/2	*50 931.42*	1.316	92	
		7/2	*51 014.95*		92	
		9/2	*51 100.49*		93	
		11/2	*51 169.18*		94	

Mn I—Continued

Configuration	Term	J	Level (cm^{-1})	g	Leading components (%) First	Second
$3d^54s(^7S)6s$	$g\ ^6S$	5/2	50 904.68			
$3d^5(^4P)4s4p(^3P^\circ)$	$x\ ^4P^\circ$	5/2	*51 305.41*	1.591	70	18 $3d^5(^4D)4s4p(^3P^\circ)\ ^4P^\circ$
		3/2	*51 445.65*	1.728	71	16
		1/2	*51 552.78*	2.664	72	15
$3d^5(^4G)4s4p(^3P^\circ)$	$z\ ^4G^\circ$	5/2	*51 515.63*		92	
		7/2	*51 530.61*		92	
		9/2	*51 546.27*		92	
		11/2	*51 560.93*	1.273	92	
$3d^7$	$e\ ^4P$	5/2	51 638.17	1.601		
		3/2	51 718.22	1.733		
		1/2	51 787.92	2.65		
$3d^5(^4D)4s4p(^3P^\circ)$	$u\ ^6P^\circ$	3/2	*52 015.00*		86	7 $3d^5(^4P)4s4p(^3P^\circ)\ ^6P^\circ$
		5/2	*52 128.65*		68	19 $3d^5(^4P)4s4p(^3P^\circ)\ ^6D^\circ$
		7/2	*52 253.24*	1.71	43	30 $3d^5(^4P)4s4p(^3P^\circ)\ ^6D^\circ$
$3d^54s(^7S)5d$	$f\ ^8D$	3/2-7/2	52 702.48?			
		9/2	52 703.1			
		11/2	52 705.23			
$3d^54s(^7S)5d$	$f\ ^6D$	9/2	52 726.39			
		7/2	52 730.41			
		5/2	52 733.22			
		3/2	52 735.01			
		1/2	52 735.83			
$3d^5(^4D)4s4p(^3P^\circ)$	$x\ ^6D^\circ$	9/2	*52 758.11*	1.552	82	13 $3d^5(^4P)4s4p(^3P^\circ)\ ^6D^\circ$
		7/2	*52 870.10*	1.57	47	37 $3d^5(^4D)4s4p(^3P^\circ)\ ^6P^\circ$
		1/2	*52 883.10*		75	15 $3d^5(^4P)4s4p(^3P^\circ)\ ^6D^\circ$
		5/2	*52 883.87*		56	18 $3d^5(^4D)4s4p(^3P^\circ)\ ^6P^\circ$
		3/2	*52 883.87*		71	14 $3d^5(^4P)4s4p(^3P^\circ)\ ^6D^\circ$
$3d^54s(^7S)4f$	$z\ ^8F^\circ$	1/2-13/2	*52 974.5?*			
$3d^54s(^7S)4f$	$w\ ^6F^\circ$	9/2	*52 977.75*			
		7/2	*52 977.82*			
		11/2	*52 977.89*			
		3/2	*52 977.93*			
		5/2	*52 978.03*			
$3d^5(^4P)4s4p(^3P^\circ)$	$y\ ^4D^\circ$	1/2	*53 101.32*		86	
		3/2	*53 103.19*		85	
		5/2	*53 109.21*		84	
		7/2	*53 124.09*	1.423	86	
$3d^54s(^7S)6p$	$t\ ^6P^\circ$	7/2	*53 261.42*			
		5/2	*53 291.58*			
		3/2	*53 311.37*			

Mn I—Continued

Configuration	Term	J	Level (cm^{-1})	g	Leading components (%)	
					First	Second
$3d^5(^4P)4s4p(^3P°)$	$z\ ^4S°$	3/2	*54 218.71*	1.770	76	19 $3d^6(a\ ^3P)4p\ ^4S°$
$3d^54s(^7S)7s$	$h\ ^6S$	5/2	54 460.30			
$3d^54s(^5S)4d$	$g\ ^6D$	9/2	54 938.56			
		7/2	54 946.09			
		1/2	54 949.90			
		5/2	54 950.66			
		3/2	54 953.02			
$3d^5(^4D)4s4p(^3P°)$	$x\ ^4D°$	7/2	*55 107.52*	1.407	86	7 $3d^5(^4F)4s4p(^3P°)\ ^4D°$
		5/2	*55 186.17*	1.365	84	
		3/2	*55 279.91*	0.826	67	13 $3d^5(^4P)4s4p(^3P°)\ ^2P°$
$3d^54s(^5S)5p$	$w\ ^4P°$	3/2	*55 368.66*			
		5/2	*55 405.14*			
		1/2	*55 457.20*	2.28		
$3d^54s(^7S)6d$	$g\ ^8D$	7/2	55 374.76			
		9/2	55 375.70			
		11/2	55 376.70			
$3d^54s(^7S)5f$	$v\ ^6F°$	5/2	*55 491.57*			
		3/2	*55 491.95*			
		7/2	*55 492.08*			
		9/2	*55 492.52*			
		11/2	*55 492.74*			
$3d^54s(^7S)5f$	$y\ ^8F°$	13/2	*55 498.5*			
		11/2	*55 499.09*			
		9/2	*55 499.09*			
		7/2	*55 499.5*			
		3/2	*55 499.75*			
		5/2	*55 499.90*			
$3d^54s(^7S)6d$	$h\ ^6D$	9/2	55 681.90			
		7/2	55 688.10			
		5/2	55 690.80			
		3/2	55 691.90			
		1/2	55 692.40			
		5/2	*55 923.81*			
$3d^54s(^5S)5p$	$s\ ^6P°?$	3/2	*55 996.62*			
		5/2	*56 007.91*			
		7/2	*56 012.42*			
$3d^54s(^7S)8s$	$g\ ^8S$	7/2	56 144.16			

Mn I—Continued

Configuration	Term	J	Level (cm⁻¹)	g	Leading components (%) First	Second
$3d^6(^5D)5s$	$i\ ^6D$	9/2	56 189.45			
		7/2	56 356.21	1.57		
		5/2	56 490.79			
		3/2	56 567.93			
		1/2	56 666.06			
	$e\ ^4D$	7/2	56 462.08			
		5/2	56 561.95			
		3/2	56 601.63			
$3d^54s(^7S)7d$	$h\ ^8D$	3/2-11/2	56 801.4?			
$3d^54s(^7S)6f$	$u\ ^6F°$	1/2-13/2	*56 867.1*			
$3d^54p^2$	$e\ ^8P$	5/2	57 086.33	2.27		
		7/2	57 218.15			
		9/2	57 388.90	1.767		
$3d^5(^4D)4s4p(^3P°)$	$v\ ^4P°$	1/2	*57 228.30*	2.671	63	21 $3d^5(^4P)4s4p(^3P°)\ ^4P°$
		3/2	*57 360.78*	1.736	48	20 $3d^6(a\ ^3P)4p\ ^4S°$
		5/2	*57 487.08*	1.590	56	26 $3d^5(^4P)4s4p(^3P°)\ ^4P°$
$3d^6(^5D)5s$	$f\ ^4D$	7/2	57 305.62			
		5/2	57 485.97	1.372		
		3/2	57 621.90			
		1/2	57 705.83			
$3d^6(a\ ^3P)4p$	$y\ ^4S°$	3/2	*57 512.16*	2.000	32	32 $3d^5(^4P)4s4p(^3P°)\ ^4S°$
$3d^54s(^7S)7f$	$t\ ^6F°$	1/2-13/2	*57 697.2*			
$3d^5(^4G)4s4p(^1P°)$	$y\ ^4G°$	11/2	*58 075.06*	1.269	54	35 $3d^6(^3H)4p\ ^4G°$
		9/2	*58 110.24*	1.168	55	32
		7/2	*58 136.69*	0.980	56	31
		5/2	*58 159.73*	0.578	57	30
$3d^6(^3H)4p$	$y\ ^4H°$	13/2	*58 338.67*	1.228	62	24 $3d^5(^4G)4s4p(^3P°)\ ^4H°$
		11/2	*58 427.30*	1.133	60	24
		9/2	*58 485.52*	0.968	59	23
		7/2	*58 519.90*	0.665	60	24
$3d^6(^3H)4p$	$z\ ^4I°$	13/2	*58 843.39*	1.09	50	43 $3d^5(^2I)4s4p(^3P°)\ ^4I°$
		11/2	*58 851.49*		49	45
		15/2	*58 852.60*		55	44
		9/2	*58 866.66*	0.73	49	47
$3d^6(a\ ^3P)4p$	$u\ ^4P°$	5/2	*59 116.60*	1.558	52	21 $3d^5(^4D)4s4p(^3P°)\ ^4P°$
		3/2	*59 384.45*	1.608	46	14
		1/2	*59 568.29*	1.94	55	15

Mn I—Continued

Configuration	Term	J	Level (cm^{-1})	g	Leading components (%)	
					First	Second
$3d^6(a\ ^3F)4p$	$x\ ^4F°$	9/2	*59 257.44*	1.327	41	17 $3d^6(a\ ^3F)4p\ ^4G°$
		7/2	*59 290.23*	1.325	43	16 $3d^5(^4G)4s4p(^1P°)\ ^4F°$
		5/2	*59 360.72*	1.11	44	15 $3d^5(^4G)4s4p(^1P°)\ ^4F°$
		3/2	*59 416.15*	0.39	44	17 $3d^5(^4G)4s4p(^1P°)\ ^4F°$
$3d^6(a\ ^3F)4p$	$^4D°$	7/2	*59 339.55*	1.362	33	38 $3d^6(a\ ^3P)4p\ ^4D°$
		1/2	*59 527.36*		44	23 $3d^5(^4P)4s4p(^3P°)\ ^4D°$
		3/2	*59 527.89*		39	20 $3d^5(^4P)4s4p(^3P°)\ ^4D°$
		5/2	*59 600.35*	1.277	34	16 $3d^5(^4P)4s4p(^3P°)\ ^4D°$
$3d^6(a\ ^3P)4p$	$^4D°$	7/2	*59 470.14*	1.386	30	24 $3d^6(a\ ^3F)4p\ ^4D°$
		5/2	*60 101.65*	1.31	56	10 $3d^6(a\ ^3F)4p\ ^4D°$
		1/2	*60 141.98*	0.17	65	11 $3d^5(a\ ^2F)4s4p(^3P°)\ ^4D°$
		3/2	*60 395.64*	0.91	59	12 $3d^5(a\ ^2F)4s4p(^3P°)\ ^4D°$
$3d^6(a\ ^3P)4p$	$^2D°$	5/2	*59 480.80*	1.281	24	23 $3d^5(^4D)4s4p(^3P°)\ ^2F°$
		3/2	*59 989.77*	1.194	49	11 $3d^6(a\ ^3F)4p\ ^4F°$
$3d^6(^3H)4p$	$z\ ^2I°$	13/2	*59 617.12*	1.074	89	6 $3d^5(^2I)4s4p(^3P°)\ ^2I°$
		11/2	*59 827.88*	0.93	87	6
$3d^6(a\ ^3F)4p$	$x\ ^4G°$	11/2	*59 652.90*	1.239	57	22 $3d^6(^3H)4p\ ^4G°$
		9/2	*59 731.94*	1.169	43	16 $3d^6(a\ ^3F)4p\ ^4F°$
		7/2	*59 784.31*	0.990	46	16 $3d^6(^3H)4p\ ^4G°$
		5/2	*59 817.70*	0.584	52	18 $3d^6(^3H)4p\ ^4G°$
Mn II ($^7S_3$)	***Limit***	....	**59 981**			
$3d^6(^3H)4p$	$z\ ^2G°$	9/2	*60 668.49*	1.112	49	17 $3d^6(^3G)4p\ ^2G°$
		7/2	*60 739.42*		42	14 $3d^6(a\ ^3F)4p\ ^2F°$
$3d^5(a\ ^2D)4s4p(^3P°)$	$w\ ^4F°$	3/2	*60 760.87*		58	23 $3d^5(a\ ^2F)4s4p(^3P°)\ ^4F°$
		5/2	*60 820.35*		58	20
		7/2	*60 902.80*		58	21
		9/2	*60 938.97*		57	18
$3d^5(^2I)4s4p(^3P°)$	$x\ ^4H°$	13/2	*60 891.48*	1.228	59	20 $3d^5(^4G)4s4p(^1P°)\ ^4H°$
		11/2	*60 933.73*	1.134	58	19
		9/2	*60 955.88*		55	16
		7/2	*60 957.21*		58	15
$3d^5(^2I)4s4p(^3P°)$	$y\ ^4I°$	15/2	*61 204.54*	1.20	54	43 $3d^6(^3H)4p\ ^4I°$
		9/2	*61 211.43*	0.75	34	29
		13/2	*61 225.55*		49	46
		11/2	*61 225.77*		42	40
$3d^6(^3H)4p$	$^2H°$	11/2	*61 469.21*	1.164	55	13 $3d^5(^2I)4s4p(^3P°)\ ^2H°$
$3d^6(a\ ^3F)4p$	$^2F°$	5/2	*61 471.23*		64	8 $3d^5(^4D)4s4p(^3P°)\ ^2F°$
		7/2	*61 480.60*	1.13	35	16 $3d^6(a\ ^3F)4p\ ^2G°$

Mn I—Continued

Configuration	Term	J	Level (cm^{-1})	g	Leading components (%) First	Second
$3d^6(a\ ^3F)4p$	$^2G°$	9/2	*61 485.34*	1.020	30	18 $3d^6(^3H)4p\ ^4I°$
		7/2	*61 785.94*	0.93	63	5 $3d^6(^3H)4p\ ^2G°$
$3d^5(^4G)4s4p(^1P°)$	$^4F°$	7/2	*61 710.98*		17	12 $3d^5(a\ ^2D)4s4p(^3P°)\ ^4D°$
		9/2	*61 714.52*		13	14 $3d^6(^3G)4p\ ^4F°$
		5/2	*61 727.46*		21	15 $3d^5(a\ ^2D)4p4p(^3P°)\ ^4D°$
$3d^6(^5D)5d$	$e\ ^6F$	11/2	61 713.62			
		9/2	62 030.18			
		7/2	62 294.66			
		5/2	62 905.81			
		3/2	63 083.24			
$3d^6(^3G)4p$	$^4G°$	11/2	*61 744.04*		44	16 $3d^6(a\ ^3F)4p\ ^4G°$
		7/2	*62 034.04*		31	10
		5/2	*62 075.02*	0.58	28	12
	$y\ ^2I°$	11/2	*61 819.07*			
		13/2	*61 912.57*			
$3d^6(^5D)4d$	$e\ ^6G$	13/2	62 001.09			
		11/2	62 134.45			
		9/2	62 300.63			
		7/2	62 426.48			
		5/2	62 514.59			
		3/2	62 573.11			
$3d^6(^5D)4d$	$e\ ^4G$	11/2	62 295.36			
		9/2	62 479.04			
		7/2	62 632.77			
		5/2	62 753.37			
$3d^6(a\ ^3P)4p$	$z\ ^2P°$	3/2	*62 354.76*	1.24	33	28 $3d^5(^4D)4s4p(^3P°)\ ^2P°$
		1/2	*62 391.05*	0.81	42	29
$3d^6(^3G)4p$	$v\ ^4F°$	3/2	*62 390.20*		25	14 $3d^5(a\ ^2F)4s4p(^3P°)\ ^4F°$
		9/2	*62 392.82*	1.35	29	37
		5/2	*62 487.36*		24	19
		7/2	*62 505.29*		27	28
$3d^5(^4F)4s4p(^3P°)$	$^6F°$	9/2	*62 670.81*		85	
		5/2	*62 761.33*		81	
		1/2	*62 768.16*		82	
		3/2	*62 787.63*		82	
		7/2	*62 851.47*		83	
$3d^6(a\ ^3F)4p$	$y\ ^2D°$	5/2	*63 081.28*	1.24	53	8 $3d^5(a\ ^2F)4s4p(^3P°)\ ^4G°$
		3/2	*63 114.11*	0.758	65	7 $3d^6(^3G)4p\ ^4F°$
$3d^5(a\ ^2F)4s4p(^3P°)$	$^4G°$	5/2	*63 139.70*		56	13 $3d^6(^3G)4p\ ^4G°$
		7/2	*63 288.78*		68	8 $3d^6(^3G)4p\ ^4G°$
		11/2	*63 288.78*	1.127	63	10 $3d^5(^4G)4s4p(^1P°)\ ^4H°$
		9/2	*63 347.91*		61	10 $3d^5(^4G)4s4p(^1P°)\ ^4H°$

Mn I—Continued

Configuration	Term	J	Level (cm^{-1})	g	Leading components (%) First	Second
$3d^6(^5D)4d$	$e\ ^4F$	9/2	63 231.43			
		7/2	63 424.00			
		7/2	*63 319.85?*			
$3d^5(^4G)4s4p(^1P°)$	$w\ ^4H°$	13/2	*63 363.54*	1.231	44	30 $3d^6(^3G)4p\ ^4H°$
		7/2	*63 395.45*	0.70	42	26
		9/2	*63 444.61*		35	21
		11/2	*63 457.85*	1.14	31	21
		5/2	*63 371.56*			
$3d^5(^4F)4s4p(^3P°)$	$^6D°$	9/2	*63 374.53*		89	
		5/2	*63 523.82*		86	
		7/2	*63 546.30*		87	
		3/2	*63 583.84*		81	6 $3d^5(a\ ^2D)4s4p(^3P°)\ ^4P°$
$3d^6(^3G)4p$	$^2H°$	11/2	*63 449.13*		65	13 $3d^6(^3H)4p\ ^2H°$
		9/2	*63 548.49*	0.92	72	10
$3d^5(a\ ^2D)4s4p(^3P°)$	$x\ ^2D°$	5/2	*63 764.90*		57	16 $3d^5(a\ ^2F)4s4p(^3P°)\ ^2D°$
		3/2	*63 845.32*		50	27
	$x\ ^2H°$	11/2	*64 051.91*			
		9/2	*64 055.37*			
$3d^5(a\ ^2F)4s4p(^3P°)$	$u\ ^4D°$	7/2	*64 409.69*	1.42	70	7 $3d^6(a\ ^3P)4p\ ^4D°$
		1/2	*64 638.68*	0.22	59	16 $3d^5(a\ ^2D)4s4p(^3P°)\ ^2P°$
		3/2	*64 683.95*	1.22	61	13 $3d^5(a\ ^2D)4s4p(^3P°)\ ^2P°$
		5/2	*64 712.94*		59	8 $3d^5(a\ ^2D)4s4p(^3P°)\ ^2F°$
$3d^5(a\ ^2F)4s4p(^3P°)$	$^4F°$	9/2	*64 585.44*	1.307	30	17 $3d^5(a\ ^2D)4s4p(^3P°)\ ^4F°$
		7/2	*64 649.20*		21	14
$3d^6(^3G)4p$	$v\ ^4H°$	13/2	*64 731.88*	1.236	48	21 $3d^5(^2I)4s4p(^3P°)\ ^4H°$
		11/2	*64 819.53*	1.137	51	19
		9/2	*64 888.00*	0.974	52	18
		7/2	*64 920.33*		38	12
$3d^5(a\ ^2D)4s4p(^3P°)$	$w\ ^2F°$	5/2	*64 823.21*		56	8 $3d^5(a\ ^2F)4s4p(^3P°)\ ^4D°$
		7/2	*64 988.22*		45	15 $3d^6(^3G)4p\ ^4H°$
$3d^5(a\ ^2F)4s4p(^3P°)$	$w\ ^2G°$	9/2	*65 262.28*	1.13	52	27 $3d^6(^3G)4p\ ^2G°$
		7/2	*65 305.13*		58	15
$3d^6(^3G)4p$	$v\ ^2F°$	7/2	*65 617.37*	1.015	33	19 $3d^6(^3G)4p\ ^2G°$
		5/2	*65 649.13?*		55	11 $3d^5(a\ ^2F)4s4p(^3P°)\ ^2F°$
$3d^6(^3G)4p$	$^2G°$	9/2	*65 768.81*	1.12	43	32 $3d^5(a\ ^2F)4s4p(^3P°)\ ^2G°$

Mn I—Continued

Configuration	Term	J	Level (cm^{-1})	g	Leading components (%) First	Second
$3d^6(^3H)4p$	$v\ ^4G°$	5/2	*65 873.40*		10	15 $3d^5(a\ ^2G)4s4p(^3P°)\ ^4G°$
		7/2	*65 876.34*		10	14
		11/2	*65 887.31*	1.259	13	15
		9/2	*65 908.92*	1.160	12	15
$3d^5(^4P)4s4p(^1P°)$	$^4D°$	5/2	*65 946.87*	1.30	20	27 $3d^6(^3D)4p\ ^4D°$
		3/2	*65 961.90*		21	19
$3d^5(a\ ^2F)4s4p(^3P°)$	$u\ ^2F°$	5/2	*66 020.63*		25	18 $3d^5(^4F)4s4p(^3P°)\ ^4G°$
		7/2	*66 149.10*	1.14	34	21 $3d^6(a\ ^1G)4p\ ^2F°$
$3d^5(a\ ^2G)4s4p(^3P°)$	$u\ ^4H°$	7/2	*66 334.47*	0.764	31	23 $3d^5(^2H)4s4p(^3P°)\ ^4H°$
		9/2	*66 356.40*	1.022	28	19
		11/2	*66 418.55*		39	27
		13/2	*66 568.58*	1.23	46	32
$3d^5(^4F)4s4p(^3P°)$	$u\ ^4G°$	5/2	*66 395.19*	0.611	19	10 $3d^6(^3D)4p\ ^4F°$
		7/2	*66 454.27*	0.932	12	15 $3d^6(a\ ^1G)4p\ ^2G°$
		9/2	*66 522.62*	1.13	34	13 $3d^5(^2H)4s4p(^3P°)\ ^4G°$
		11/2	*66 573.60*	1.24	54	17 $3d^5(^2H)4s4p(^3P°)\ ^4G°$
$3d^5(^4P)4s4p(^1P°)$	$^4S°$	3/2	*66 504.21*		62	27 $3d^6(a\ ^3P)4p\ ^4S°$
		7/2	*66 600.17*			
$3d^6(a\ ^1G)4p$	$v\ ^2G°$	9/2	*66 630.92*	1.13	22	11 $3d^5(a\ ^2G)4s4p(^3P°)\ ^4H°$
		7/2	*66 737.82*	0.46	23	16 $3d^5(^4F)4s4p(^3P°)\ ^4G°$
		5/2	*66 654.65?*			
$3d^6(^3D)4p$	$u\ ^4F°$	7/2	*66 783.05*	1.21	14	17 $3d^5(^4F)4s4p(^3P°)\ ^4G°$
		5/2	*66 837.64*		15	12 $3d^5(^4F)4s4p(^3P°)\ ^4G°$
		3/2	*66 843.79*	0.46	27	25 $3d^5(^4D)4s4p(^1P°)\ ^4F°$
		9/2	*66 855.00*	1.33	8	11 $3d^6(a\ ^1G)4p\ ^2G°$
		5/2?	*66 910.02*			
$3d^5(^4D)4s4p(^1P°)$	$^4D°$	7/2	*66 981.30*	1.33	40	30 $3d^5(^4P)4s4p(^1P°)\ ^4D°$
$3d^5(^4D)4s4p(^1P°)$	$^4P°$	5/2	*67 008.54*		42	18 $3d^5(^4P)4s4p(^1P°)\ ^4P°$
$3d^6(^1I)4p$	$w\ ^2H°$	11/2	*67 504.90*	1.09	39	35 $3d^6(a\ ^1G)4p\ ^2H°$
		9/2	*67 576.84*	0.90	34	42
$3d^5(^2H)4s4p(^3P°)$	$t\ ^4G°$	11/2	*67 752.84*	1.266	23	22 $3d^5(a\ ^2G)4s4p(^3P°)\ ^4G°$
		5/2	*67 964.87*		17	13
		9/2	*67 819.17*		16	14
		7/2	*67 891.36*		18	16
$3d^5(a\ ^2G)4s4p(^3P°)$	$^4F°$	9/2	*68 286.44*	1.320	58	13 $3d^5(^4F)4s4p(^3P°)\ ^4F°$
		7/2	*68 338.59*		45	21 $3d^5(^4F)4s4p(^3P°)\ ^4D°$

Mn I—Continued

Configuration	Term	J	Level (cm^{-1})	g	Leading components (%)	
					First	Second
$3d^54s(^5G)5s$	$f\ ^4G$	11/2	68 693.02			
		9/2	68 716.22	1.17		
$3d^6(^1I)4p$	$z\ ^2K^\circ$	15/2	*68 797.56?*	1.07	92	7 $3d^5(^2I)4s4p(^1P^\circ)\ ^2K^\circ$
		13/2	*68 842.52?*	0.93	91	8
$3d^6(^1I)4p$	$x\ ^2I^\circ$	13/2	*69 560.88?*	1.07		
		11/2	*69 629.85?*	0.924		
	$v\ ^2H^\circ$	9/2	*69 663.20?*			
		11/2	*69 722.96*	1.10		

Mn II

Cr I isoelectronic sequence Z=25

Ground state: $1s^22s^22p^63s^23p^63d^54s\ ^7S_3$ Ionization energy = 126 145.0 cm^{-1} (15.64011 eV)

Work on the analysis of Mn II was initiated by Catalan in 1922 in conjunction with his work on Mn I. He discovered four multiplets, known in modern terminology as: the resonance septet $3d^54s\ a\ ^7S$–$3d^54p\ z\ ^7P°$, a higher septet $3d^54p\ z\ ^7P°$–$3d^54d\ e\ ^7D$, and two quintets, $3d^54s\ a^5S$–$3d^54p\ z\ ^5P°$ and $3d^6\ a\ ^5D$–$3d^54p\ z\ ^5P°$. Russell (1927) interpreted these multiplets and added the higher $3d^55s\ e\ ^7S°$ term.

The analysis was continued by Curtis (1938), who found most of the quintet and septet terms and classified over 700 lines. In a later paper Curtis (1952) reported many new terms of the triplet system and classified about 500 more lines.

Subsequently the work moved to Madrid where Iglesias and Velasco (1963) announced the discovery of about 200 new levels, including numerous singlets. In 1964 they published a monograph collecting all the data on wavelengths, energy levels, and classifications. From this publication the experimental data reported here are taken.

The Zeeman effect was observed at the Massachusetts Institute of Technology by Catalan for his work on Mn I. The analysis of the Mn II patterns was done by Catalan and Velasco, who determined the g-values.

The theoretical interpretation of the low even and odd configurations was started by Racah and Shadmi (1959) and Racah and Spector (1960). Their work had an important influence on the later stages of the analysis. Later Shadmi, Oreg, and Stein (1968) calculated the even configurations $3d^6$, $3d^54s$, and $3d^44s^2$ but gave percentage compositions for only $a\ ^3G$, $b\ ^3G$, $a\ ^5F$, $c\ ^3D$, and $b\ ^1F$, which are highly mixed terms. Calculations of percentage composition for $3d^54s$ terms, without configuration interaction, were made by Vizbaraite, Kupliauskis, and Tutlys (1968). Their results indicate that the percentages omitted by Shadmi et al. are greater than 70%.

Roth (1969) calculated the percentage compositions for $3d^54p$ used here. He labeled repeating terms of the $3d^5$ core by "a" and "b" rather than by seniority number. Percentages for these terms represent the sum of seniority states contributing to the same core term. Percentages for the $x\ ^3D°$, $y\ ^5G°$, $x\ ^5F°$, and $y\ ^3G°$ are omitted because of wrong identifications by Roth arising from misprints in the earlier published analysis by Iglesias and Velasco (1963). Velasco and Iglesias (1969) have commented on this matter.

The ionization energy was derived from numerous series in the papers of Curtis (1938), Garcia-Riquelme, Iglesias, and Velasco (1957), and by Iglesias and Velasco (1964). The value quoted here is from Iglesias and Velasco (1964). The uncertainty is given as 0.6 cm^{-1}.

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Mn II

Configuration	Term	J	Level (cm^{-1})	g	Leading components (%)	
					First	Second
$3d^5(^6S)4s$	$a\ ^7S$	3	0.00	1.992		
$3d^5(^6S)4s$	$a\ ^5S$	2	9472.97	2.006		
$3d^6$	$a\ ^5D$	4	14 325.86	1.49		
		3	14 593.82	1.487		
		2	14 781.19	1.501		
		1	14 901.18	1.495		
		0	14 959.84			

Mn II—Continued

Configuration	Term	J	Level (cm^{-1})	g	Leading components (%)	
					First	Second
$3d^5(^4G)4s$	$a\ ^5G$	6	27 547.25	1.349		
		5	27 571.25	1.274		
		4	27 583.57	1.16		
		3	27 588.50	0.98		
		2	27 589.28	0.34		
$3d^6$	$a\ ^3P$	2	29 869.48	1.497		
		1	30 685.07	1.48		
		0	31 022.05			
$3d^5(^4P)4s$	$a\ ^5P$	3	29 889.52	1.652		
		2	29 919.43	1.813		
		1	29 951.42	2.475		
$3d^6$	$a\ ^3H$	6	30 523.70	1.141		
		5	30 679.51	1.03		
		4	30 796.07	0.80		
$3d^6$	$a\ ^3F$	4	31 514.66	1.25		
		3	31 661.96	1.066		
		2	31 761.15	0.66		
$3d^5(^4D)4s$	$b\ ^5D$	4	32 787.87	1.497		
		0	32 818.33			
		1	32 836.66	1.507		
		3	32 857.19	1.515		
		2	32 859.09	1.497		
$3d^5(^4G)4s$	$a\ ^3G$	5	33 147.71	1.202	57	42 $3d^6\ ^3G$
		4	33 248.60	1.054	64	34
		3	33 278.72	0.746	68	31
$3d^6$	$b\ ^3G$	5	34 762.11	1.204	56	43 $3d^5(^4G)4s\ ^3G$
		4	34 910.75	1.054	63	36
		3	35 004.77	0.745	67	32
$3d^5(^4P)4s$	$b\ ^3P$	2	36 274.58	1.463		
		1	36 364.59	1.474		
		0	36 428.17			
$3d^6$	$a\ ^3D$	1	37 811.86	0.524		
		2	37 848.18	1.15		
		3	37 851.47	1.37		
$3d^5(^6S)4p$	$z\ ^7P^\circ$	2	*38 366.18*	2.315	100	
		3	*38 543.08*	1.923	100	
		4	*38 806.67*	1.740	100	
$3d^6$	$a\ ^1I$	6	38 720.02	1.022		
$3d^6$	$a\ ^1G$	4	38 901.8	0.96		

Mn II—Continued

Configuration	Term	J	Level (cm^{-1})	g	Leading components (%)	
					First	Second
$3d^5(^4D)4s$	$b\ ^3D$	3	39 808.46	1.34		
		2	39 813.68	1.15		
		1	39 826.84	0.518		
$3d^6$	$a\ ^1S$	0	40 759.5			
$3d^5(^2I)4s$	$a\ ^3I$	7	41 182.53	1.133		
		6	41 190.47	1.025		
		5	41 204.34	0.849		
$3d^6$	$a\ ^1D$	2	43 131.4	1.01		
$3d^5(^4F)4s$	$a\ ^5F$	1	43 311.30	0.00	61	37 $(^2D)\ ^3D$
		5	43 528.64	1.44	99	
		4	43 537.18	1.39	99	
		3	43 696.19	1.251	70	12 $(^2D)\ ^3D$
		2	43 850.42	0.986	51	21 $(^2D)\ ^3D$
$3d^5(^2D)4s$	$c\ ^3D$	2	43 339.42	1.11	40	44 $(^4F)\ ^5F$
		3	43 395.38	1.23	54	28
		1	44 138.96	0.347	58	39
$3d^5(^6S)4p$	$z\ ^5P^\circ$	3	*43 370.51*	1.658	98	
		2	*43 484.64*	1.833	98	
		1	*43 557.14*	2.493	99	
$3d^5(^2I)4s$	$b\ ^1I$	6	44 315.17	1.009		
$3d^5(^2F)4s$	$b\ ^3F$	4	44 521.52	1.242		
		2	44 745.46	0.832		
		3	44 899.82	1.145		
$3d^5(^2D)4s$	$b\ ^1D$	2	46 903.26	0.971		
$3d^5(^2F)4s$	$a\ ^1F$	3	47 073.56	1.024		
$3d^5(^2H)4s$	$b\ ^3H$	4	48 317.85	0.807		
		5	48 333.06	1.030		
		6	48 435.96	1.144		
$3d^6$	$b\ ^1F$	3	49 291.31	0.90	49	30 $3d^5(^2G)4s\ ^3G$
$3d^5(^2G)4s$	$c\ ^3G$	4	49 427.32	1.051		
		3	49 465.13	0.874		
		5	49 517.58	1.186		
$3d^5(^4F)4s$	$c\ ^3F$	2	49 820.16	0.69		
		4	49 882.15	1.25		
		3	49 889.86	1.04		
$3d^5(^2H)4s$	$a\ ^1H$	5	51 553.06	1.002		

Mn II—Continued

Configuration	Term	J	Level (cm^{-1})	g	Leading components (%)	
					First	Second
$3d^5(^2F)4s$	$d\ ^3F$	3	52 373.18			
		2	52 379.38	0.71		
		4	52 383.72	1.23		
$3d^5(^2G)4s$	$b\ ^1G$	4	52 653.27	1.004		
$3d^6$	$c\ ^3P$	0	52 718.8			
		1	53 017.16			
		2	53 597.13			
$3d^6$	$e\ ^3F$	2	53 698.7	0.69		
		3	53 781.71	1.07		
		4	53 805.8	1.23		
$3d^44s^2$	$c\ ^5D$	0	54 846.24			
		1	54 938.19			
		2	55 116.31			
		3	55 371.68			
		4	55 696.99			
$3d^5(^2F)4s$	$c\ ^1F$	3	55 759.27	1.006		
$3d^5(^2S)4s$	$a\ ^3S$	1	56 883.38			
$3d^6$	$c\ ^1G$	4	59 537.4	0.98		
$3d^5(^2D)4s$	$d\ ^3D$	1	62 564.7		100	
		2	62 572.2		100	
		3	62 587.5		100	
$3d^5(^4G)4p$	$z\ ^5G^\circ$	2	*64 456.69*		97	
		3	*64 473.39*		93	
		4	*64 494.14*	1.17	91	7 $(^4G)\ ^5H^\circ$
		5	*64 518.87*	1.269	90	8 $(^4G)\ ^5H^\circ$
		6	*64 550.04*	1.331	92	6 $(^4G)\ ^5H^\circ$
$3d^5(^4G)4p$	$z\ ^5H^\circ$	3	*65 483.09*		95	
		4	*65 565.96*		92	7 $(^4G)\ ^5G^\circ$
		5	*65 658.59*		92	8
		6	*65 754.80*	1.23	94	6
		7	*65 847.03*	1.31	100	
$3d^5(^2D)4s$	$c\ ^1D$	2	65 567.07	1.04		
$3d^5(^4G)4p$	$z\ ^5F^\circ$	5	*66 542.53*	1.395	93	
		4	*66 643.31*	1.368	83	6 $(^4P)\ ^5D^\circ$
		3	*66 686.70*	1.309	56	27 $(^4P)\ ^5D^\circ$
		1	*66 894.09*	1.50	82	9 $(^4P)\ ^5D^\circ$
		2	*66 901.44*	1.48	64	26 $(^4P)\ ^5D^\circ$

Mn II—Continued

Configuration	Term	J	Level (cm^{-1})	g	Leading components (%)	
					First	Second
$3d^5(^4P)4p$	$z\ ^5D°$	0	*66 625.28*		83	16 (^{4}D) ^{5}D°
		1	*66 645.07*	1.36	73	14 (^{4}D) ^{5}D°
		2	*66 676.78*	1.312	54	26 (^{4}G) ^{5}F°
		3	*67 009.16*	1.44	52	35 (^{4}G) ^{5}F°
		4	*67 295.43*	1.479	78	11 (^{4}D) ^{5}D°
$3d^5(^4P)4p$	$z\ ^5S°$	2	*66 929.52*	1.645	95	
$3d^5(^4G)4p$	$z\ ^3H°$	6	*67 744.37*	1.160	97	
		5	*67 846.19*	1.028	98	
		4	*67 910.56*	0.789	98	
$3d^5(^4G)4p$	$z\ ^3F°$	2	*67 766.76*	0.657	92	
		3	*67 812.05*	1.080	92	
		4	*67 865.85*	1.259	93	
$3d^5(^4P)4p$	$y\ ^5P°$	3	*68 284.62*	1.655	74	20 (^{4}D) ^{5}P°
		2	*68 417.61*	1.80	74	12
		1	*68 496.61*	2.41	83	8
$3d^5(^4P)4p$	$z\ ^3P°$	2	*69 044.90*	1.540	68	16 (^{4}D) ^{3}P°
		1	*69 216.02*	1.474	74	15
		0	*69 319.26*		80	15
$3d^5(^4D)4p$	$y\ ^5F°$	1	*70 150.74*	0.00	86	8 (^{4}G) ^{5}F°
		2	*70 231.47*	1.013	85	7
		3	*70 342.93*	1.22	84	6
		4	*70 497.80*	1.250	90	6
		5	*70 657.58*	1.38	91	5
$3d^5(^4G)4p$	$z\ ^3G°$	3	*70 518.05*	0.754	96	
		5	*70 527.62*	1.199	95	
		4	*70 546.37*	1.167	96	
$3d^5(^4P)4p$	$z\ ^3D°$	3	*70 745.38*	1.36	79	5 (^{4}D) ^{5}F°
		2	*70 940.54*	1.143	83	5 (^{4}D) ^{5}D°
		1	*71 078.44*	0.478	89	
$3d^5(^4D)4p$	$x\ ^5P°$	1	*71 264.42*	2.477	60	26 (^{4}D) ^{5}D°
		2	*71 323.62*	1.805	46	33
		3	*71 390.48*	1.644	52	21
$3d^5(^4D)4p$	$y\ ^5D°$	4	*72 011.02*	1.477	84	13 (^{4}P) ^{5}D°
		3	*72 247.71*	1.455	57	23 (^{4}D) ^{5}P°
		2	*72 307.21*		44	37 (^{4}D) ^{5}P°
		1	*72 321.06*	1.52	52	29 (^{4}D) ^{5}P°
		0	*72 322.49*		81	16 (^{4}P) ^{5}D°
$3d^5(^2G)4s$	$d\ ^1G$	4	72 648.8	1.01		

Mn II—Continued

Configuration	Term	J	Level (cm^{-1})	g	Leading components (%)	
					First	Second
$3d^5(^4D)4p$	$y\ ^3D°$	1	*73 385.46*	0.530	89	5 (^{4}F) ^{3}D°
		3	*73 395.44*	1.21	81	5
		2	*73 396.26*		87	5
$3d^5(^4D)4p$	$y\ ^3F°$	4	*73 683.44*	1.253	92	
		3	*73 781.11*	1.09	88	
		2	*73 785.53*	0.746	91	
$3d^5(^4P)4p$	$z\ ^3S°$	1	*73 911.6*	1.986	96	
$3d^5(^6S)5s$	$e\ ^7S$	3	74 560.01			
$3d^5(^4D)4p$	$y\ ^3P°$	0	*75 563.49*		81	16 (^{4}P) ^{3}P°
		1	*75 719.93*	1.490	78	16
		2	*75 919.09*	1.50	77	19
$3d^5(^6S)5s$	$e\ ^5S$	2	76 374.60			
$3d^5(^2I)4p$	$z\ ^3K°$	8	*77 820.28*	1.14	100	
		6	*77 842.09*	0.909	91	8 (^{2}I) ^{3}I°
		7	*77 945.71*	1.050	91	5 (^{2}I) ^{3}I°
$3d^5(^2I)4p$	$z\ ^3I°$	5	*78 085.2*	0.83	90	5 (^{2}I) ^{1}H°
		6	*78 340.72*	1.014	88	8 (^{2}I) ^{3}K°
		7	*78 475.43*	1.13	81	8 (^{2}I) ^{1}K°
$3d^5(a\ ^2D)4p$	$z\ ^1D°$	2	*78 913.17*	0.938	44	24 (a ^{2}F) ^{1}D°
$3d^5(^2I)4p$	$z\ ^1H°$	5	*79 112.56*	1.011	78	6 (^{2}I) ^{3}I°
$3d^5(^2I)4p$	$z\ ^1K°$	7	*79 147.10*	1.003	88	11 (^{2}I) ^{3}I°
$3d^5(a\ ^2D)4p$	$x\ ^3F°$	2	*79 458.38*	0.734	44	29 (a ^{2}F) ^{3}F°
		3	*79 512.73*	1.075	60	34
		4	*79 913.35*	1.24	66	30
$3d^5(^6S)4d$	$e\ ^7D$	1	79 540.87			
		2	79 544.68			
		3	79 550.44			
		4	79 558.54			
		5	79 569.27			
$3d^5(^2I)4p$	$y\ ^3H°$	6	*79 592.14*	1.16	94	
		5	*79 739.88*	1.03	90	
		4	*79 800.52*	0.81	92	
$3d^5(a\ ^2D)4p$	$x\ ^3P°$	2	*81 147.65*	1.372	77	12 (a ^{2}D) ^{3}D°
		1	*81 322.33*		74	12 (a ^{2}D) ^{3}D°
		0	*81 713.02*		92	4 (^{4}F) ^{5}D°
$3d^5(a\ ^2D)4p$	$z\ ^1F°$	3	*81 220.58*	0.92	45	35 (a ^{2}F) ^{3}G°

Mn II—Continued

Configuration	Term	J	Level (cm^{-1})	g	Leading components (%)	
					First	Second
$3d^5(a\ ^2F)4p$	$z\ ^1G°$	4	*81 279.71*	1.010	53	24 $(a\ ^2F)\ ^3G°$
$3d^5(^2D)4p$	$x\ ^3D°$	3	*81 659.50*	1.32		
		1	*81 732.0*	0.44		
		2	*81 812.9*	0.90		
$3d^5(^4F)4p$	$y\ ^5G°$	3	*81 780.70*	0.92		
		4	*81 862.84*	1.20		
		5	*82 117.16*	1.28		
		6	*82 142.46*	1.36		
		2	*82 193.04*			
$3d^5(^2I)4p$	$z\ ^1I°$	6	*81 802.58*	1.00	94	
$3d^5(^4F)4p$	$x\ ^5F°$	5	*81 886.33*			
		4	*81 993.85*	1.25		
		3	*82 051.62*	1.24		
		2	*82 054.35*	1.18		
		1	*82 236.89*			
$3d^5(^2F)4p$	$y\ ^3G°$	4	*82 099.82*			
		5	*82 232.18*	1.29		
		3	*82 387.53*	0.90		
$3d^5(^6S)4d$	$e\ ^5D$	4	82 136.40			
		3	82 144.48			
		2	82 151.16			
		1	82 155.84			
		0	82 158.17			
$3d^5(a\ ^2F)4p$	$w\ ^3D°$	3	*82 419.48*	1.33	57	21 $(a\ ^2F)\ ^3F°$
		1	*82 939.00*	0.51	56	35 $(a\ ^2D)\ ^1P°$
		2	*83 070.97*	1.21	80	6 $(^4F)\ ^5D°$
$3d^5(^4F)4p$	$x\ ^5D°$	4	*82 605.29*	1.47	86	9 $(^4F)\ ^5F°$
		3	*82 712.55*	1.46	85	8 $(^4F)\ ^5F°$
		2	*82 735.29*		82	5 $(a\ ^2F)\ ^3D°$
		1	*82 774.73*		91	4 $(a\ ^2D)\ ^3P°$
		0	*82 839.49*		94	4 $(a\ ^2D)\ ^3P°$
$3d^5(a\ ^2F)4p$	$w\ ^3F°$	4	*82 830.75*	1.22	33	23 $(a\ ^2D)\ ^3F°$
		2	*82 917.78*	0.70	46	16 $(a\ ^2D)\ ^3F°$
		3	*82 936.01*	1.12	36	35 $(a\ ^2F)\ ^3D°$
$3d^44s4p$?	$y\ ^7P°$	2	*83 255.79*			
		3	*83 375.63*			
		4	*83 529.33*			
$3d^5(^4F)4p$	$x\ ^3G°$	4	*83 875.46*	1.02	46	16 $(^2H)\ ^3H°$
		5	*83 912.38*	1.20		
		3	*83 933.77*	0.76	69	17 $(^2H)\ ^3G°$
$3d^5(a\ ^2D)4p$	$z\ ^1P°$	1	*84 268.06*	0.96	58	30 $(a\ ^2F)\ ^3D°$

Mn II—Continued

Configuration	Term	J	Level (cm^{-1})	g	Leading components (%) First	Second
$3d^5(a\ ^2G)4p$	$x\ ^3H°$	4	*84 307.20*	0.81	31	31 (^{2}H) ^{3}H°
		5	*84 428.21*	1.03	32	31 (^{4}F) ^{3}G°
		6	*84 643.86*	1.15	46	45 (^{2}H) ^{3}H°
$3d^5(a\ ^2F)4p$	$y\ ^1D°$	2	*85 367.85*	1.03	64	32 (a ^{2}D) ^{1}D°
$3d^5(^2H)4p$	$y\ ^3I°$	5	*85 447.70*	0.82	89	5 (^{2}H) ^{3}H°
		6	*85 636.10*	1.05	89	5 (^{2}H) ^{3}H°
		7	*85 811.43*	1.12	97	
$3d^5(^2H)4p$	$w\ ^3G°$	5	*85 543.23*	1.19	34	40 (a ^{2}G) ^{3}G°
		4	*85 673.72*	1.051	32	44
		3	*85 734.62*	0.75	18	35
$3d^5(a\ ^2G)4p$	$^1G°$	4	*85 759.3*	1.15	37	19 (^{2}H) ^{1}G°
$3d^5(^6S)5p$?	$x\ ^7P°$	2	*85 895.30*			
		3	*85 960.46*			
		4	*86 057.44*			
$3d^5(^4F)4p$	$^3F°$	3	*85 952.6*	1.06	40	24 (^{4}F) ^{3}D°
		2	*85 989.12*	0.77	43	24 (a ^{2}G) ^{3}F°
		4	*86 449.24*	1.092	49	17 (a ^{2}G) ^{3}F°
$3d^5(a\ ^2F)4p$	$y\ ^1F°$	3	*86 061.75*		51	14 (a ^{2}G) ^{3}G°
$3d^5(^4F)4p$	$v\ ^3D°$	2	*86 190.18*		62	18 (^{4}F) ^{3}F°
		1	*86 208.4*	0.58	85	8 (a ^{2}F) ^{3}D°
		3	*86 302.55*	1.15	57	20 (^{4}F) ^{3}F°
$3d^5(^2H)4p$	$y\ ^1I°$	6	*86 869.39*	1.02	90	5 (^{2}H) ^{3}H°
$3d^5(^6S)5p$	$w\ ^5P°$	3	*86 897.67*			
		2	*86 936.81*			
		1	*86 960.96*			
$3d^5(a\ ^2G)4p$	$u\ ^3F°$	4	*87 580.23*	1.23	55	21 (^{4}F) ^{3}F°
		3	*87 717.62*	1.06	51	25
		2	*87 858.51*		51	26
$3d^5(^2H)4p$	$w\ ^3H°$	4	*87 941.08*	0.82	49	45 (a ^{2}G) ^{3}H°
		5	*87 995.50*	1.03	44	47
		6	*88 198.07*	1.16	43	49
$3d^5(a\ ^2G)4p$	$^3G°$	5	*88 772.30*		40	20 (a ^{2}F) ^{3}G°
		4	*89 096.56*	1.08	45	18
		3	*89 126.0*	0.78	43	21
$3d^44s4p$?	$v\ ^5P°$	1	*88 839.7*			
		2	*89 079.2*			
		3	*89 429.0*			

Mn II—Continued

Configuration	Term	J	Level (cm^{-1})	g	Leading components (%)	
					First	Second
$3d^5(a\ ^2G)4p$	$^1H°$	5	*89 062.6*	1.14	66	24 (^{2}H) ^{1}H°
$3d^5(b\ ^2F)4p$	$x\ ^1G°$	4	*89 465.3*		48	19 ($a\ ^2$G) ^{1}G°
$3d^5(b\ ^2F)4p$	$t\ ^3F°$	2	*89 519.25?*		75	13 ($a\ ^2$G) ^{3}F°
		3	*89 572.03*	1.14?	76	8
		4	*89 800.34*		77	8
$3d^5(^2H)4p$	$x\ ^1H°$	5	*89 760.33*	1.02	60	24 ($a\ ^2$G) ^{1}H°
$3d^5(a\ ^2G)4p$	$x\ ^1F°$	3	*89 950.40*		76	6 ($a\ ^2$F) ^{3}F°
$3d^44s4p$	$w\ ^5F°$	1	*90 459.9*			
		2	*90 582.2*	1.01		
		3	*90 785.7*			
		4	*91 037.8*			
		5	*91 385.1*			
$3d^5(b\ ^2F)4p$	$x\ ^1D°$	2	*90 596.8*	1.02	85	7 ($b\ ^2$F) ^{3}F°
$3d^5(b\ ^2F)4p$	$u\ ^3G°$	3	*91 018.3*	0.71	59	33 (^{2}H) ^{3}G°
		4	*91 178.8*		62	30
		5	*91 301.8*	1.24	66	29
$3d^5(b\ ^2F)4p$	$u\ ^3D°$	2	*92 039.8*	1.17	91	5 (^{4}F) ^{3}D°
		1	*92 060.8?*		93	4
		3	*92 083.0*		83	8
$3d^5(^2H)4p$	$w\ ^1G°$	4	*92 516.65*	1.01	37	41 ($b\ ^2$F) ^{1}G°
$3d^44s4p$	$w\ ^3P°$	0	*93 056.1*			
		1	*93 366.0*			
		2	*93 920.9*			
$3d^5(^2S)4p$	$^3P°$	0	*93 719.6*		89	9 ($b\ ^2$D) ^{3}P°
		1	*93 868.5*		88	9
		2	*94 230.9*		88	10
$3d^5(b\ ^2F)4p$	$w\ ^1F°$	3	*94 182.2*	1.00	95	
$3d^44s4p$	$w\ ^5D°$	0	*94 748.0?*			
		1	*94 795.5*			
		2	*94 886.5*			
		3	*94 989.7*			
		4	*95 206.3*			
$3d^5(^2S)4p$	$y\ ^1P°$	1	*95 080.76*		84	13 ($b\ ^2$D) ^{1}P°
$3d^44s4p$	$s\ ^3F°$	2	*96 614.1*			
		3	*96 799.9*			
		4	*97 049.9*			

Mn II—Continued

Configuration	Term	J	Level (cm^{-1})	g	Leading components (%)	
					First	Second
$3d^5(^6S)6s$	^7S	3	97 728.54			
$3d^5(^6S)6s$	^5S	2	98 410.35			
$3d^5(^6S)4f$	$^7F°$	6	*98 423.3*			
		5	*98 423.4*			
		4	*98 423.6*			
		3	*98 423.7*			
		2	*98 423.8*			
$3d^5(^6S)4f$	$^5F°$	1	*98 461.77*			
		2	*98 462.41*			
		3	*98 463.23*			
		4	*98 464.20*			
		5	*98 465.21*			
$3d^5(^6S)5d$	^7D	1	99 890.51			
		2	99 892.32			
		3	99 895.13			
		4	99 898.98			
		5	99 904.10			
$3d^5(^6S)5d$	^5D	4	100 682.38			
		3	100 688.58			
		2	100 693.16			
		1	100 696.1			
$3d^44s4p$	$t\ ^3D°$	1	*100 928.2?*			
		2	*101 084.1*			
		3	*101 313.0*			
$3d^5(^4G)5s$	$e\ ^5G$	6	101 468.04			
		5	101 489.61			
		4	101 499.40			
		2	101 500.25			
		3	101 501.67			
$3d^5(b\ ^2D)4p$	$^1F°$	3	*101 588.3*	1.04	88	7 $(b\ ^2G)\ ^1F°$
$3d^5(^4G)5s$	$e\ ^3G$	5	102 680.35			
		4	102 703.67			
		3	102 705.66			
$3d^5(b\ ^2D)4p$	$w\ ^1D°$	2	*103 600.17*		94	
$3d^5(^4P)5s$	$e\ ^5P$	3	103 803.1			
		2	103 836.3			
		1	103 868.4			
$3d^5(^4P)5s$	$e\ ^3P$	2	104 914.48?			
		1	105 020.95			
		0	105 055.7			

Mn II—Continued

Configuration	Term	J	Level (cm^{-1})	g	Leading components (%)	
					First	Second
$3d^5(^4G)4d$	$e\ ^5H$	3	106 157.83			
		4	106 164.38			
		7	106 167.98			
		5	106 169.03			
		6	106 170.25			
$3d^44s4p$	$v\ ^5F^\circ$	1	*106 265.7*			
		2	*106 374.3*			
		3	*106 526.2*			
		4	*106 707.9*			
		5	*106 894.4*			
$3d^44s4p$	$u\ ^5P^\circ$	1	*106 479.2*			
		2	*106 750.0*			
		3	*107 172.9*			
$3d^5(^4G)4d$	$e\ ^5I$	8	106 508.6			
		4	106 512.48			
		5	106 519.43			
		7	106 520.1			
		6	106 522.87			
$3d^5(^4D)5s$	$g\ ^5D$	4	106 886.19			
		3	106 950.57			
		0	106 956.7			
		1	106 962.9			
		2	106 967.32			
$3d^5(^4D)5s$	$e\ ^3D$	3	108 102.5			
		2	108 170.7			
		1	108 172.8			
$3d^5(^6S)7s$	^7S	3	108 126.18			
$3d^5(^6S)5f$	$^7F^\circ$	6	*108 409.9*			
		5	*108 410.0*			
		4	*108 410.1*			
		3	*108 410.2*			
		2	*108 410.3*			
$3d^5(^6S)5f$	$^5F^\circ$	1	*108 435.6*			
		2	*108 437.3*			
		3	*108 439.0*			
		4	*108 441.4*			
		5	*108 443.1*			
$3d^5(^6S)7s$	^5S	2	108 447.30			
	$x\ ^5G^\circ$	2	*108 486.0*			
		3	*108 503.5*			
		4	*108 524.2*			
		5	*108 550.7*			
		6	*108 587.4*			

Mn II—Continued

Configuration	Term	J	Level (cm^{-1})	g	Leading components (%)	
					First	Second
$3d^5(^6S)5g$	^7G	7-1	108 555.7			
$3d^5(^6S)5g$	^5G	6-2	108 556.1			
	$t\ ^5P°$	1	*108 727.1*			
		2	*108 975.0*			
		3	*109 379.5*			
	$u\ ^5F°$	1	*108 994.4*			
		2	*109 046.4*			
		3	*109 123.3*			
		4	*109 221.9*			
		5	*109 327.5*			
	$v\ ^5D°$	0	*109 167.7*			
		1	*109 235.3*			
		2	*109 344.3*			
		3	*109 476.6*			
		4	*109 608.3*			
$3d^5(^6S)6d$	^7D	1	109 241.33			
		2	109 242.40			
		3	109 244.01			
		4	109 246.20			
		5	109 249.05			
$3d^5(b\ ^2G)4p$	$v\ ^1G°$	4	*109 473.9*		96	
$3d^44s4p$	$y\ ^5S°$	2	*109 704.0*			
	$r\ ^3F°$	2	*109 900.7*			
		3	*110 018.3*			
		4	*110 141.4*			
$3d^44s4p$	$u\ ^5D°$	0	*109 959.0*			
		1	*109 994.6*			
		2	*110 068.8*			
		3	*110 205.6*			
		4	*110 429.2*			
	$y\ ^5H°$	3	*110 547.7*			
		4	*110 602.3*			
		5	*110 691.9*			
		6	*110 795.3*			
		7	*110 926.3*			

Mn II—Continued

Configuration	Term	J	Level (cm⁻¹)	g	Leading components (%) First	Second
$3d^44s4p$	$y\ ^3S°$	1	*110 671.6*			
	$t\ ^5F°$	1	*111 017.5*			
		2	*111 060.5*			
		3	*111 116.0*			
		4	*111 159.6*			
		5	*111 160.3*			
$3d^44s4p$	$x\ ^3I°$	5	*111 083.8*			
		6	*111 339.2*			
		7	*111 816.5*			
	$s\ ^5P°$	1	*111 162.3*			
		2	*111 178.5*			
		3	*111 213.3*			
	$u\ ^3H°$	4	*111 720.0*			
		5	*111 854.5*			
		6	*112 128.5*			
	$s\ ^3D°$	1	*112 274.0?*			
		2	*112 717.6*			
		3	*113 251.4*			
	$w\ ^5G°$	2	*112 424.2*			
		3	*112 453.2*			
		4	*112 463.2*			
		5	*112 468.8*			
		6	*112 472.4*			
	$q\ ^3F°$	2	*112 563.2*			
		3	*112 673.9*			
		4	*112 879.8*			
	$v\ ^5G°$	2	*113 092.5*			
		3	*113 109.7*			
		4	*113 181.7*			
		5	*113 251.4*			
		6	*113 322.7*			
	$t\ ^3G°$	5	*113 515.0?*			
		3	*113 520.0*			
		4	*113 560.1*			
	$s\ ^5F°$	3	*113 642.0*			
		2	*113 645.4*			
		1	*113 645.8*			
		4	*113 647.2*			
		5	*113 658.1*			

Mn II—Continued

Configuration	Term	*J*	Level (cm^{-1})	*g*	Leading components (%) First	Second
$3d^5(^6S)8s$	^7S	3	113 697.68			
	$s\ ^3G^\circ$	3	*113 773.4*			
		4	*113 926.2*			
		5	*114 090.6*			
$3d^5(^6S)6f$	$^7F^\circ$	6	*113 840.0*			
		5	*113 840.2*			
		4	*113 840.3*			
		3	*113 840.4*			
$3d^5(^6S)8s$	^5S	2	113 895.25			
$3d^5(^6S)6g$	^7G	7-1	113 931.7			
$3d^5(^6S)6g$	^5G	6-2	113 932.1			
$3d^5(^6S)6f$	$^5F^\circ$	1	*114 023.6*			
		2	*114 024.9*			
		3	*114 026.5*			
		5	*114 027.0*			
		4	*114 028.0*			
$3d^5(^6S)7d$	^7D	1	114 344.24			
		2	114 344.90			
		3	114 345.96			
		4	114 347.38			
		5	114 349.16			
$3d^5(^6S)7d$	^5D	4	114 932.3			
		3	114 944.0			
		2	114 951.7			
		1	114 956.3			
		0	114 958.4			
$3d^5(^6S)9s$	^7S	3	117 031.23			
$3d^5(^6S)7f$	$^7F^\circ$	6	*117 113.1*			
		5-3	*117 113.2*			
$3d^5(^6S)7f$	$^5F^\circ$	1	*117 135*			
		2	*117 138*			
		4	*117 138*			
		3	*117 139*			
		5	*117 148*			
	$r\ ^5F^\circ$	1	*117 165.0*			
		2	*117 232.1*			
		3	*117 314.9*			
		4	*117 399.6*			
		5	*117 483.6*			

Mn II—Continued

Configuration	Term	J	Level (cm^{-1})	g	Leading components (%)	
					First	Second
$3d^5(^6S)7g$	^7G	7-1	117 172.9			
$3d^5(^6S)7g$	^5G	6-2	117 173.8			
$3d^5(^6S)10s$	^7S	3	119 186.0			
$3d^5(^6S)8f$	$^5F°$	1-5	*119 253*			
$3d^5(^6S)8g$	^7G	7-1	119 276.8			
$3d^5(^6S)8g$	^5G	6-2	119 278.3			
$3d^5(^6S)8h$	$^7H°$	8-2	*119 282.3*			
$3d^5(^6S)9h$	$^7H°$	8-2	*120 721.9*			
Mn III ($^6S_{5/2}$)	***Limit***	....	**126 145.0**			

Mn III

V I isoelectronic sequence Z=25

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

Ionization energy = 271 550 cm⁻¹ (33.668 eV)

The analysis is from Garcia-Riquelme (1968) with additional and corrected terms from Yarosewick, DaVia, and Moore (1971).

The percentage composition of the $3d^5$ levels is from Pasternak and Goldschmidt (1974). Percentages for the $3d^44s$ configuration are taken from an ab initio (Hartree-Fock) calculation by Vizbaraite, Kupliauskis and Tutlys (1968).

The compositions of the $3d^44p$ configuration are from Roth (1968). His a's and b's indicate that the percentages are the sum of the percentages of seniority states contributing to the core term.

The ionization energy was determined by Garcia-Riquelme from the three-member series of $3d^4ns\ ^6D$.

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Mn *III*

Configuration	Term	J	Level (cm⁻¹)	Leading components (%)	
				First	Second
$3d^5$	$a\ ^6S$	5/2	0.0	100	
$3d^5$	$a\ ^4G$	11/2	26 824.40	100	
		9/2	26 851.10	100	
		7/2	26 859.90	100	
		5/2	26 857.80	100	
$3d^5$	$a\ ^4P$	5/2	29 167.70	97	
		1/2	29 207.30	99	
		3/2	29 241.40	98	
$3d^5$	$a\ ^4D$	7/2	32 307.30	100	
		1/2	32 368.9	99	
		5/2	32 383.70	97	
		3/2	32 384.70	98	
$3d^5$	$a\ ^2I$	11/2	39 174.4	99	
		13/2	39 176.5	100	
$3d^5$	$a\ ^2D3$	5/2	41 238.1	58	22 $^2F1$
		3/2	41 569.8	73	24 $^2D1$
$3d^5$	$a\ ^2F1$	7/2	42 606.5	98	
		5/2	43 105.4	72	14 $^2D3$
$3d^5$	$a\ ^4F$	9/2	43 573.16	99	
		7/2	43 602.50	99	
		5/2	43 668.84	90	
		3/2	43 674.7	96	
$3d^5$	$a\ ^2H$	9/2	46 515.9	92	
		11/2	46 670.7	99	

Mn III—Continued

Configuration	Term	J	Level (cm^{-1})	Leading components (%) First	Second
$3d^5$	a ^{2}G2	7/2	47 842.0	99	
		9/2	48 005.2	91	
$3d^5$	b ^{2}F2	5/2	51 002.7	99	
		7/2	51 059.7	99	
$3d^5$	b ^{2}D2	3/2	61 580.2	100	
		5/2	61 603.8	100	
$3d^4(^5D)4s$	a ^{6}D	1/2	62 456.99	100	
		3/2	62 568.08	100	
		5/2	62 747.50	100	
		7/2	62 988.92	100	
		9/2	63 285.37	100	
$3d^5$	b ^{2}G1	7/2	68 892.00	100	
		9/2	68 899.20	100	
$3d^4(^5D)4s$	b ^{4}D	1/2	71 395.27	100	
		3/2	71 564.21	100	
		5/2	71 831.98	100	
		7/2	72 183.33	100	
$3d^4(^3P2)4s$	b ^{4}P	1/2	84 610.53	61	38 (^{3}P1) ^{4}P
		3/2	85 173.88	61	38
		5/2	86 051.50	62	38
$3d^4(^3H)4s$	a ^{4}H	7/2	84 981.63	100	
		9/2	85 077.09	100	
		11/2	85 200.76	94	6 (^{3}G) ^{4}H
		13/2	85 346.72	100	
$3d^4(^3F2)4s$	b ^{4}F	3/2	86 486.77	79	20 (^{3}F1) ^{4}F
		5/2	86 520.94	79	20
		7/2	86 578.24	79	19
		9/2	86 654.07	79	19
$3d^4(^3G)4s$	b ^{4}G	5/2	88 880.08	98	
		7/2	89 052.44	98	
		9/2	89 204.69	81	18 (^{3}H) ^{2}H
		11/2	89 307.22	94	6 (^{3}H) ^{4}H
$3d^4(^3P2)4s$	b ^{2}P	1/2	89 898.08	61	38 (^{3}P1) ^{2}P
		3/2	90 936.22	61	38
$3d^4(^3H)4s$	b ^{2}H	9/2	90 440.50	81	
		11/2	90 746.06	98	
$3d^4(^3F2)4s$	c ^{2}F	5/2	91 906.10	79	20 (^{3}F1) ^{2}F
		7/2	91 948.30	79	19

Mn III—Continued

Configuration	Term	J	Level (cm^{-1})	Leading components (%)	
				First	Second
$3d^4(^3G)4s$	$c\ ^2G$	7/2	94 397.20	98	
		9/2	94 707.20	100	
$3d^4(^3D)4s$	$c\ ^4D$	7/2	94 697.85	100	
		5/2	94 771.47	100	
		3/2	94 850.66	100	
		1/2	94 906.45	100	
$3d^4(^1G2)4s$	$d\ ^2G$	9/2	96 430.4	66	34 $(^1G1)\ ^2G$
		7/2	96 487.5	66	34
$3d^4(^1I)4s$	$b\ ^2I$	13/2	97 239.86	100	
		11/2	97 271.76	100	
$3d^4(^3D)4s$	$d\ ^2D$	5/2	100 001.30	100	
		3/2	100 085.20	100	
$3d^4(^1S2)4s$	$b\ ^2S$	1/2	100 054.10	77	22 $(^1S1)\ ^2S$
$3d^4(^1D2)4s$	$e\ ^2D$	5/2	104 470.8	77	22 $(^1D1)\ ^2D$
		3/2	104 517.9	77	21
$3d^4(^1F)4s$	$d\ ^2F$	5/2	109 780.40	100	
		7/2	109 841.12	100	
$3d^4(^5D)4p$	$z\ ^6F^\circ$	1/2	*110 036.14*	100	
		3/2	*110 172.69*	100	
		5/2	*110 398.50*	100	
		7/2	*110 711.62*	100	
		9/2	*111 111.39*	100	
		11/2	*111 601.45*	100	
$3d^4(^5D)4p$	$z\ ^6P^\circ$	3/2	*111 776.60*	98	
		5/2	*111 883.60*	98	
		7/2	*112 057.80*	100	
$3d^4(^5D)4p$	$z\ ^4P^\circ$	1/2	*112 645.31*	73	24 $(^5D)\ ^6D^\circ$
		3/2	*113 078.34*	66	30
		5/2	*113 676.53*	51	48
$3d^4(^5D)4p$	$z\ ^6D^\circ$	1/2	*113 991.31*	75	24 $(^5D)\ ^4P^\circ$
		3/2	*114 094.97*	69	30 $(^5D)\ ^4P^\circ$
		7/2	*114 209.01*	99	
		5/2	*114 287.91*	52	46 $(^5D)\ ^4P^\circ$
		9/2	*114 501.18*	97	
$3d^4(^3F1)4s$	$c\ ^4F$	9/2	115 711.60	81	19 $(^3F2)\ ^4F$
		3/2	115 762.60	79	20
		7/2	115 774.00	79	20
		5/2	115 780.23	79	20

Mn III—Continued

Configuration	Term	J	Level (cm^{-1})	Leading components (%)	
				First	Second
$3d^4(^5D)4p$	$z\ ^4F°$	3/2	*116 580.17*	96	
		5/2	*116 692.14*	96	
		7/2	*116 851.69*	95	
		9/2	*117 063.74*	94	
$3d^4(^5D)4p$	$z\ ^4D°$	1/2	*120 974.25*	98	
		3/2	*121 091.08*	98	
		5/2	*121 267.32*	98	
		7/2	*121 480.24*	98	
$3d^4(^3F1)4s$	$e\ ^2F$	7/2	121 117.14	81	19 $(^3F2)\ ^2F$
		5/2	121 197.05	79	20
$3d^4(^1G1)4s$	$e\ ^2G$	7/2	124 754.80	56	34 $(^1G2)\ ^2G$
		9/2	124 823.90	66	34
$3d^4(^3H)4p$	$z\ ^4H°$	7/2	*130 731.31*	80	18 $(^3G)\ ^4H°$
		9/2	*130 895.39*	79	17
		11/2	*131 123.64*	79	16
		13/2	*131 420.03*	82	14
$3d^4(a\ ^3P)4p$	$y\ ^4D°$	1/2	*131 287.18*	83	14 $(a\ ^3F)\ ^4D°$
		3/2	*131 701.69*	82	16
		5/2	*132 297.55*	78	20
		7/2	*132 971.99*	69	29
$3d^4(a\ ^3F)4p$	$z\ ^4G°$	5/2	*132 897.74*	72	18 $(^3G)\ ^4G°$
		7/2	*133 059.84*	59	15 $(^3G)\ ^4G°$
		9/2	*133 276.40*	45	13 $(^3G)\ ^4G°$
		11/2	*133 736.64*	55	22 $(^3H)\ ^4G°$
$3d^4(a\ ^3P)4p$	$z\ ^2S°$	1/2	*132 937.06*	50	42 $(a\ ^3P)\ 4p$
$3d^4(^3H)4p$	$z\ ^4I°$	9/2	*133 086.57*	94	
		11/2	*133 455.64*	95	
		13/2	*133 804.28*	96	
		15/2	*134 136.60*	100	
$3d^4(^3H)4p$	$z\ ^2G°$	7/2	*133 751.50*	49	28 $(a\ ^3F)\ ^2G°$
		9/2	*133 949.54*	39	27
$3d^4(a\ ^3P)4p$	$y\ ^4P°$	1/2	*134 286.00*	52	32 $(a\ ^3P)\ ^2S°$
		3/2	*134 638.39*	91	
		5/2	*135 246.27*	90	
$3d^4(a\ ^3P)4p$	$z\ ^2P°$	1/2	*134 789.08*	71	17 $(a\ ^3P)\ ^2S°$
		3/2	*135 041.25*	44	28 $(a\ ^3P)\ ^4S°$
$3d^4(a\ ^3F)4p$	$z\ ^2D°$	3/2	*135 116.80*	33	26 $(a\ ^3F)\ ^4F°$
		5/2	*135 510.70*	54	18

Mn III—Continued

Configuration	Term	J	Level (cm^{-1})	Leading components (%)	
				First	Second
$3d^4(^3H)4p$	$y\ ^4G°$	7/2	*135 692.17*	52	28 $(a\ ^3F)\ ^4G°$
		5/2	*135 709.90*	34	24 $(a\ ^3F)\ ^4F°$
		9/2	*135 732.50*	54	31 $(a\ ^3F)\ ^4G°$
		11/2	*135 781.09*	51	40 $(a\ ^3F)\ ^4G°$
$3d^4(a\ ^3F)4p$	$y\ ^4F°$	5/2	*135 858.96*	50	25 $(^3H)\ ^4G°$
		3/2	*135 861.32*	50	30 $(a\ ^3F)\ ^2D°$
		7/2	*135 869.76*	84	8 $(^3H)\ ^4G°$
		9/2	*135 944.08*	86	4 $(^3H)\ ^4G°$
$3d^4(^3H)4p$	$z\ ^2I°$	11/2	*136 421.50*	92	4 $(^1I)\ ^2I°$
		13/2	*136 500.63*	93	
$3d^4(a\ ^3F)4p$	$x\ ^4D°$	5/2	*136 796.61*	62	18 $(a\ ^3P)\ ^4D°$
		7/2	*136 823.86*	51	27
		3/2	*136 888.70*	61	15
		1/2	*136 935.60*	78	15
$3d^4(a\ ^3P)4p$	$z\ ^4S°$	3/2	*137 137.69*	39	30 $(a\ ^3P)\ ^2P°$
$3d^4(a\ ^3F)4p$	$z\ ^2F°$	5/2	*137 282.40*	35	28 $(^3G)\ ^2F°$
		7/2	*137 599.20*	38	23
$3d^4(^3H)4p$	$z\ ^2H°$	9/2	*137 436.70*	71	14 $(a\ ^1G)\ ^2H°$
		11/2	*137 908.20*	72	11
$3d^4(^3G)4p$	$y\ ^4H°$	7/2	*137 660.24*	80	17 $(^3H)\ ^4H°$
		9/2	*137 935.53*	76	15
		11/2	*138 245.09*	73	13
		13/2	*138 605.80*	83	14
$3d^4(^3G)4p$	$x\ ^4F°$	3/2	*138 234.79*	68	14 $(^3D)\ ^4F°$
		9/2	*138 312.70*	71	13 $(^3D)\ ^4F°$
		5/2	*138 340.62*	50	25 $(a\ ^3P)\ ^2D°$
		7/2	*138 362.80*	69	14 $(^3D)\ ^4F°$
$3d^4(a\ ^3P)4p$	$y\ ^2D°$	3/2	*138 692.0*	70	13 $(a\ ^3F)\ ^2D°$
		5/2	*139 273.2*	55	21 $(^3G)\ ^4F°$
$3d^4(a\ ^3F)4p$	$y\ ^2G°$	7/2	*139 643.6*	53	24 $(^3H)\ ^2G°$
		9/2	*139 971.6*	44	24
$3d^4(^3G)4p$	$y\ ^2H°$	9/2	*139 857.84*	48	18 $(^3G)\ ^4G°$
		11/2	*139 902.06*	53	23
$3d^4(^3G)4p$	$y\ ^2F°$	5/2	*139 944.4*	42	41 $(a\ ^3F)\ ^2F°$
		7/2	*140 401.1*	48	40
$3d^4(^3G)4p$	$x\ ^4G°$	5/2	*140 207.09*	57	25 $(^3H)\ ^4G°$
		7/2	*140 294.44*	62	24 $(^3H)\ ^4G°$
		9/2	*140 557.46*	46	17 $(^3G)\ ^2H°$
		11/2	*140 776.88*	47	27 $(^3G)\ ^2H°$

Mn III—Continued

Configuration	Term	J	Level (cm^{-1})	Leading components (%) First	Second
$3d^4(^3G)4p$	$x\ ^2G°$	7/2	*143 097.00*	74	15 (^{3}H) ^{2}G°
		9/2	*143 161.50*	67	17
$3d^4(^3D)4p$	$w\ ^4D°$	1/2	*143 127.00*	92	
		3/2	*143 148.40*	87	
		5/2	*143 209.80*	79	12 (^{3}D) ^{4}P°
		7/2	*143 345.07*	88	
$3d^4(a\ ^1G)4p$	$^2F°$	7/2	*144 129.8*	82	4 (^{3}G) ^{2}F°
		5/2	*144 718.4*	81	5
$3d^4(^1I)4p$	$y\ ^2I°$	13/2	*144 258.5*	74	23 (^{1}I) ^{2}K°
		11/2	*144 311.0*	90	7 ($a\ ^1$G) ^{2}H°
$3d^4(a\ ^1G)4p$	$x\ ^2H°$	9/2	*144 522.30*	80	10 (^{3}H) ^{2}H°
		11/2	*144 880.10*	76	10
$3d^4(^3D)4p$	$w\ ^4F°$	3/2	*144 619.19*	70	16 (^{3}G) ^{4}F°
		5/2	*144 672.38*	72	16
		7/2	*144 817.68*	77	16
		9/2	*144 959.74*	83	16
$3d^4(^1I)4p$	$z\ ^2K°$	13/2	*145 008.36*	77	23 (^{1}I) ^{2}I°
		15/2	*145 455.10*	100	
$3d^4(^3D)4p$	$y\ ^2P°$	1/2	*145 280.9*	45	47 ($a\ ^1$S) ^{2}P°
		3/2	*145 462.2*	56	38
$3d^4(^3D)4p$	$x\ ^4P°$	5/2	*145 643.45*	81	10 (^{3}D) ^{4}D°
		3/2	*146 066.07*	82	8 (^{3}D) ^{4}D°
		1/2	*146 391.30*	93	
$3d^4(a\ ^1G)4p$	$w\ ^2G°$	7/2	*146 591.9*	80	10 (^{3}G) ^{2}G°
		9/2	*146 788.4*	78	15
$3d^4(^1I)4p$	$w\ ^2H°$	11/2	*148 206.90*	85	9 (^{3}G) ^{2}H°
		9/2	*148 560.50*	87	9
$3d^4(^3D)4p$	$x\ ^2F°$	7/2	*148 355.60*	73	9 (^{3}G) ^{2}F°
		5/2	*148 568.40*	73	11
$3d^4(^3D)4p$	$x\ ^2D°$	5/2	*149 234.40*	58	30 ($a\ ^1$D) ^{2}D°
		3/2	*149 540.5*	64	15
$3d^4(a\ ^1S)4p$	$x\ ^2P°$	3/2	*149 512.90*	43	24 (^{3}D) ^{2}P°
		1/2	*149 621.00*	41	42
$3d^4(a\ ^1D)4p$	$w\ ^2D°$	3/2	*151 628.8*	67	15 (^{3}D) ^{2}D°
		5/2	*151 871.3*	58	23

Mn III—Continued

Configuration	Term	J	Level (cm^{-1})	Leading components (%)	
				First	Second
$3d^4(^1F)4p$	$u\ ^2F°$	5/2	*156 621.7*	81	7 $(a\ ^1D)\ ^2F°$
		7/2	*156 809.6*	78	10
$3d^4(^1F)4p$	$v\ ^2G°$	9/2	*158 016.3*	95	
$3d^4(b\ ^3F)4p$	$v\ ^4F°$	3/2	*162 999.8*	96	
		5/2	*163 022.3*	92	
		7/2	*163 078.5*	92	
		9/2	*163 194.6*	98	
$3d^4(b\ ^3F)4p$	$t\ ^2F°$	7/2	*165 702.9*	73	17 $(b\ ^3F)\ ^4G°$
		5/2	*165 922.9*	73	16
$3d^4(^5D)4d$	$e\ ^6G$	3/2	172 451.23		
		5/2	172 547.85		
		7/2	172 682.64		
		9/2	172 855.02		
		11/2	173 063.55		
		13/2	173 306.45		
$3d^4(^5D)4d$	$e\ ^6P$	3/2	172 569.27		
		5/2	172 613.87		
		7/2	172 755.95		
$3d^4(^5D)4d$	$e\ ^6D$	1/2	173 835.07		
		3/2	173 920.69		
		5/2	174 048.89		
		7/2	174 243.33		
		9/2	174 464.07		
$3d^4(^5D)4d$	$e\ ^6F$	1/2	174 247.63		
		3/2	174 332.91		
		5/2	174 436.59		
		7/2	174 575.87		
		9/2	174 874.50		
		11/2	174 975.65		
$3d^4(^5D)4d$	$e\ ^4P$	1/2	175 918.50		
		3/2	176 265.78		
		5/2	176 683.76		
$3d^4(^5D)5s$	$f\ ^6D$	1/2	176 100.71		
		3/2	176 209.15		
		5/2	176 390.67		
		7/2	176 641.14		
		9/2	176 945.20		
$3d^4(^5D)4d$	$e\ ^4G$	5/2	176 270.25		
		7/2	176 464.78		
		9/2	176 695.06		
		11/2	176 970.01		

Mn III—Continued

Configuration	Term	J	Level (cm^{-1})	Leading components (%)	
				First	Second
$3d^4(^5D)4d$	$e\ ^4D$	1/2	177 185.18		
		3/2	177 269.34		
		5/2	177 477.23		
		7/2	177 687.54		
$3d^4(^5D)5s$	$f\ ^4D$	1/2	178 386.00		
		3/2	178 558.30		
		5/2	178 816.96		
		7/2	179 152.09		
$3d^4(^5D)4d$	$e\ ^4F$	3/2	179 228.69		
		5/2	179 339.59		
		9/2	179 683.61		
$3d^4(^5D)4d$	$e\ ^6S$	5/2	181 949.34		
$3d^4(^5D)5p$	$y\ ^6F°$	1/2	*191 915.43*		
		3/2	*192 012.75*		
		5/2	*192 172.89*		
		7/2	*192 392.20*		
		9/2	*192 665.80*		
		11/2	*192 989.05*		
$3d^4(^5D)5p$	$y\ ^6P°$	3/2	*192 365.52*		
		5/2	*192 576.42*		
		7/2	*192 880.16*		
$3d^4(^5D)5p$	$y\ ^6D°$	1/2	*192 741.67*		
		3/2	*192 948.29*		
		5/2	*193 235.43*		
		7/2	*193 498.07*		
		9/2	*193 756.79*		
$3d^4(^3H)4d$	$e\ ^4I$	9/2	194 446.1		
		11/2	194 893.0		
		13/2	195 141.8		
		15/2	195 455.5		
$3d^4(^5D)5p$	$w\ ^4P°$	1/2	*194 545.78*		
		3/2	*194 894.78*		
		5/2	*195 315.78*		
$3d^4(^3H)4d$	$e\ ^4H$	7/2	194 555.4		
		9/2	194 744.0		
$3d^4(^5D)5p$	$v\ ^4F°$	3/2	*194 849.10*		
		5/2	*194 971.15*		
		7/2	*195 112.81*		
		9/2	*195 308.79*		

Mn III—Continued

Configuration	Term	J	Level (cm^{-1})	Leading components (%) First	Second
$3d^4(^3H)4d$	$e\ ^4K$	11/2	194 900.40		
		13/2	195 036.20		
		15/2	195 186.90		
		17/2	195 343.10		
$3d^4(^3H)4d$	$e\ ^4H$	11/2	194 908.20		
		13/2	195 036.20		
$3d^4(^3H)4d$	$f\ ^4G$	9/2	195 415.20		
		11/2	195 682.50		
$3d^4(^5D)5p$	$v\ ^4D^\circ$	1/2	*195 462.26*		
		3/2	*195 592.09*		
		5/2	*195 752.48*		
		7/2	*195 948.44*		
$3d^4(^5D)4f$	$z\ ^6G^\circ$	7/2	*208 650.54*		
		9/2	*208 751.60*		
		11/2	*209 032.30*		
		13/2	*209 323.03*		
$3d^4(^5D)4f$	$z\ ^6H^\circ$	5/2	*208 743.10*		
		7/2	*208 819.64*		
		9/2	*208 935.88*		
		11/2	*209 091.41*		
		13/2	*209 289.76*		
		15/2	*209 530.38*		
$3d^4(^5D)5d$	$f\ ^6G$	3/2	215 473.20		
		5/2	215 520.22		
		7/2	215 663.50		
		9/2	215 917.52		
		11/2	216 194.05		
		13/2	216 533.06		
$3d^4(^5D)5d$	$f\ ^6F$	1/2	215 580.87		
		3/2	215 715.41		
		5/2	215 875.73		
		7/2	216 149.32		
		9/2	216 307.29		
		11/2	216 691.83		
$3d^4(^5D)5d$	$g\ ^6D$	3/2	215 911.73		
		5/2	216 062.13		
		7/2	216 283.58		
		9/2	216 670.58		
$3d^4(^5D)5d$	$f\ ^6P$	3/2	216 162.90		
		5/2	216 403.86		
		7/2	216 557.38		

Mn III—Continued

Configuration	Term	J	Level (cm^{-1})	Leading components (%) First	Second
$3d^4(^5D)6s$	$h\ ^6D$	1/2	216 423.25		
		3/2	216 531.99		
		5/2	216 712.73		
		7/2	216 961.62		
		9/2	217 271.59		
$3d^4(^5D)6s$	$g\ ^4D$	3/2	217 807.57?		
		5/2	218 067.19?		
		7/2	218 400.40?		
$3d^4(^5D)5d$	$h\ ^4G$	5/2	217 975.30		
		7/2	218 115.15		
		9/2	218 375.61		
		11/2	218 596.69		
$3d^4(^5D)5d$	$h\ ^4D$	1/2	218 085.88		
		3/2	218 180.90		
		5/2	218 307.98		
		7/2	218 506.39		
$3d^4(^5D)5d$	$f\ ^4P$	1/2	218 127.59		
		3/2	218 373.00		
		5/2	218 705.25		
$3d^4(^5D)5d$	$g\ ^4F$	3/2	218 669.26		
		5/2	218 816.97		
		7/2	218 977.34		
		9/2	219 195.95		
$3d^4(^3H)4f$	$z\ ^4L^\circ$	13/2	*230 134.95*		
		11/2	*230 281.25*		
		9/2	*230 369.62*		
		7/2	*230 506.52*		
$3d^4(^5D)5f$	$y\ ^6H^\circ$	5/2	*231 361.28*		
		7/2	*231 387.66*		
		9/2	*231 487.34*		
		11/2	*231 752.76*		
		13/2	*232 075.44*		
		15/2	*232 433.03*		
$3d^4(^5D)5f$	$w\ ^6F^\circ$	5/2	*232 065.03*		
		7/2	*232 264.42*		
		9/2	*232 478.68*		
		11/2	*232 761.16*		
Mn IV ($^5D_0$)	***Limit***	....	**271 550**		

Mn IV

Ti I isoelectronic sequence Z=25

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

Ionization energy = 413 000 cm^{-1} (51.2 eV)

White (1929) identified the $3d^34s\ {}^5F$–$3d^34p\ {}^5G^\circ$ multiplet. Bowen (1937) found the low ^5D and four of the seven triplets in the $3d^4$ ground configuration. He also found $3d^34s\ {}^3F$ and nine terms of $3d^34p$.

Yarosewick and Moore added two more triplets in $3d^4$, three more triplets in $3d^34s$ and nine new terms in $3d^34p$. They also found a ^5H term in $3d^34d$ and give new values for all levels with an estimated uncertainty of less than 1.0 cm^{-1}.

The ionization energy is from the isoelectronic extrapolation of Lotz (1967).

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Mn IV

Configuration	Term	J	Level (cm^{-1})
$3d^4$	$a\ {}^5D$	0	0.0
		1	99.0
		2	286.8
		3	552.2
		4	885.8
$3d^4$	$a\ {}^3P$	0	20 654.2
		1	21 278.8
		2	22 324.7
$3d^4$	$a\ {}^3H$	4	21 280.7
		5	21 474.8
		6	21 679.3
$3d^4$	$a\ {}^3F$	2	22 791.0
		3	22 862.3
		4	22 959.1
$3d^4$	$a\ {}^3G$	3	25 440.4
		4	25 670.8
		5	25 877.7
$3d^4$	$a\ {}^3D$	3	31 385.2
		2	31 473.5
		1	31 580.7
$3d^4$	$b\ {}^3F$	4	53 212.3
		2	53 260.7
		3	53 286.7
$3d^3(^4F)4s$	$a\ {}^5F$	1	111 506.0
		2	111 710.4
		3	112 013.3
		4	112 408.9
		5	112 882.8

Mn IV—Continued

Configuration	Term	J	Level (cm^{-1})
$3d^3(^4F)4s$	$c\ ^3F$	2	119 445.5
		3	119 961.5
		4	120 603.1
$3d^3(^2G)4s$	$b\ ^3G$	3	130 969.5
		4	131 170.1
		5	131 462.5
$3d^3(^2H)4s$	$b\ ^3H$	4	137 853.0
		5	137 930.1
		6	138 123.1
$3d^3(^2F)4s$	$d\ ^3F$	4	152 700.5
		3	152 858.2
		2	152 986.0
$3d^3(^4F)4p$	$z\ ^5G^\circ$	2	*167 890.1*
		3	*168 300.3*
		4	*168 839.7*
		5	*169 499.2*
		6	*170 285.8*
$3d^3(^4F)4p$	$z\ ^5D^\circ$	1	*170 577.8*
		2	*170 866.3*
		3	*171 276.9*
		4	*171 765.0*
$3d^3(^4F)4p$	$z\ ^5F^\circ$	1	*171 383.9*
		2	*171 698.3*
		3	*172 081.9*
		4	*172 477.2*
		5	*172 871.5*
$3d^3(^4F)4p$	$z\ ^3D^\circ$	1	*172 090.6*
		2	*172 398.7*
		3	*172 952.6*
$3d^3(^4F)4p$	$z\ ^3G^\circ$	3	*175 436.0*
		4	*175 813.4*
		5	*176 288.6*
$3d^3(^4F)4p$	$z\ ^3F^\circ$	2	*177 629.8*
		3	*178 075.1*
		4	*178 579.5*
$3d^3(^4P)4p$	$z\ ^5P^\circ$	1	*184 566.1*
		2	*184 901.2*
		3	*185 435.9*
$3d^3(^4P)4p$	$y\ ^5D^\circ$	3	*187 004.0*
		4	*187 679.5*

Mn IV—Continued

Configuration	Term	J	Level (cm^{-1})
$3d^3(^2G)4p$	$z\ ^3H^\circ$	4	*186 659.4*
		5	*187 278.5*
		6	*188 184.8*
$3d^3(^2G)4p$	$y\ ^3G^\circ$	3	*188 756.2*
		4	*189 210.9*
		5	*189 553.9*
$3d^3(^2G)4p$	$y\ ^3F^\circ$	4	*190 032.4*
		2	*190 135.9*
		3	*190 282.8*
$3d^3(^2P)4p$	$y\ ^3D^\circ$	1	*192 980.7*
		2	*193 739.6*
		3	*194 208.2*
$3d^3(^2H)4p$	$y\ ^3H^\circ$	4	*193 760.7*
		5	*193 879.4*
		6	*194 155.7*
$3d^3(^2H)4p$	$z\ ^3I^\circ$	5	*195 974.1*
		6	*196 497.9*
		7	*197 185.0*
$3d^3(^2D)4p$	$w\ ^3D^\circ$	1	*197 095.4*
		2	*197 554.8*
		3	*197 885.5*
$3d^3(^2H)4p$	$x\ ^3G^\circ$	5	*200 192.2*
		4	*200 290.4*
		3	*200 333.2*
$3d^3(^2F)4p$	$w\ ^3F^\circ$	2	*209 260.2*
		3	*209 315.5*
		4	*209 447.5*
$3d^3(^2F)4p$	$w\ ^3G^\circ$	3	*212 399.3*
		4	*212 665.3*
		5	*212 966.5*
$3d^3(^4F)4d$	$e\ ^5H$	3	248 388.6
		4	248 665.0
		5	248 983.8
		6	249 374.8
		7	249 822.7
Mn V ($^4F_{3/2}$)	*Limit*	....	**413 000**

Mn v

Sc I isoelectronic sequence Z=25

Ground state: $1s^2 2s^2 2p^6 3s^2 3p^6 3d^3\ {}^4F_{3/2}$ Ionization energy = 584 000 cm^{-1} (72.4 eV)

The initial analysis was by White (1929) who found three terms in $3d^3$, two terms in $3d^24s$ and five in $3d^24p$. It was extended by Bowen (1935) who found seven new terms in $3d^24p$. Bowen's $3d^3\ {}^2P$ and ${}^2D$ were published by Pasternack (1940).

More precise values for the $3d^2\ 4s$ levels have been provided in advance of publication by Yarosewick and Moore (1976). They are based on Bowen's value for $3d^24p\ {}^4G^\circ_{5/2}$ taken as 241907.1 cm^{-1}. Yarosewick and Moore also found a ${}^4H$ term in $3d^24d$.

Kovalev, Ramonas and Ryabtsev (1976) have extended the analysis of the $3d^3$–$3d^24p$ transition array from new observations in the range 382–548 Å. We have used their level values for $3d^3$ and $3d^24p$ and adjusted Yarosewick and Moore's values for $3d^24s$ and $3d^24d$ accordingly. The percentage compositions are from parametric calculations of Kovalev, Ramonas, and Ryabtsev.

The ionization energy is from an isoelectronic extrapolation by Lotz (1967).

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Mn v

Configuration	Term	J	Level (cm^{-1})	Leading components (%)	
				First	Second
$3d^3$	${}^4F$	3/2	0.0	100	
		5/2	359.0	100	
		7/2	835.1	100	
		9/2	1412.2	100	
$3d^3$	${}^4P$	1/2	16 434.0	100	
		3/2	16 594.6	98	
		5/2	17 048.6	100	
$3d^3$	${}^2G$	7/2	17 892.4	100	
		9/2	18 398.8	98	
$3d^3$	${}^2P$	3/2	22 918.8	64	27 ${}^2D2$
		1/2	23 081.6	100	
$3d^3$	${}^2D2$	5/2	24 630.0	79	20 ${}^2D1$
		3/2	24 670.5	50	35 ${}^2P$
$3d^3$	${}^2H$	9/2	24 974.8	98	
		11/2	25 333.8	100	
$3d^3$	${}^2F$	7/2	40 423.3	100	
		5/2	40 707.1	100	
$3d^3$	${}^2D1$	5/2	62 608.2	79	20 ${}^2D2$
		3/2	62 853.5	77	22
$3d^2({}^3F)4s$	${}^4F$	3/2	176 945.5		
		5/2	177 326.2		
		7/2	177 872.6		
		9/2	178 572.2		

Mn v—Continued

Configuration	Term	J	Level (cm^{-1})	Leading components (%)	
				First	Second
$3d^2(^3F)4s$	^2F	5/2	183 537.8		
		7/2	184 633.3		
$3d^2(^3F)4p$	$^4G°$	5/2	*241 907.1*	92	5 (^3F) $^2F°$
		7/2	*242 766.9*	94	4 (^3F) $^4F°$
		9/2	*243 803.1*	94	5 (^3F) $^4F°$
		11/2	*245 046.7*	100	
$3d^2(^3F)4p$	$^4F°$	3/2	*243 120.9*	94	4 (^3F) $^2D°$
		5/2	*243 678.5*	96	
		7/2	*244 382.1*	96	4 (^3F) $^4G°$
		9/2	*245 135.6*	94	5 (^3F) $^4G°$
$3d^2(^3F)4p$	$^2F°$	5/2	*245 497.8*	67	10 (^3F) $^2D°$
		7/2	*246 324.7*	67	26 (^3F) $^4D°$
$3d^2(^3F)4p$	$^2D°$	3/2	*246 161.2*	44	41 (^3F) $^4D°$
		5/2	*248 088.4*	59	21
$3d^2(^3F)4p$	$^4D°$	1/2	*246 539.1*	94	6 (^3P) $^4D°$
		5/2	*246 897.6*	62	18 (^3F) $^2F°$
		3/2	*247 222.1*	53	35 (^3F) $^2D°$
		7/2	*247 705.2*	69	24 (^3F) $^2F°$
$3d^2(^3F)4p$	$^2G°$	7/2	*250 966.5*	94	5 (^1G) $^2G°$
		9/2	*251 719.6*	94	4
$3d^2(^3P)4p$	$^2S°$	1/2	*253 893.8*	98	
$3d^2(^3P)4p$	$^4S°$	3/2	*257 436.8*	90	9 (^1D) $^2P°$
$3d^2(^1D)4p$	$^2P°$	3/2	*259 043.8*	83	10 (^3P) $^4S°$
		1/2	*260 042.8*	92	
$3d^2(^1D)4p$	$^2F°$	5/2	*259 583.3*	85	7 (^3F) $^2F°$
		7/2	*260 680.8*	79	10 (^3P) $^4D°$
$3d^2(^3P)4p$	$^4D°$	1/2	*260 460.8*	90	6 (^3F) $^4D°$
		3/2	*260 806.2*	90	6 (^3F) $^4D°$
		5/2	*261 464.4*	86	5 (^3F) $^4D°$
		7/2	*262 574.9*	85	10 (^1D) $^2F°$
$3d^2(^1D)4p$	$^2D°$	3/2	*262 252.0*	81	6 (^3F) $^2D°$
		5/2	*262 836.1*	79	7 (^3P) $^4P°$
$3d^2(^3P)4p$	$^4P°$	1/2	*264 400.6*	98	
		3/2	*264 732.4*	98	
		5/2	*265 488.4*	92	8 (^1D) $^2D°$
$3d^2(^1G)4p$	$^2G°$	7/2	*265 579.3*	94	5 (^3F) $^2G°$
		9/2	*265 734.0*	94	5

Mn v—Continued

Configuration	Term	J	Level (cm^{-1})	Leading components (%)	
				First	Second
$3d^2(^3P)4p$	$^2D°$	5/2	*269 955.4*	81	12 (^3F) $^2D°$
		3/2	*269 968.3*	79	11
$3d^2(^1G)4p$	$^2H°$	9/2	*271 494.6*	98	
		11/2	*272 640.4*	100	
$3d^2(^3P)4p$	$^2P°$	1/2	*272 982.9*	98	
		3/2	*273 212.3*	96	
$3d^2(^1G)4p$	$^2F°$	7/2	*276 592.0*	96	4 (^1D) $^2F°$
		5/2	*277 398.1*	96	
$3d^2(^1S)4p$	$^2P°$	1/2	*303 705*	98	
		3/2	*305 247.4*	98	
$3d^2(^3F)4d$	^4H	7/2	338 057.2		
		9/2	338 584.9		
		11/2	339 165.5		
		13/2	339 745.1		
Mn VI ($^3F_2$)	*Limit*	....	**584 000**		

Mn VI

Ca I isoelectronic sequence Z=25

Ground state: $1s^2 2s^2 2p^6 3s^2 3p^6 3d^2\ ^3F_2$

Ionization energy = 766 000 cm⁻¹ (95 eV)

The $3d^2$ and $3d4p$ configurations were identified by Cady (1933) from observations he made in the range 307–330 Å. Revised level values were communicated to C. E. Moore by B. Edlén in 1949 and are used here.

The terms $3d4s\ ^3D, ^1D$ and $3d4d\ ^3G$ were first reported by King, Davis, and Shalimoff (1974), who also measured improved values for $3d4p$. The rest of $3d4d$ and the values of levels reported here to one decimal place are from unpublished results of W. H. King (1977). All four configurations are complete, except for the ^1S of $3d^2$ and $3d4d$.

The ionization energy is from the isoelectronic extrapolation of Lotz (1967).

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Mn VI

Configuration	Term	J	Level (cm⁻¹)
$3d^2$	^3F	2	0
		3	746
		4	1669
$3d^2$	^1D	2	15 336
$3d^2$	^3P	0	17 782
		1	18 057
		2	18 628
$3d^2$	^1G	4	25 511
$3d\,4s$	^3D	1	250 096.6
		2	250 527.0
		3	251 403.0
$3d\,4s$	^1D	2	255 239.7
$3d\,4p$	$^1D^\circ$	2	*319 821.2*
$3d\,4p$	$^3D^\circ$	1	*321 693.5*
		2	*322 409.6*
		3	*323 282.5*
$3d\,4p$	$^3F^\circ$	2	*323 796.1*
		3	*324 849.1*
		4	*326 372.6*
$3d\,4p$	$^3P^\circ$	1	*329 634.5*
		0	*329 729.3*
		2	*329 992.0*
$3d\,4p$	$^1F^\circ$	3	*333 054.5*

Mn VI—Continued

Configuration	Term	J	Level (cm^{-1})
$3d\,4p$	$^1P°$	1	*336 130.8*
$3d\,4d$	^1F	3	429 104.8
$3d\,4d$	^3D	2	431 059.4
		3	431 606.6
$3d\,4d$	^1P	1	432 313.3
$3d\,4d$	^3G	3	432 090.5
		4	432 652.6
		5	433 463.6
$3d\,4d$	^3S	1	436 451.0
$3d\,4d$	^3F	2	439 105.0
		3	439 643.4
		4	440 234.1
$3d\,4d$	^1D	2	444 637.1
$3d\,4d$	^3P	1	445 581.9
		2	446 044.2
$3d\,4d$	^1G	4	447 701.8
Mn VII ($^2D_{3/2}$)	*Limit*	....	**766 000**

Mn VII

K I isoelectronic sequence Z=25

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

Ionization energy = 962 000 cm^{-1} (119.27 eV)

The first observations of this spectrum were reported by Gibbs and White (1926) who observed the $4s$–$4p$ doublet at 1229 and 1267 Å.

The separation of the levels of the $3d\ ^2D$ ground term and the identification of the one-electron configurations $5s$, $6s$, $4p$, and $4f$ to $9f$ are from Kruger and Weissberg (1937).

The $3p^53d^2$ configuration is from Gabriel, Fawcett, and Jordan (1966). The designations are obtained by analogy with Fe VIII as calculated by Cowan and Peacock (1965). The levels of $3p^53d4s$ were identified by Cowan (1969) from lines reported by Feldman and Fraenkel (1966).

The ionization energy was derived by Kruger and Weissberg from the nf series (n =6, 7, and 8).

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Mn VII

Configuration	Term	J	Level (cm^{-1})
$3p^63d$	^2D	3/2	0
		5/2	1350
$3p^64s$	^2S	1/2	318 740
$3p^64p$	$^2P°$	1/2	*397 650*
		3/2	*400 120*
$3p^5(^2P°)3d^2(^3F)$	$^2F°$	5/2	*489 880*
		7/2	*494 300*
$3p^5(^2P°)3d^2(^3F)$	$^2D°$	5/2	*547 370*
		3/2	*547 930*
$3p^65s$	^2S	1/2	613 940
$3p^64f$	$^2F°$	5/2	*615 960*
		7/2	*616 100*
$3p^53d(^3P°)4s$	$^4P°$	3/2?	*696 420*
$3p^53d(^3P°)4s$	$^2P°$	1/2	*700 870*
		3/2	*705 170*
$3p^53d(^3F°)4s$	$^4F°$	7/2	*709 720*
		5/2	*712 350*
$3p^53d(^3F°)4s$	$^2F°$	7/2	*717 430*
		5/2	*722 100*
$3p^53d(^3D°)4s$	$^4D°$	7/2	*735 510*
		5/2	*737 020*

Mn VII—Continued

Configuration	Term	J	Level (cm^{-1})
$3p^6 5f$	$^2F°$	5/2	*739 770*
		7/2	*739 940*
$3p^5 3d(^1F°)4s$	$^2F°$	7/2	*746 450*
$3p^5 3d(^3D°)4s$	$^2D°$	3/2	*748 170*
		5/2	*749 430*
$3p^6 6s$	^2S	1/2	752 150
$3p^6 6f$	$^2F°$	5/2,7/2	*807 760*
$3p^6 7f$	$^2F°$	5/2,7/2	*848 850*
$3p^6 8f$	$^2F°$	5/2,7/2	*875 530*
$3p^6 9f$	$^2F°$	5/2,7/2	*893 740*
Mn VIII ($^1S_0$)	***Limit***	....	**962 000**

Mn VIII

Ar I isoelectronic sequence Z=25

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

Ionization energy = 1 569 000 cm^{-1} (194.5 eV)

The resonance lines arising from the two J=1 levels of the $3p^54s$ configuration were observed and identified by Kruger, Weissberg, and Phillips (1937). The designation given here for those levels conforms to that given by Reader and Sugar (1975) for the isoelectronic Fe IX.

The $^1P^\circ_1$ level of the $3p^53d$ configuration was identified by Alexander, Feldman, Fraenkel and Hoory (1965) and also by Gabriel, Fawcett, and Jordan (1965).

The levels of $3p^54d$ were identified by Alexander, Feldman, and Fraenkel (1965), who designated them in *jj* notation. The suitability of the $j_1\ell$-coupling designations for this configuration is indicated by the calculations of Ekberg (1976) in Cr VII for the corresponding configurations.

A dozen lines of the $3d$–$4f$ transition array have been identified by Wagner and House (1971) but none of the $3p^54f$ levels are connected to the levels in the present list.

We derived the ionization energy from $3p^53d$ and $4d\ ^1P^\circ_1$ levels, assuming a change in effective quantum number Δn^* between them of 0.9986 obtained from the same terms in Cr VII.

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Mn VIII

Configuration	Term	*J*	Level (cm^{-1})
$3p^6$	^1S	0	0
$3p^53d$	$^1P^\circ$	1	*539 200*
$3p^5(^2P^\circ_{3/2})4s$	$(3/2,1/2)^\circ$	1	*806 100*
$3p^5(^2P^\circ_{1/2})4s$	$(1/2,1/2)^\circ$	1	*818 500*
$3p^5(^2P^\circ_{3/2})4d$	$^2[3/2]^\circ$	1	*1 026 600*
$3p^5(^2P^\circ_{1/2})4d$	$^2[3/2]^\circ$	1	*1 038 100*
Mn IX ($^2P^\circ_{3/2}$)	***Limit***	....	**1 569 000**

Mn IX

Cl I isoelectronic sequence

Z=25

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

Ionization energy = 1 789 000 cm^{-1} (221.8 eV)

The transition array $3s^2 3p^5$–$3s^2 3p^4 4s$ was observed by Edlén (1937). The separation of the $^2P^\circ$ ground term is from Smitt, Svensson, and Outred (1976) who observed the $3s^2 3p^5\ ^2P^\circ$–$3s 3p^6\ ^2S$ doublet at 376 and 395 Å with an uncertainty of 2 cm^{-1}.

The three terms of $3p^4(^1D)3d$ are from Fawcett and Gabriel (1966), and the level values for $3p^4 4d$ are from Fawcett, Cowan, Kononov, and Hayes (1972). The latter authors give six lines of the array $3p^4 3d$–$3p^4 4f$, none of which are connected with the present system of levels.

The ionization energy is an extrapolated value by Lotz (1967).

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Mn IX

Configuration	Term	J	Level (cm^{-1})
$3s^2 3p^5$	$^2P^\circ$	3/2	*0*
		1/2	*12 546*
$3s3p^6$	^2S	1/2	265 408
$3s^2 3p^4(^1D)3d$	^2S	1/2	501 710
$3s^2 3p^4(^1D)3d$	^2P	3/2	521 840
		1/2	526 380
$3s^2 3p^4(^1D)3d$	^2D	5/2	530 560
		3/2	541 160
$3s^2 3p^4(^3P)4s$	^4P	5/2	873 580
		3/2	880 070
$3s^2 3p^4(^3P)4s$	^2P	3/2	889 560
		1/2	896 860
$3s^2 3p^4(^1D)4s$	^2D	5/2	910 890
		3/2	911 310
$3s^2 3p^4(^1S)4s$	^2S	1/2	950 060
$3s^2 3p^4(^3P)4d$	^2D	5/2	1 109 500
		3/2	1 110 700
$3s^2 3p^4(^3P)4d$	^4F	5/2	1 112 200
$3s^2 3p^4(^3P)4d$	^2F	5/2	1 113 800
$3s^2 3p^4(^3P)4d$	^2P	3/2	1 116 300
$3s^2 3p^4(^1D)4d$	^2S	1/2	1 130 700

Mn IX—Continued

Configuration	Term	J	Level (cm^{-1})
$3s^23p^4(^1D)4d$	^2P	3/2	1 137 000
		1/2	1 139 000
$3s^23p^4(^1D)4d$	^2D	5/2	1 142 200
		3/2	1 145 700
Mn X ($^3P_2$)	*Limit*	....	**1 789 000**

Mn x

S I isoelectronic sequence Z=25

Ground state: $1s^22s^22p^63s^23p^4\,{}^3P_2$

Ionization energy = 2 003 000 cm^{-1} (248.3 eV)

Edlén (1937) observed and identified the $3p^4$–$3p^34s$ array which occurs at 100 Å. He identified singlets and triplets but no intercombinations. The present values for the ^{3}P ground term were measured by Smitt, Svensson and Outred (1976) who also measured the present values for $3s3p^5\,{}^3$P°.

The $3p^33d$ configuration was first observed by Gabriel, Fawcett, and Jordan (1966) and by Fawcett and Gabriel (1966) except for the ^{1}P° term observed by Fawcett (1971). Fawcett also first observed the $3s3p^5$ configuration and two intersystem combinations between $3p^4\,{}^1$D and $3p^33d\,{}^3$P°. These two combinations are used to establish the values for the singlet levels relative to the triplets. The present values for $3p^33d\,{}^3$P° and ^{3}D° are also from Fawcett (1971).

The $3p^34d$ terms were first identified by Fawcett, Peacock, and Cowan (1968) and the present values are from Fawcett, Cowan, Kononov, and Hayes (1972). The latter group also observed nine transitions in the $3d$–$4f$ array but they are not connected with the present systems of levels.

The ionization energy is an extrapolated value by Lotz (1967).

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Mn x

Configuration	Term	J	Level (cm^{-1})
$3s^23p^4$	^{3}P	2	0
		1	10 019
		0	11 797
$3s^23p^4$	^{1}D	2	33 820
$3s^23p^4$	^{1}S	0	73 545
$3s3p^5$	^{3}P°	2	*261 072*
		1	*268 874*
		0	*273 615*
$3s3p^5$	^{1}P°	1	*333 402*
$3s^23p^3(^2D°)3d$	^{3}P°	1	*492 320*
		2	*492 770*
$3s^23p^3(^4S°)3d$	^{3}D°	3	*514 670*
		2	*520 620*
		1	*524 520*
$3s^23p^3(^2D°)3d$	^{1}D°	2	*536 130*
$3s^23p^3(^2D°)3d$	^{1}F°	3	*550 800*

Mn X—Continued

Configuration	Term	J	Level (cm^{-1})
$3s^23p^3(^2D°)3d$	$^1P°$	1	*577 530*
$3s^23p^3(^4S°)4s$	$^3S°$	1	*965 970*
$3s^23p^3(^2D°)4s$	$^3D°$	1	*991 860*
		2	*992 220*
		3	*994 180*
$3s^23p^3(^2D°)4s$	$^1D°$	2	*1 002 160*
$3s^23p^3(^2P°)4s$	$^1P°$	1	*1 032 090*
$3s^23p^3(^4S°)4d$	$^3D°$	2	*1 196 370*
		3	*1 197 350*
$3s^23p^3(^2D°)4d$	$^1D°$	2	*1 237 650*
$3s^23p^3(^2D°)4d$	$^1F°$	3	*1 241 140*
Mn XI ($^4S°_{3/2}$)	***Limit***	....	**2 003 000**

Mn XI

P I isoelectronic sequence Z=25

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

Ionization energy = 2 307 000 cm^{-1} (286.0 eV)

The levels of the $3s^2 3p^3$–$3s3p^4$ array are from Smitt, Svensson, and Outred (1976) who improved the measurements and extended the classifications of the earlier work of Fawcett and Peacock (1967) and Fawcett (1970, 1971). The coronal forbidden line at 1359.59 Å observed on the NRL-Skylab spectra by Feldman and Doschek (1976) provides a forbidden transition $3p^3\ ^4S^\circ_{3/2}$–$3p^3\ ^2P^\circ_{3/2}$, in exact agreement with the calculated value of Svensson (1971).

The $3p^2 3d$ configuration is from Fawcett (1971) who greatly extended the earlier identifications of Gabriel, Fawcett and Jordan (1966) and Fawcett, Gabriel and Saunders (1967).

The $3p^2 4s$, $4d$, and $4f$ configurations are from the paper by Fawcett, Cowan, Kononov, and Hayes (1972) who also identified two unconnected multiplets in the $3d$–$4f$ array. The ionization energy is from Lotz (1967).

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Mn XI

Configuration	Term	J	Level (cm^{-1})
$3s^2 3p^3$	$^4S^\circ$	3/2	*0*
$3s^2 3p^3$	$^2D^\circ$	3/2	*39 384*
		5/2	*42 702*
$3s^2 3p^3$	$^2P^\circ$	1/2	*68 945*
		3/2	*73 552*
$3s3p^4$	^4P	5/2	253 974
		3/2	261 683
		1/2	265 144
$3s3p^4$	^2D	3/2	314 532
		5/2	315 881
$3s3p^4$	^2P	3/2	361 400
		1/2	365 689
$3s3p^4$	^2S	1/2	379 093
$3s^2 3p^2(^3P)3d$	^2P	3/2	467 240
		1/2	476 980
$3s^2 3p^2(^3P)3d$	^4P	5/2	477 170
		3/2	480 720
		1/2	483 040

Mn XI—Continued

Configuration	Term	J	Level (cm^{-1})
$3s^23p^2(^1D)3d$	^2D	3/2	515 210
		5/2	515 430
$3s^23p^2(^1D)3d$	^2P	1/2	530 620
		3/2	536 800
$3s^23p^2(^3P)3d$	^2F	7/2	541 030
$3s^23p^2(^3P)3d$	^2D	5/2	561 400
		3/2	563 060
$3s^23p^2(^3P)4s$	^4P	1/2	1 078 200
		3/2	1 084 130
		5/2	1 091 160
$3s^23p^2(^3P)4s$	^2P	3/2	1 102 840
$3s^23p^2(^1D)4s$	^2D	5/2	1 120 870
		3/2	1 121 880
$3s^23p^2(^3P)4d$	^4P	5/2	1 324 910
		3/2	1 332 280
$3s^23p^2(^3P)4d$	^4F	5/2	1 329 310
$3s^23p^2(^3P)4d$	^2F	5/2	1 331 340
		7/2	1 336 860
$3s^23p^2(^3P)4d$	^4D	7/2	1 345 410
$3s^23p^2(^3P)4d$	^2D	5/2	1 348 630
		3/2	1 350 080
$3s^23p^2(^1D)4d$	^2F	7/2	1 360 590
		5/2	1 361 630
$3s^23p^2(^1D)4d$	^2D	5/2	1 362 940
$3s^23p^2(^1D)4d$	^2S	1/2	1 374 650
Mn XII ($^3P_0$)	*Limit*	....	**2 307 000**

Mn XII

Si I isoelectronic sequence Z=25

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

Ionization energy = 2 536 000 cm⁻¹ (314.4 eV)

With one exception, all of the terms below $3p4s$ are derived from the observations and identifications of Fawcett (1971). Compared with Cr XI and Fe XIII the $3s3p^3\ {}^3D^\circ_1$ level seems to be about 5500 cm^{-1} too low. The $3p^2\ {}^1S_0$ level value has been interpolated by Smitt, Svensson, and Outred (1976).

The $3p4s$ and $3p4d$ levels are from Fawcett, Cowan, and Hayes (1972).

The ionization energy is the extrapolated value of Lotz (1967).

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Mn XII

Configuration	Term	J	Level (cm^{-1})
$3s^23p^2$	^3P	0	0
		1	7200
		2	15 000
$3s^23p^2$	^1D	2	42 150
$3s^23p^2$	^1S	0	82 860+x
$3s3p^3$	$^3D^\circ$	1	*258 890?*
		2	*264 550*
		3	*266 600*
$3s3p^3$	$^3P^\circ$	1	*303 690*
		2	*303 980*
$3s3p^3$	$^1D^\circ$	2	*333 970*
$3s3p^3$	$^3S^\circ$	1	*385 620*
$3s3p^3$	$^1P^\circ$	1	*404 750*
$3s^23p3d$	$^3P^\circ$	2	*452 420*
		1	*460 000*
$3s^23p3d$	$^1D^\circ$	2	*462 700*
$3s^23p3d$	$^3D^\circ$	1	*469 910*
		2	*472 250*
		3	*472 540*
$3s^23p3d$	$^1F^\circ$	3	*517 360*
$3s^23p3d$	$^1P^\circ$	1	*530 170*+x

Mn XII—Continued

Configuration	Term	J	Level (cm^{-1})
$3s^23p4s$	$^3P^\circ$	1	*1 168 300*
		2	*1 181 300*
$3s^23p4d$	$^3D^\circ$	3	*1 416 300*
$3s^23p4d$	$^1F^\circ$	3	*1 437 200*
Mn XIII ($^2P^\circ_{1/2}$)	***Limit***	....	***2 536 000***

Mn XIII

Al I isoelectronic sequence Z=25

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

Ionization energy = 2 771 000 cm⁻¹ (343.6 eV)

The separation of the $3s^23p\ ^2P^\circ$ ground term reported here is the average of five observations of this difference by Fawcett (1971). This separation has also been observed (Jefferies (1969)) as a forbidden line of the solar corona at 6536.3 Å (15295 cm^{-1}), which is in fair agreement with Fawcett's value.

The doublet terms of the $3s3p^2$ configuration are determined from the combinations with the ground term observed by Fawcett (1971) as is also the case with the $3s^23d\ ^2D$ term. The $4d\ ^2D$ term is from two lines identified by Edlén (1936) at 67 Å. The $4f\ ^2F^\circ$ term is from Fawcett, Cowan, Kononov, and Hayes (1972).

The quartet system is based on the $3s3p^2\ ^4P_{5/2}$ level, the position of which is from our extrapolation beyond the sequence Al I–Sc IX. Of these nine points, only the first three represent direct observation. The other six points are various extrapolated values taken from Moore (1949). The uncertainty in our extrapolation is about ± 2000 cm^{-1}.

The values for the $3p^3\ ^4S^\circ$ and $3s3p3d\ ^4D^\circ$ levels are from Fawcett (1971). The $3s3p4s\ ^4P^\circ$ level is from Fawcett, Cowan, Kononov, and Hayes (1972). They also observed the $3s3p3d\ ^4F^\circ$–$3s3p3f\ ^4G$ multiplet but the terms cannot be connected to the present system.

The ionization energy is from Lotz (1967).

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Mn XIII

Configuration	Term	J	Level (cm^{-1})
$3s^23p$	$^2P^\circ$	1/2	*0*
		3/2	*15 320*
$3s3p^2$	^4P	5/2	204 000+x
$3s3p^2$	^2D	3/2	276 580
		5/2	278 180
$3s3p^2$	^2S	1/2	339 030
$3s3p^2$	^2P	1/2	360 460
		3/2	367 530
$3s^23d$	^2D	3/2	440 700
		5/2	442 230
$3p^3$	$^4S^\circ$	3/2	*527 890*+x
$3s3p3d$	$^4D^\circ$	7/2	*631 840*+x
$3s3p4s$	$^4P^\circ$	5/2	*1 467 300*+x
$3s^24d$	^2D	3/2	1 502 090
		5/2	1 503 080
$3s^24f$	$^2F^\circ$	5/2	*1 586 200*
		7/2	*1 586 400*
Mn XIV ($^1S_0$)	*Limit*	....	**2 771 000**

Mn XIV

Mg I isoelectronic sequence Z=25

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

Ionization energy = 3 250 000 cm^{-1} (403.0 eV)

Edlén (1936) reported three unconnected systems of levels for this ion: the resonance line $3s^2\ ^1S_0$–$3s4p\ ^1P^\circ_1$; the triplet system of $3s3p$–$3s4s$, $3s4d$, and the triplets of $3s3d$–$3s4f$, $3s5f$. The triplets were unified by the work of Fawcett, Gabriel, and Saunders (1967) who identified the $3s3p\ ^3P^\circ$–$3s3d\ ^3D$ multiplet. They also reported the $3s^2\ ^1S_0$–$3s3p\ ^1P^\circ_1$ line. The triplet system remains unconnected to the ground state but its position is estimated by an interpolated value for $3s3p\ ^3P^\circ_1$ by Ekberg (1971).

The $3p^2\ ^3P$ and $3s3p\ ^1P^\circ$ terms were reported by Fawcett and Peacock (1967) and later remeasured by Fawcett (1971). Fawcett (1970) also provided the ^1S and ^1D of $3p^2$ and the known terms of $3p3d$, the $^3D^\circ$ and $^3F^\circ$. He classified the line at 260.41 as $3p^2\ ^3P_2$–$3p3d\ ^3P^\circ_2$ but this identification was later changed to $3s3p\ ^1P^\circ$–$3s3d\ ^1D$ by Fawcett, Cowan, and Hayes (1972). These authors also found the singlets of $3s4d$ and $3s4f$. Their publication was accompanied by a supplementary report, referenced in the same paper, which provides some extensions of the analysis. Here they identify the $^3S_1$ term of $3s5s$ and $3s6s$, the $^3F^\circ_4$ of $3s6f$, *the* $^1P^\circ_1$ of $3s5p$ and $3s6p$, the ^3D term of $3s5d$ and $3s6d$, the ^1D term of $3s4d$ and $3s5d$, and the $^3D_3$ of $3p4f$. Fawcett, Cowan, Kononov, and Hayes (1972) measured the $3p3d$–$3p4f$ array and identified the ^1F and ^3G terms of $3p4f$.

We derived the ionization energy from the $3snp\ ^1P^\circ_1$ n =4, 5, 6 series and the $3snf\ ^3F^\circ_4$ n =4, 5, 6, series and obtained the values of 3 249 000 cm^{-1} and 3 251 000, respectively. We use the average of these values, 3 250 000 cm^{-1} or 403.0 eV. Lotz obtained the value 404.1 eV by extrapolation. Several high-lying levels of other series reported by Fawcett, Cowan, and Hayes (1972) do not exhibit quantum defects that agree well with the isoelectronic sequence members analyzed by Ekberg (1971), K VIII through Ti XI. On this basis we find that the $3s5d\ ^3D$ and $^1D_1$ the $3s6s\ ^3S$, and the $3s6d\ ^3D$ terms need further confirmation.

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Mn XIV

Configuration	Term	J	Level (cm^{-1})
$3s^2$	^1S	0	0
$3s3p$	$^3P^\circ$	0	*217 610*+x
		1	*222 390*+x
		2	*233 790*+x
$3s3p$	$^1P^\circ$	1	*328 030*
$3p^2$	^3P	0	517 210+x
		1	524 980+x
		2	538 890+x
$3p^2$	^1D	2	521 020
$3p^2$	^1S	0	614 040
$3s3d$	^3D	1	632 430+x
		2	633 150+x
		3	634 370+x
$3s3d$	^1D	2	712 040

Mn XIV—Continued

Configuration	Term	J	Level (cm^{-1})
3p3d	^{3}F°	2	*865 400*+x
		3	*873 290*+x
		4	*882 520*+x
3p3d	^{3}P°	2	*922 900*+x
3p3d	^{3}D°	3	*926 290*+x
3s4s	^{3}S	1	1 567 810+x
3s4p	^{1}P°	1	*1 685 630*
3s4d	^{3}D	1	1 816 960+x
		2	1 817 430+x
		3	1 818 350+x
3s4d	^{1}D	2	1 820 100
3p4s	^{3}P°	2	*1 855 700*+x
3s4f	^{3}F°	2	*1 886 820*+x
		3	*1 886 900*+x
		4	*1 887 100*+x
3s4f	^{1}F°	3	*1 901 260*
3p4d	^{3}D°	2	*2 086 800*+x
		3	*2 095 800*+x
3p4d	^{3}P°	2	*2 120 400*+x
3p4f	^{3}G	3	2 140 600+x
		4	2 146 500+x
		5	2 158 800+x
3p4f	^{3}F	4	2 160 100+x
3p4f	^{3}D	3	2 169 100+x
3s5s	^{3}S	1	2 221 900+x
3s5p	^{1}P°	1	*2 286 000*
3s5d	^{3}D	3	2 319 000+x
		2	2 320 000+x
		1	2 327 000+x
3s5d	^{1}D	2	2 351 500
3s5f	^{3}F°	4	*2 381 900*+x

Mn XIV—Continued

Configuration	Term	J	Level (cm^{-1})
$3s6s$	^{3}S	1	2 559 000+x
$3s6p$	^{1}P°	1	*2 595 000*
$3s6d$	^{3}D	3	2 630 000+x
		2	2 631 000+x
$3s6f$	^{3}F°	4	*2 649 000*+x
Mn XV($^2S_{1/2}$)	***Limit***	....	**3 250 000**

Mn XV

Na I isoelectronic sequence Z=25

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

Ionization energy = 3 513 000 cm^{-1} (435.6 eV)

Edlén (1936) reported three independent systems of doublets: 3*s*–4*p*; 3*p*–4*s*,4*d*, and 5*d*; and 3*d*–4*f* and 5*f*. They were unified by the observation by Fawcett, Gabriel, and Saunders (1967) of the 3*s*–3*p* and 3*p*–3*d* transitions. The series were extended to include 5*s* to 7*s*, 5*p* to 10*p*, 6*d* to 10*d*, and 6*f* to 11*f* by Fawcett, Cowan, and Hayes (1972).

A new set of measurements by Cohen and Behring (1976) in the limited wavelength range of 30 Å to 55Å, containing wavelengths given to the thousandths place, are used by them to derive the level values. We note from their paper, where all the known measurements are compiled, that the consistency is no better than ± 300 cm^{-1} for the 3*p* ^{2}P° term interval. Therefore we have rounded off the level values that are based on transitions to this term.

We determined the ionization energy from the *nf* series, *n* =4–8, with an uncertainty of ± 1000 cm^{-1}.

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Mn XV

Configuration	Term	*J*	Level (cm^{-1})
3*s*	^{2}S	1/2	0
3*p*	^{2}P°	1/2	*259 900*
		3/2	*277 000*
3*d*	^{2}D	3/2	631 500
		5/2	633 700
4*s*	^{2}S	1/2	1 667 500
4*p*	^{2}P°	1/2	*1 770 400*
		3/2	*1 777 100*
4*d*	^{2}D	3/2	1 906 800
		5/2	1 907 800
4*f*	^{2}F°	5/2	*1 961 600*
		7/2	*1 962 000*
5*s*	^{2}S	1/2	2 375 200
5*p*	^{2}P°	1/2	*2 424 600*
		3/2	*2 428 100*
5*d*	^{2}D	3/2	2 491 100
		5/2	2 491 700
5*f*	^{2}F°	5/2	*2 519 100*
		7/2	*2 519 400*
6*s*	^{2}S	1/2	2 742 000
6*p*	^{2}P°	1/2	*2 768 600*
		3/2	*2 770 200*

Mn xv—Continued

Configuration	Term	J	Level (cm^{-1})
6*d*	^{2}D	3/2	2 805 300
		5/2	2 805 700
6*f*	^{2}F°	5/2	*2 821 700*
		7/2	*2 821 900*
7*s*	^{2}S	1/2	2 950 000
7*p*	^{2}P°	1/2,3/2	*2 973 100*
7*d*	^{2}D	3/2	2 993 900
		5/2	2 994 200
7*f*	^{2}F°	5/2	*3 003 900*
		7/2	*3 004 200*
8*p*	^{2}P°	1/2,3/2	*3 102 700*
8*d*	^{2}D	5/2	3 115 600
8*f*	^{2}F°	7/2	*3 125 000*
9*p*	^{2}P°	3/2	*3 188 000*
9*d*	^{2}D	5/2	3 199 000
9*f*	^{2}F°	7/2	*3 205 000*
10*p*	^{2}P°	3/2	*3 246 000*
10*d*	^{2}D	5/2	3 258 000
10*f*	^{2}F°	7/2	*3 264 000*
11*f*	^{2}F°	7/2	*3 306 000*
Mn XVI ($^1S_0$)	***Limit***	....	**3 509 500**

Mn XVI

Ne I isoelectronic sequence Z=25

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

Ionization energy = 9 139 000 cm^{-1} (1133.1 eV)

Only resonance lines are classified by this system of energy levels. Tyrén (1938) identified resonance lines from the $2s^22p^53s$, $3d$, and $4d$ as well as the $2s2p^63p$ levels. Swartz, Kastner, Rothe, and Neupert (1971) made preliminary identifications of $2s^22p^54s$, $4d$, $5d$, and $6d$ levels and confirmed Tyrén's $2s2p^63p$ levels. We adopted the $j\ell$-coupling designations for levels of the $2p^5nd$ configurations by comparison with isoelectronic spectra (the rare-gas type).

Kastner, Behring, and Cohen (1975) identified transitions between $2p^53p$ and $2p^54d$, but there is no connection with the levels given here.

We derived the ionization energy from the $2s^22p^5(^2P^\circ_{3/2})$ $nd\ ^2[3/2]^\circ$ series for n =4, 5, and 6.

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Mn XVI

Configuration	Term	J	Level (cm^{-1})
$2s^22p^6$	^1S	0	0
$2s^22p^5(^2P^\circ_{3/2})3s$	$(3/2,1/2)^\circ$	1	*5 281 200*
$2s^22p^5(^2P^\circ_{1/2})3s$	$(1/2,1/2)^\circ$	1	*5 360 800*
$2s^22p^5(^2P^\circ_{3/2})3d$	$^2[1/2]^\circ$	1	*5 849 700*
$2s^22p^5(^2P^\circ_{3/2})3d$	$^2[3/2]^\circ$	1	*5 923 500*
$2s^22p^5(^2P^\circ_{1/2})3d$	$^2[3/2]^\circ$	1	*6 018 300*
$2s2p^63p$	$^3P^\circ$	1	*6 530 800*
$2s2p^63p$	$^1P^\circ$	1	*6 562 500*
$2s^22p^5(^2P^\circ_{3/2})4s$	$(3/2,1/2)^\circ$	1	*7 092 000*
$2s^22p^5(^2P^\circ_{3/2})4d$	$^2[3/2]^\circ$	1	*7 349 000*
$2s^22p^5(^2P^\circ_{1/2})4d$	$^2[3/2]^\circ$	1	*7 429 000*
$2s^22p^5(^2P^\circ_{3/2})5d$	$^2[3/2]^\circ$	1	*7 994 000*
$2s^22p^5(^2P^\circ_{1/2})5d$	$^2[3/2]^\circ$	1	*8 084 000*
$2s^22p^5(^2P^\circ_{3/2})6d$	$^2[3/2]^\circ$	1	*8 354 000*
$2s^22p^5(^2P^\circ_{1/2})6d$	$^2[3/2]^\circ$	1	*8 439 000*
Mn XVII ($^2P^\circ_{3/2}$)	*Limit*	....	**9 139 000**

Mn XVII

F I isoelectronic sequence Z=25

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

Ionization energy = 9 872 000 cm^{-1} (1244 eV)

Fawcett, Gabriel, and Saunders (1967) observed six resonance transitions between $2p^5\ ^2P^\circ_{3/2}$ and the $2p^4 3s$ and $3d$ configurations in the region from 15.7 to 17.8 Å. Later Fawcett (1971) measured the $^2P^\circ$ ground state interval from transitions with the $2s2p^6\ ^2S_{1/2}$ term. Cohen, Feldman, and Kastner (1968) revised and extended the identifications of $2p^4 3s$ and $3d$. The analysis of $2p^4 3s$ and $3d$ was further revised and extended by Feldman, Doschek, Cowan, and Cohen (1973), from whose wavelengths all of the 3s and 3d levels are determined.

The ionization energy is from Lotz (1967) who derived it by isoelectronic extrapolation.

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Mn XVII

Configuration	Term	J	Level (cm^{-1})
$2s^2 2p^5$	$^2P^\circ$	3/2	*0*
		1/2	*85 300*
$2s2p^6$	^2S	1/2	999 900
$2s^2 2p^4(^3P)3s$	^4P	5/2	5 619 900
		3/2	5 644 800
$2s^2 2p^4(^3P)3s$	^2P	3/2	5 700 900
		1/2	5 725 700
$2s^2 2p^4(^1D)3s$	^2D	5/2	5 780 000
		3/2	5 783 300
$2s^2 2p^4(^1S)3s$	^2S	1/2	5 922 700
$2s^2 2p^4(^3P)3d$	^4P	1/2	6 215 000
		3/2	6 228 800
		5/2	6 255 100
$2s^2 2p^4(^3P)3d$	^4F	5/2	6 234 000
$2s^2 2p^4(^3P)3d$	^2D	3/2	6 266 400
		5/2	6 300 800
$2s^2 2p^4(^3P)3d$	^2F	5/2	6 279 000
$2s^2 2p^4(^1D)3d$	^2S	1/2	6 356 500
$2s^2 2p^4(^1D)3d$	^2P	3/2	6 379 000
$2s^2 2p^4(^1D)3d$	^2D	5/2	6 381 600
		3/2	6 404 100

Mn XVII—Continued

Configuration	Term	J	Level (cm^{-1})
$2s^22p^4(^1S)3d$	^2D	5/2	6 491 800
		3/2	6 507 900
Mn XVIII ($^3P_2$)	*Limit*	....	**9 872 000**

Mn XVIII

O I isoelectronic sequence Z=25

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

Ionization energy = 10 620 000 cm⁻¹ (1317 eV)

Resonance lines of this spectrum were first observed by Fawcett (1971) near 110 Å.

The $2s^2 2p^4$–$2s2p^5$ transition array was completely observed and identified by Doschek, Feldman, Cowan, and Cohen (1974) and also in part by Fawcett, Galanti, and Peacock (1974). The levels are from Doschek et al. (1974). Since no intersystem transitions have been observed, we calculated the position of $2s^2 2p^4\ ^1D$ with the formulas suggested by Edlén (1972). Its uncertainty may be ± 100 cm^{-1}.

The $2p^6$ level is taken from Doschek, Feldman, Davis, and Cowan (1975); it was observed earlier at lower dispersion by Fawcett et al. (1974).

The levels of $2p^3 3s$, which is not completely known, are from observations of transitions with $2p^4$ at 16 Å by Doschek, Feldman, and Cohen (1973), and those of $2p^3 3d$ are from Fawcett and Hayes (1975).

The ionization energy is from Lotz's extrapolation.

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Mn XVIII

Configuration	Term	J	Level (cm⁻¹)
$2s^2 2p^4$	^3P	2	0
		0	66 500
		1	73 800
$2s^2 2p^4$	^1D	2	151 800+x
$2s^2 2p^4$	^1S	0	292 800+x
$2s2p^5$	$^3P°$	2	*866 900*
		1	*919 600*
		0	*956 600*
$2s2p^5$	$^1P°$	1	*1 190 900*+x
$2p^6$	^1S	0	2 008 900+x
$2s^2 2p^3(^4S°)3s$	$^3S°$	1	*6 052 900*
$2s^2 2p^3(^2D°)3s$	$^3D°$	2	*6 152 200*
		1	*6 154 800*
		3	*6 178 600*
$2s^2 2p^3(^2D°)3s$	$^1D°$	2	*6 197 700*+x
$2s^2 2p^3(^2P°)3s$	$^1P°$	1	*6 325 300*+x
$2s^2 2p^3(^4S°)3d$	$^3D°$	3	*6 562 000*
		2	*6 566 000*

Mn XVIII—Continued

Configuration	Term	J	Level (cm^{-1})
$2s^22p^3(^2D°)3d$	$^3D°$	3	*6 722 000*
$2s^22p^3(^2P°)3d$	$^3P°$	2	*6 779 000*
$2s^22p^3(^2P°)3d$	$^3D°$	3	*6 804 000*
Mn XIX ($^4S°_{3/2}$)	***Limit***	....	**10 620 000**

Mn XIX

N I isoelectronic sequence Z=25

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

Ionization energy = 11 590 000 cm^{-1} (1437 eV)

The strong transition array $2s^2 2p^3$–$2s2p^4$ was identified by Doschek, Feldman, Cowan, and Cohen (1974) and confirmed by Fawcett, Galanti, and Peacock (1974). The position of the doublets relative to the ground state is based on the estimated position of $2s^2 2p^3\ {}^2D^\circ_{5/2}$ by Fawcett (1975).

The $2p^5\ {}^2P^\circ$ term was found by Doschek, Feldman, Davis and Cowan (1975) and the $2p^2 3d\ {}^4P$ term by Fawcett and Hayes (1975). Feldman, Doschek, Cowan, and Cohen (1975) identified the $2s2p^4\ {}^2S$ term.

The ionization energy is from Lotz's extrapolation.

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Mn XIX

Configuration	Term	J	Level (cm^{-1})
$2s^2 2p^3$	$^4S^\circ$	3/2	*0*
$2s^2 2p^3$	$^2D^\circ$	3/2	*122 400*+x
		5/2	*153 000*+x
$2s^2 2p^3$	$^2P^\circ$	1/2	*232 800*+x
		3/2	*282 400*+x
$2s2p^4$	^4P	5/2	709 100
		3/2	765 800
		1/2	785 700
$2s2p^4$	^2D	3/2	971 800+x
		5/2	983 200+x
$2s2p^4$	^2S	1/2	1 117 600+x
$2s2p^4$	^2P	3/2	1 161 600+x
		1/2	1 242 800+x
$2p^5$	$^2P^\circ$	3/2	*1 835 000*+x
		1/2	*1 925 200*+x
$2s^2 2p^2(^3P)3d$	^4P	3/2,5/2	7 093 000
Mn XX ($^3P_0$)	*Limit*	....	**11 590 000**

Mn XX

C I isoelectronic sequence Z=25

Ground state: $1s^22s^22p^2\,^3P_0$

Ionization energy = 12 410 000 cm^{-1} (1539 eV)

The strong transition array $2s^22p^2$–$2s2p^3$ was identified by Feldman, Doschek, Cowan and Cohen (1975) from the spectrum of a laser-produced plasma in the region 100–140 Å. The $2p3d\,^1F°$ level is due to Fawcett and Hayes (1975). The position of the singlets relative to the ground state is based on their estimated position of $2s^22p^2\,^1D_2$.

The value for the ionization energy was extrapolated by Lotz.

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Mn XX

Configuration	Term	J	Level (cm^{-1})
$2s^22p^2$	^3P	0	0
		1	59 600
		2	98 500
$2s^22p^2$	^1D	2	213 600+x
$2s2p^3$	$^3P°$	2	*870 400*
$2s2p^3$	$^3S°$	1	*1 025 500*
$2s2p^3$	$^1D°$	2	*1 050 100*+x
$2s2p^3$	$^1P°$	1	*1 173 900*+x
$2s^22p3d$	$^1F°$	3	*7 643 000*+x
Mn XXI ($^2P^o_{1/2}$)	*Limit*	....	**12 410 000**

Mn XXI

B I isoelectronic sequence

Z=25

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

Ionization energy = 13 260 000 cm^{-1} (1644 eV)

Doschek, Feldman, and Cohen (1975) observed two lines of the $2s^22p\ ^2P^\circ$–$2s2p^2\ ^2P$ multiplet at 108.15 and 121.16 Å in spectra of laser-produced plasmas. This observation establishes the ground ($^2P^\circ$) term and the $2s2p^2\ ^2P_{3/2}$ level.

The ionization energy is from Lotz's extrapolation.

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Lotz, W. (1967), J. Opt. Soc. Am. **57**, 873.

Mn XXI

Configuration	Term	*J*	Level (cm^{-1})
$2s^22p$	$^2P^\circ$	1/2	*0*
		3/2	*99 200*
$2s2p^2$	^2P	3/2	924 600
Mn XXII ($^1S_0$)	*Limit*	....	**13 260 000**

Mn XXII

Be I isoelectronic sequence

Z = 25

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

Ionization energy = 14 420 000 cm^{-1} (1788 eV)

The intersystem resonance line, $2s^2\ ^1S_0$–$2s2p\ ^3P_1^\circ$ at 277.80 Å, was identified by Sandlin, Brueckner, Scherrer, and Tousey (1976) from Skylab data.

The $2s3d\ ^3D$ term was observed by Swartz, Kastner, Rothe, and Neupert (1971) at 12 Å and identified by Fawcett and Hayes (1975).

The position of the $2s2p\ ^1P_1^\circ$ term was calculated by Kononov, Koshelev, and Podobedova (1974). The high singlets that combine with this term are from Aglitskii, Boiko, Pikus, Safronova, and Faenov (1976).

The ionization energy is from Lotz's extrapolation.

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Mn XXII

Configuration	Term	J	Level (cm^{-1})
$2s^2$	^1S	0	0
$2s2p$	$^3P^\circ$	1	*359 970*
$2s2p$	$^1P^\circ$	1	*708 800*+x
$2s3p$	$^3P^\circ$	1	*8 354 000*
$2s3d$	^3D	2	8 442 000
$2s3p$	$^1P^\circ$	1	*8 756 000*+x
$2s3p$	$^1D^\circ$	2	*8 924 000*+x
$2s3s$	^1S	0	8 988 000+x
Mn XXIII ($^2S_{1/2}$)	*Limit*	....	**14 420 000**

Mn XXIII

Li I isoelectronic sequence Z=25

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

Ionization energy = 15 160 000 cm^{-1} (1880 eV)

The $2s$–$2p$ resonance lines at 206 and 266 Å have been observed in the spectra of solar flares from Skylab and measured by Widing and Purcell (1976) and by Sandlin, Brueckner, Scherrer and Tousey (1976). The $2p$–$3s$ and $2p$–$3d$ lines at 12 Å have been observed in sparks in the laboratory by Goldsmith, Feldman, Oren, and Cohen (1972).

We have derived the ionization energy from the two member *ns* series using the quantum defect change from Fe XXIV.

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Mn XXIII

Configuration	Term	*J*	Level (cm^{-1})
$2s$	^2S	1/2	0
$2p$	$^2P^\circ$	1/2	*374 700*
		3/2	*483 340*
$3s$	^2S	1/2	8 557 200
$3d$	^2D	5/2	8 708 000
Mn XXIV ($^1S_0$)	*Limit*	....	**14 900 000**

Mn XXIV

He I isoelectronic sequence Z=25

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

Ionization energy = 65 663 900 cm^{-1} (8141.35 eV)

The theoretical values calculated by Ermolaev and Jones (1974) for the singlet and triplet S and P terms of this two-electron ion are more accurate than the observed values, and we have quoted them up to $n=4$. The uncertainty of the ionization energy and level values is estimated to be of the order of ± 100 cm^{-1}. For comparison, the $1s^2$–$1s2p$ transition of this ion has been observed by Neupert at 2.009 Å (49 800 000 cm^{-1}) in a solar flare.

References

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Mn XXIV

Configuration	Term	J	Level (cm^{-1})
$1s^2$	^1S	0	0
$1s2s$	^3S	1	49 376 000
$1s2p$	$^3P°$	0	*49 599 200*
		1	*49 614 100*
		2	*49 711 300*
$1s2s$	^1S	0	49 617 300
$1s2p$	$^1P°$	1	*49 853 100*
$1s3s$	^3S	1	58 493 600
$1s3p$	$^3P°$	0	*58 555 200*
		1	*58 559 200*
		2	*58 588 500*
$1s3s$	^1S	0	58 557 300
$1s3p$	$^1P°$	1	*58 627 100*
$1s4s$	^3S	1	61 650 000
$1s4p$	$^3P°$	0	*61 675 600*
		1	*61 677 300*
		2	*61 689 600*
$1s4s$	^1S	0	61 675 800
$1s4p$	$^1P°$	1	*61 705 400*
Mn XXV ($^2S_{1/2}$)	*Limit*	....	**65 663 900**

Mn XXV

H I isoelectronic sequence $Z=25$

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

Ionization energy = 69 136 800 cm^{-1} (8571.94 eV)

The theoretical values calculated by Erikson for terms of this hydrogen-like ion are much more accurate than any observed values and they are given below. The binding energy of the 1*s* electron is given with an uncertainty of ± 300 cm^{-1}; the levels measured from the ground state taken as zero will also have this uncertainty.

Reference

Erikson, G. W. (1977), J. Phys. Chem. Ref. Data **6**, 831.

Mn XXV

Configuration	Term	*J*	Level (cm^{-1})
1*s*	^2S	1/2	0
2*p*	$^2P°$	1/2	*51 808 900*
		3/2	*51 954 900*
2*s*	^2S	1/2	51 813 000
3*p*	$^2P°$	1/2	*61 451 800*
		3/2	*61 495 100*
3*s*	^2S	1/2	61 453 000
3*d*	^2D	3/2	61 495 000
		5/2	61 509 200
4*p*	$^2P°$	1/2	*64 820 800*
		3/2	*64 839 100*
4*s*	^2S	1/2	64 821 300
4*d*	^2D	3/2	64 839 000
		5/2	64 845 000
4*f*	$^2F°$	5/2	*64 845 000*
		7/2	*64 848 000*
	Limit	....	**69 136 800**