Energy Levels of Calcium, Ca I through Ca XX

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The energy levels of the calcium atom in all of its stages of ionization, as derived from the analyses of atomic spectra, have been critically compiled. In cases where only line classifications are reported in the literature, level values have been derived. Electron configurations, term designations, J-values, experimental *g*-values, and ionization energies are included. Calculated percentages of the two leading components of the eigenvectors of the levels are given.

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

Contents

Introduction

At the time of the first compilation of atomic energy levels by Bacher and Goudsmit in 1932, only the first 5 of the 20 spectra of calcium had been studied. By 1949, Moore was able to compile the first 12 spectra of calcium. At that time, oxygen was the heaviest atom for which some levels of all stages of ionization were known.

A great amount of new experimental work has been carried out since then, particularly in the higher stages of ionization. Today, experimental results are available for every stage of ionization of calcium. This is the result of the development of more energetic light sources, which was stimulated by the need to interpret new spectroscopic observations of the sun at short wavelengths from rocket- and satellite-borne spectrographs. A new impetus for the interpretation of spectra of highly ionized atoms has arisen from the investigation of hot laboratory plasmas generated to achieve nuclear fusion.

These activities have produced a substantial increase in spectroscopic information, particularly for elements of the iron period, making the earlier compilations of energy levels inadequate. The NBS Atomic Energy Levels Data Center has undertaken to provide new compilations of energy levels, including the elements of the iron period. The material on each atom and its ions is being published as a separate paper. A collection of these compilations, with revisions, is planned as one volume for the iron period. Already completed are the compilation for iron by Reader and Sugar (1975), chromium and vanadium by Sugar and Corliss (1977, 1978), and manganese and titanium by Corliss and Sugar (1977, 1979). The present work on calcium will be followed by a compilation of the energy levels of potassium.

The present compilation comprises the energy levels of the calcium atom and all of its ions, as derived from analyses of atomic spectra. 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 generally we used only published papers as sources of data, unpublished data have been included when they constituted a substantial improvement over material in the literature.

Ionization energies found in the literature are usually given in their equivalence in cm^{-1}. The conversion factor 8065.479 ± 0.021 cm^{-1}/eV, as given by Cohen and Taylor

(1973), was used to obtain values in eV. In a few cases where adequate data were available but the ionization energy was not derived, we carried out the calculation. For a large number of ions, no suitable series are known. In these cases we have quoted values obtained by extrapolation along isoelectronic sequences. Although uncertainties are not usually provided with these extrapolated values, they are probably accurate to a few units of the last significant figure given.

Nearly all of the data are the result 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 are available preference is generally given to the laboratory measurements in order to avoid the problem of blended lines of various elements in the solar spectrum.

For a convenient source of wavelengths of calcium lines below 2000 Å we refer the reader to the compilation by Kelly and Palumbo (1973).

We sometimes assign a calculated value to a level of a term in a system not connected to the ground state. The error in the calculated value is indicated by the letter x following the level values of that system. For Ca XIX and XX, which are isoelectronic with He I and H I we give only theoretical level values. They are much more accurate than experimental x-ray wavelengths from which level values may be obtained.

For a given configuration a certain number of terms of various types are theoretically expected, and spectroscopists have given names on the basis of J-values, g-values, intensities, arrangement of the levels, and, more recently, theoretical calculations. We have included the results of calculations, under the heading "Leading percentages", that express the percentage composition of levels in terms of the basis states of a single configuration, or more than one configuration where configuration interaction has been included. Where these results contradict an author's designation, we have accepted the theoretical term and configuration labeling of a level to conform with its calculated leading percentages. In some cases these are low and the labeling has less physical meaning.

The percentage compositions have the following meaning. Suppose that for a given configuration there is a set of n basis states, written symbolically as ψ_1, ψ_2, ..., ψ_n. Usually these basis states are taken to be the LS-states for a configuration, but other coupling schemes are often used. (See Martin, Zalubas, and Hagan (1978) for coupling notation.) Then the eigenvector ψ_A of an actual energy level A can be expressed as

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

where $\alpha_1{}^2 + \alpha_2{}^2 + \dots \alpha^2{}_n = 1$. The squared quantities $\alpha^2{}_1$, $\alpha_2{}^2$, etc., multiplied by 100, represent the percentage composition of a given level. Levels are given names corresponding to the basis state having the largest percentage.

In the columns of the present tables headed "Leading percentages" we give first the percentage of the basis state corresponding to the level's name; next the second largest percentage together with the related basis state. We have not listed any second component representing less than 4 percent.

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. In the present tables, the percentages are taken mostly 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.

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

i. papers cited by Moore (1949)
ii. C. E. Moore (1968)
iii. L. Hagan and W. C. Martin (1972).
iv. L. Hagan (1977)
v. 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. The text for each ion is not always a complete review of the literature but is intended to credit the major contributions. A final check for new data was made on September 1, 1978, at which time the compilations were considered completed.

Acknowledgements

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

We thank Dr. W. C. Martin for a critical reading of the manuscript.

This work was supported by the U.S. Department of Energy, Division of Magnetic Fusion Energy, the Office of Standard Reference Data of the National Bureau of Standards, and by the National Aeronautics and Space Administration, Astrophysics Division.

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Energy Level Tables

Ca I

$Z=20$

Ground state: $1s^22s^22p^63s^23p^64s^2\ {}^1S_0$

Ionization energy $=49\ 305.96\pm0.08$ cm^{-1} $(6.11321\pm0.00002$ eV$)$

Early History

The observation and analysis of the first spectrum of calcium have played an important role in the development of experimental methods and theoretical ideas in the field of atomic spectra. Saunders (1920) summarized the considerable early work on this spectrum which included observations of the $4snp$, $4pns$, $4pnd$, and $3dnf$ series of triplets and singlets. The longest was $4snp\ {}^1P^\circ{}_1$ reaching $n=11$. Shortly thereafter Russell and Saunders (1925), and independently Bohr (1923), recognized the excitation of two electrons to form terms above the ionization energy. In the same paper Russell and Saunders proposed the now universally accepted designations for levels in LS-coupling. They also introduced the concept of ordering level values from zero for the level of highest binding energy. The paper reports an extension of the analysis of Ca I which classified the remaining strong lines of this spectrum. The ${}^3P$ terms of $4p^2$, $3d^2$, and $3dnd$ $(n=4\text{-}6)$ are given, the latter occurring entirely above the principal ionization limit. For the configuration $3d4p$ the terms ${}^3P^\circ$, ${}^3D^\circ$, and ${}^3F^\circ$ were found, and for $3d5p$ the ${}^3D^\circ$ was observed above the limit. Several undesignated levels are included whose interpretation was provided by later workers. In a later paper Russell (1927) identified the $4s5s\ {}^3S_1$ and ${}^1S_0$, the $4p^2\ {}^1D$, and the $3d4d\ {}^3S_1$ and ${}^3D_1$.

Measurements of the Zeeman effect are due to Back (1925), who observed the $3d4s$–$3d4p$ transition array in a field of 39 000 gauss (3.9 T) and derived the following g-values for Ca I:

Config.	Term	J	g
$3d4s$	${}^3D$	1	0.502
		2	1.162
		3	1.328
	${}^1D$	2	1.007
$3d4p$	${}^3F^\circ$	2	0.754
		3	1.076
		4	1.245
	${}^1D^\circ$	2	0.893

An additional term of the $3d^2$ configuration, the ${}^3F$, was discovered by Humphreys (1951) from observations in the infrared of the $3d4p$–$3d^2\ {}^3F^\circ$–${}^3F$ and ${}^3D^\circ$–${}^3F$ multiplets.

Absorption measurements in the range of 1590–2400 Å by Garton and Codling (1965) produced 82 newly observed lines of calcium. Their classifications extended the knows series as follows: $4snp\ {}^1P^\circ{}_1$ to $n=33$, $3dnp\ {}^1P^\circ{}_1$ to $n=29$, $3dnp\ {}^3P^\circ{}_1$ to $n=25$, $3dnp\ {}^3D^\circ{}_1$ to $n=19$, $3dnf\ {}^1P^\circ{}_1$ to $n=15$, $3dnf\ {}^3P^\circ{}_1$ to $n=10$, and $3dnf\ {}^3D^\circ{}_1$ to $n=15$. A single line at 1740.32 Å was classified as $4s^2\ {}^1S_0$–$4s5p\ {}^1P^\circ{}_1$. Their classification of the level at 43 933 cm^{-1} as mainly $3d4p\ {}^1P^\circ{}_1$ was accepted in several subsequent papers by other authors but was abandoned in the light of recent theoretical work cited below. It is now apparent that no level is preponderantly of this nature.

Sources of Level Values

The emission spectrum was completely reobserved by Risberg (1968) from 195 Å to 30 000 Å by means of a hollow cathode discharge. In this range 275 lines were measured, about 100 of which were observed for the first time. Autoionization and the low pressure of this light source prevented the detection of all but four levels above the ionization limit, ${}^3P_1$ and ${}^3D_{1,2,3}$ of the $3d4d$ configuration. The other members of the $3d4d$ and $3d5d$ configurations are derived from the classified lines of Russell and Saunders (1925) combined with the lower level values given by Risberg.

Several revisions and extensions are proposed in Risberg's paper. The earlier assignments of $4s6s\ {}^1S_0$ and $4p^2\ {}^1S_0$ to 41 786 cm^{-1} and 40 690 cm^{-1} respectively are interchanged. The $J=0$ level of $4s7p\ {}^3P^\circ$ and the $J=1,2$ levels of $4s8p\ {}^3P^\circ$ were found. The ${}^1D_2$ terms of $3d5s$ and $3d^2$ were also discovered, and in the $4snf$ series the ${}^1F^\circ{}_3$ of $4s12f$ was added.

Risberg has incorporated the interferometric measurements of the strong lines by Wagman (1937) and the accurate measurements of Grafenberger (1937) with her own extensive measurements to redetermine all the energy level values. Risberg's results are quoted here.

The data available for Ca I are particularly rich in long series. Those series for which the maximum observed value of n is 10 or more are listed below.

Brown, Tilford, and Ginter (1973) observed absorption spectra of calcium series in the range of 1500–1770 Å and 2020–2090 Å at high dispersion. They recorded the $4snp\ {}^1P^\circ{}_1$ series for $n=11$-79 and deduced from these data an ionization energy of $49\ 305.99\pm0.12$ cm^{-1}.

Series in Ca I

Config.	Term	n_{max}	References
1. 4*snp*	^{3}P°	60	Armstrong et al. (1979)
2. 4*snp*	^{1}P°	79	Brown et al. (1973)
3. 4*snd*	^{3}D	17	Risberg (1968), Camus (1974)
4. 4*snd*	^{1}D	62	Borgström and Rubbmark (1977), Armstrong et al. (1977)
5. 4*sns*	^{3}S	18	Risberg (1968), Camus (1974)
6. 4*sns*	^{1}S	32	Borgström and Rubbmark (1977), Armstrong et al. (1977)
7. 3*dnp*	^{3}D°	58	Brown et al. (1973)
8. 3*dnp*	^{3}P°	33	Brown et al. (1973)
9. 3*dnp*	^{1}P°	61	Brown et al. (1973)
10. 4*snf*	^{3}F°	13	Risberg (1968), Camus (1974)
11. 4*snf*	^{1}F°	28	Borgström and Rubbmark (1977)
12. 3*dnf*	^{3}D°	30	Brown et al. (1973)
13. 3*dnf*	^{3}P°	38	Brown et al. (1973)
14. 3*dnf*	^{1}P°	39	Brown et al. (1973)
15. $3p^5(^2P^\circ_{3/2})$ $4s^2nd$	$^2[3/2]^\circ$	16	Mansfield and Newsom (1977)
16. $3p^5(^2P^\circ_{1/2})$ $4s^2nd$	$^2[3/2]^\circ$	17	Mansfield and Newsom (1977)
17. $3p^5(^2P^\circ_{3/2})$ $4s^2ns$	$^2[3/2]^\circ$	10	Mansfield and Newsom (1977)
18. $3p^5(^2P^\circ_{1/2})$ $4s^2ns$	$^2[1/2]^\circ$	14	Mansfield and Newsom (1977)

Series of doubly excited configurations converging to the $3d\ ^2$D limit were extended. The $3dnp\ ^3D^\circ_1$ series was measured through $n=58$, the $3dnp\ ^1P^\circ_1$ through $n=61$, the $3dnp\ ^3P^\circ_1$ through $n=33$, the $3dnf\ ^1P^\circ_1$ through $n=39$, the $3dnf\ ^3P^\circ_1$ through $n=38$ and the $3dnf\ ^3D^\circ_1$ through $n=30$. They note that "the $3dnp\ ^1P^\circ_1$ series lines are the strongest and most diffuse of the six observed series." Two levels that perturb this series at $n=6$ and $n=7$ were measured. They have been identified as $5s4p\ ^3P^\circ_1$ and $^1P^\circ_1$ by Newsom (1966). The results of Brown, Tilford, and Ginter are quoted here for series members beyond the observations of Risberg.

In a paper by Armstrong, Esherick, and Wynne (1979) they report observations by means of multiphoton absorption experiments of the $4snp\ ^3P^\circ_0$ series to $n=60$. This was previously given to $n=7$ by Risberg (1968).

Armstrong, Esherick, and Wynne (1977) greatly extended the observations of the $4sns\ ^1S_0$ series from $n=12$ to 32 and the $4snd\ ^1D_2$ series from $n=8$ to 62. In the latter series they substituted the level 46 199.23 cm^{-1} for $4s7d$, rejecting the level 46 308.257 given by Risberg. The level 47 449.083 cm^{-1} assigned by Risberg to $3d^2\ ^1D_2$ is renamed $3d5s\ ^1D_2$. This designation was used by Risberg for the level 48 083.383 cm^{-1}, which is now named $4s10d\ ^1D_2$ by Armstrong et al. These changes are confirmed by additional observations by Palenius and Risberg (1977). No level was found to replace the $3d^2\ ^1D_2$.

Borgström and Rubbmark (1977) observed absorption series from the $4s4p\ ^1P^\circ_1$ level. They report values for $4sns\ ^1S_0$ from $n=12$ to 28 and $4snd\ ^1D_2$ from $n=7$ to 59. These two series have been extended to $n=32$ and $n=62$, respectively, by Armstrong, Esherick, and Wynne (1977). Borgström and Rubbmark observed the $4snf\ ^1F^\circ_3$ series from $n=13$ to 28.

Mansfield and Newsom (1977) have observed absorption from the 3*p* shell between 320 and 500 Å. We have given the $3p^54s^2ns$ and $3p^54s^2nd$ series from their paper.

Ionization Potential

Borgström and Rubbmark have determined a value of the ionization energy from the $4snf\ ^1F^\circ_3$ series equal to 49 305.92±0.10 cm^{-1} which is within the error limits of the value of Brown et al., 49 305.99±0.12 cm^{-1}. We have adopted the mean of the two values, 49 305.96±0.08 cm^{-1} as the best value. The uncertainty in the conversion factor, 8065.479±0.021 cm^{-1}/eV, determines the uncertainty in the value given in eV.

Perturbed Series

The identification of $3d4p\ ^1P^\circ_1$, which perturbs the $4snp\ ^1P^\circ_1$ series, has been the subject of much discussion in the literature. Russell and Shenstone (1932) decided from intensity and energy considerations that it must be the level at 36 731 cm^{-1}. Roth (1969) attributes to Racah his identification of this term with the level at 41 679 cm^{-1}. Friedrich and Trefftz (1969), on the basis of multiconfiguration calculations, retained it at 36 731 cm^{-1}. Garton and Codling (1965), from intensity considerations, placed it at 43 933 cm^{-1}. This assignment has been adopted by Risberg in her analysis of Ca I and by Moores (1966) in his multichannel quantum defect theory (MQDT) calculation of the $4snp\ ^1P^\circ_1$ series. The investigation of the $4snp\ ^1P^\circ_1$ series by Armstrong et al. (unpublished) using MQDT has shown that all of the above levels contain less than 30% $3dnp\ ^1P^\circ_1$ composition (summed over all *n*). The $3d4p\ ^1P^\circ_1$ state is diluted beyond recognition by mixing into the 4*snp* series. Among these levels the largest percentage of $3dnp\ ^1P^\circ_1$ (27%) is present in the level at 43 933 cm^{-1}. Since this level is identified in the modern literature with $3d4p\ ^1P^\circ_1$ and the rest of the quantum numbers are assigned accordingly, we retain this nominal labeling. In the light of this mixing, Roth's calculation of the $(3d+4s)4p$ interaction is inappropriate and his results are not included here.

Another well-known perturbed series in Ca I is the 4*snd* ^{3}D series, strongly perturbed by $3d5s\ ^3$D between $n=8$ and 9. This has been studied by Seaton (1966) using his MQDT method.

Some parity-forbidden series have been observed in Ca I. In Saunders' (1920) paper the first four members of $4s^2\ ^1S_0$–$4snd\ ^1D_2$ series are reported. Transitions to the ground state from $4p^2\ ^1S_0$ and from $4s7s$ and $4s8s\ ^1S_0$ are also given. McIlrath (1974) has observed lines in absorption between 2048 and 2091 Å which Palenius and Risberg have identified as transitions to $4s9d$–$14d\ ^1D_2$ and $4s13s$–$17s\ ^1S_0$ from the $4s^2\ ^1S_0$ ground state.

Arrangement of Tables

The first table of energy levels presented here for neutral calcium is arranged in the usual way; the terms are listed in order of increasing energy without regard to configuration assignments. Because many long Rydberg series have been observed in Ca I, we present a second table for this spectrum in which the series are listed separately, followed by their series limits. This table reveals more clearly the character of the observed spectrum. The series are listed in order of increasing first series member. The series member with the largest value of n for each term type is followed by the limit or limits of that series in Ca II. The assignment of the limits is discussed by Brown et al. and graphically displayed in their figure 10.

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Ca I: Ordered by term values

Configuration	Term	J	Level (cm^{-1})	Configuration	Term	J	Level (cm^{-1})
$4s^2$	^1S	0	0.000	$3d\,4p$	$^3D^{\circ}$	1	*38 192.392*
						2	*38 219.118*
$4s4p$	$^3P^{\circ}$	0	*15 157.901*			3	*38 259.124*
		1	*15 210.063*				
		2	*15 315.943*	$4p^2$	^3P	0	38 417.543
						1	38 464.808
$3d\,4s$	^3D	1	20 335.360			2	38 551.558
		2	20 349.260				
		3	20 371.000	$3d\,4p$	$^3P^{\circ}$	0	*39 333.382*
						1	*39 335.322*
$3d\,4s$	^1D	2	21 849.634			2	*39 340.080*
$4s4p$	$^1P^{\circ}$	1	*23 652.304*	$4s6s$	^3S	1	40 474.241
$4s5s$	^3S	1	31 539.495	$3d\,4p$	$^1F^{\circ}$	3	*40 537.893*
$4s5s$	^1S	0	33 317.264	$4s6s$	^1S	0	40 690.435
$3d\,4p$	$^3F^{\circ}$	2	*35 730.454*	$4p^2$	^1D	2	40 719.847
		3	*35 818.713*				
		4	*35 896.889*	$4s6p$	$^1P^{\circ}$	1	*41 679.008*
$3d\,4p$	$^1D^{\circ}$	2	*35 835.413*	$4p^2$	^1S	0	41 786.276
$4s5p$	$^3P^{\circ}$	0	*36 547.688*	$4s4f$	$^3F^{\circ}$	2	*42 170.214*
		1	*36 554.749*			3	*42 170.558*
		2	*36 575.119*			4	*42 171.026*
$4s5p$	$^1P^{\circ}$	1	*36 731.615*	$4s4f$	$^1F^{\circ}$	3	*42 343.587*
$4s4d$	^1D	2	37 298.287				
$4s4d$	^3D	1	37 748.197	$4s6p$	$^3P^{\circ}$	0	*42 514.845*
		2	37 751.867			1	*42 518.708*
		3	37 757.449			2	*42 526.591*

Ca I: Ordered by term values—Continued

Configuration	Term	J	Level (cm^{-1})
$4s5d$	^{3}D	1	42 743.002
		2	42 744.716
		3	42 747.387
$4s5d$	^{1}D	2	42 919.053
$3d^2$	^{3}F	2	43 474.827
		3	43 489.119
		4	43 508.088
$3d\,4p$	^{1}P°	1	*43 933.477*
$4s7s$	^{3}S	1	43 980.767
$4s7s$	^{1}S	0	44 276.538
$4s5f$	^{3}F°	2	*44 762.620*
		3	*44 762.839*
		4	*44 763.118*
$4s5f$	^{1}F°	3	*44 804.878*
$4s7p$	^{3}P°	0	*44 955.67*
		1	*44 957.655*
		2	*44 961.757*
$4s6d$	^{1}D	2	44 989.830
$4s6d$	^{3}D	1	45 049.073
		2	45 050.419
		3	45 052.374
$4s7p$	^{1}P°	1	*45 425.358*
$4s8s$	^{3}S	1	45 738.684
$4s8s$	^{1}S	0	45 887.200
$4s6f$	^{3}F°	2	*46 164.644*
		3	*46 164.785*
		4	*46 164.971*
$4s6f$	^{1}F°	3	*46 182.399*
$4s7d$	^{1}D	2	46 200.13
$4s8p$	^{3}P°	0	*46 284.12*
		1	*46 285.23*
		2	*46 287.63*
$4s7d$	^{3}D	1	46 301.973
		2	46 303.649
		3	46 306.059
$4s8p$	^{1}P°	1	*46 479.813*
$4s9s$	^{3}S	1	46 748.283
$4s9s$	^{1}S	0	46 835.055
$4s8d$	^{1}D	2	46 948.98

Configuration	Term	J	Level (cm^{-1})
$4s7f$	^{3}F°	2	*47 006.194*
		3	*47 006.280*
		4	*47 006.400*
$4s7f$	^{1}F°	3	*47 015.141*
$4s8d$	^{3}D	1	47 036.225
		2	47 040.007
		3	47 045.241
$4s9p$	^{3}P°	1	*47 085.38*
		2	*47 086.99*
$4s9p$	^{1}P°	1	*47 184.370*
$4s10s$	^{3}S	1	47 382.048
$4s10s$	^{1}S	0	47 437.471
$3d\,5s$	^{1}D	2	47 449.083
$3d\,5s$	^{3}D	1	47 456.452
		2	47 466.014
		3	47 475.915
$4s8f$	^{3}F°	2	*47 550.214*
		3	*47 550.271*
		4	*47 550.371*
$4s8f$	^{1}F°	3	*47 555.23*
$4s10p$	^{3}P°	1	*47 604.75*
		2	*47 605.77*
$4s10p$	^{1}P°	1	*47 662.10*
$4s9d$	^{3}D	1	47 752.655
		2	47 757.286
		3	47 765.697
$4s11s$	^{3}S	1	47 806.17
$4s9d$	^{1}D	2	47 812.39
$4s11s$	^{1}S	0	47 843.76
$4s9f$	^{3}F°	2	*47 921.87*
		3	*47 921.981*
		4	*47 922.033*
$4s9f$	^{1}F°	3	*47 924.947*
$4s11p$	^{3}P°	1	*47 960.87*
		2	*47 961.53*
$4s11p$	^{1}P°	1	*47 997.49*
$4s10d$	^{3}D	1	48 031.58
		2	48 033.23
		3	48 036.212
$4s10d$	^{1}D	2	48 083.41

Ca I: Ordered by term values—Continued

Configuration	Term	J	Level (cm^{-1})
4s12s	^3S	1	48 103.93
4s12s	^1S	0	48 130.75
4s10f	$^3F^\circ$	2	48 187.045
		3	48 187.075
		4	48 187.118
4s10f	$^1F^\circ$	3	48 188.990
4s12p	$^3P^\circ$	1	48 215.81
		2	48 216.36
4s12p	$^1P^\circ$	1	48 240.53
4s11d	^3D	1	48 258.30
		2	48 258.98
		3	48 260.25
4s11d	^1D	2	48 290.85
4s13s	^3S	1	48 321.00
4s13s	^1S	0	48 340.75
4s11f	$^3F^\circ$	2	48 382.70
		3	48 382.781
		4	48 382.801
4s11f	$^1F^\circ$	3	48 384.039
4s13p	$^3P^\circ$	1	48 404.57
		2	48 404.95
4s13p	$^1P^\circ$	1	48 422.09
4s12d	^3D	1	48 433.23
		2	48 433.65
		3	48 434.36
4s12d	^1D	2	48 451.73
4s14s	^3S	1	48 484.12
4s14s	^1S	0	48 499.14
$3d^2$	^3P	0	48 524.093
		1	48 537.623
		2	48 563.522
4s12f	$^3F^\circ$	3,4	48 531.04
4s12f	$^1F^\circ$	3	48 532.139
4s14p	$^3P^\circ$	1	48 548.30
		2	48 548.51
4s14p	$^1P^\circ$	1	48 561.10
4s13d	^3D	1	48 568.95
		2	48 569.16
		3	48 569.59
4s13d	^1D	2	48 578.32

Configuration	Term	J	Level (cm^{-1})
4s15s	^3S	1	48 609.75
4s15s	^1S	0	48 621.53
4s13f	$^3F^\circ$	4	48 646.38
4s13f	$^1F^\circ$	3	48 647.30
4s15p	$^3P^\circ$	2	48 660.23
4s15p	$^1P^\circ$	1	48 669.83
4s14d	^3D	1	48 675.68
		2	48 675.87
		3	48 676.13
4s14d	^1D	2	48 678.97
4s16s	^3S	1	48 708.67
4s16s	^1S	0	48 718.02
4s14f	$^1F^\circ$	3	48 738.54
4s16p	$^3P^\circ$	2	48 749.04
4s16p	$^1P^\circ$	1	48 756.45
4s15d	^1D	2	48 760.14
4s15d	^3D	1	48 761.11
		2	48 761.21
		3	48 761.31
4s17s	^3S	1	48 787.89
4s17s	^1S	0	48 795.46
4s15f	$^1F^\circ$	3	48 812.09
4s17p	$^3P^\circ$	2	48 820.60
4s17p	$^1P^\circ$	1	48 826.54
4s16d	^1D	2	48 827.05
4s16d	^3D	2	48 830.41
		1	48 830.44
		3	48 830.64
4s18s	^3S	1	48 852.18
4s18s	^1S	0	48 858.59
4s16f	$^1F^\circ$	3	48 872.20
4s18p	$^3P^\circ$	2	48 879.31
4s17d	^1D	2	48 882.37
4s18p	$^1P^\circ$	1	48 884.06
4s17d	^3D	3	48 887.58
		2	48 887.68

Ca I: Ordered by term values—Continued

Configuration	Term	*J*	Level (cm^{-1})	Configuration	Term	*J*	Level (cm^{-1})
4*s*19*s*	^{1}S	0	48 910.65	4*s*23*f*	^{1}F°	3	*49 096.74*
4*s*17*f*	^{1}F°	3	*48 921.95*	4*s*25*p*	^{3}P°	2	*49 099.25*
4*s*19*p*	^{3}P°	2	*48 927.93*	4*s*25*p*	^{1}P°	1	*49 100.72*
4*s*18*d*	^{1}D	2	48 928.79	4*s*26*s*	^{1}S	0	49 109.85
4*s*19*p*	^{1}P°	1	*48 931.82*	4*s*25*d*	^{1}D	2	49 113.41
4*s*20*s*	^{1}S	0	48 954.13	4*s*24*f*	^{1}F°	3	*49 113.85*
4*s*18*f*	^{1}F°	3	*48 963.67*	4*s*26*p*	^{3}P°	2	*49 116.07*
4*s*19*d*	^{1}D	2	48 968.10	4*s*26*p*	^{1}P°	1	*49 117.38*
4*s*20*p*	^{3}P°	2	*48 968.67*	4*s*27*s*	^{1}S	0	49 125.44
4*s*20*p*	^{1}P°	1	*48 971.93*	4*s*26*d*	^{1}D	2	49 128.34
4*s*21*s*	^{1}S	0	48 990.83	4*s*25*f*	^{1}F°	3	*49 129.00*
4*s*19*f*	^{1}F°	3	*48 998.89*	4*s*27*p*	^{3}P°	2	*49 130.94*
4*s*20*d*	^{1}D	2	49 001.66	4*s*27*p*	^{1}P°	1	*49 132.09*
4*s*21*p*	^{3}P°	2	*49 003.21*	4*s*28*s*	^{1}S	0	49 139.31
4*s*21*p*	^{1}P°	1	*49 005.92*	4*s*27*d*	^{1}D	2	49 141.63
4*s*22*s*	^{1}S	0	49 022.02	4*s*26*f*	^{1}F°	3	*49 142.38*
4*s*20*f*	^{1}F°	3	*49 028.93*	4*s*28*p*	^{3}P°	2	*49 144.19*
4*s*21*d*	^{1}D	2	49 030.55	4*s*28*p*	^{1}P°	1	*49 145.15*
4*s*22*p*	^{3}P°	2	*49 032.70*	4*s*29*s*	^{1}S	0	49 151.59
4*s*22*p*	^{1}P°	1	*49 034.98*	4*s*28*d*	^{1}D	2	49 153.49
4*s*23*s*	^{1}S	0	49 048.85	4*s*27*f*	^{1}F°	3	*49 154.29*
4*s*21*f*	^{1}F°	3	*49 054.80*	4*s*29*p*	^{3}P°	2	*49 155.90*
4*s*22*d*	^{1}D	2	49 055.62	4*s*29*p*	^{1}P°	1	*49 156.78*
4*s*23*p*	^{3}P°	2	*49 058.02*	4*s*30*s*	^{1}S	0	49 162.47
4*s*23*p*	^{1}P°	1	*49 060.02*	4*s*29*d*	^{1}D	2	49 164.12
4*s*24*s*	^{1}S	0	49 071.99	4*s*28*f*	^{1}F°	3	*49 164.99*
4*s*22*f*	^{1}F°	3	*49 077.20*	4*s*30*p*	^{3}P°	2	*49 166.43*
4*s*23*d*	^{1}D	2	49 077.48	4*s*30*p*	^{1}P°	1	*49 167.20*
4*s*24*p*	^{3}P°	2	*49 080.04*	4*s*31*s*	^{1}S	0	49 172.43
4*s*24*p*	^{1}P°	1	*49 081.75*	4*s*30*d*	^{1}D	2	49 173.70
4*s*25*s*	^{1}S	0	49 092.19	4*s*31*p*	^{3}P°	2	*49 175.87*
4*s*24*d*	^{1}D	2	49 096.52	4*s*31*p*	^{1}P°	1	*49 176.58*

Ca I: Ordered by term values—Continued

Configuration	Term	J	Level (cm⁻¹)	Configuration	Term	J	Level (cm⁻¹)
4s32s	^{1}S	0	49 181.49	4s41d	^{1}D	2	49 236.45
4s31d	^{1}D	2	49 182.36	4s42p	^{3}P°	2	*49 237.55*
4s32p	^{3}P°	2	*49 184.37*	4s42p	^{1}P°	1	*49 237.82*
4s32p	^{1}P°	1	*49 185.02*	4s42d	^{1}D	2	49 239.80
4s32d	^{1}D	2	49 190.17	4s43p	^{3}P°	2	*49 240.81*
4s33p	^{3}P°	2	*49 192.08*	4s43p	^{1}P°	1	*49 241.09*
4s33p	^{1}P°	1	*49 192.68*	4s43d	^{1}D	2	49 242.93
4s33d	^{1}D	2	49 197.30	4s44p	^{3}P°	2	*49 243.87*
4s34p	^{3}P°	2	*49 199.09*	4s44p	^{1}P°	1	*49 244.13*
4s34p	^{1}P°	1	*49 199.62*	4s44d	^{1}D	2	49 245.80
4s34d	^{1}D	2	49 203.78	4s45p	^{3}P°	2	*49 246.74*
4s35p	^{3}P°	2	*49 205.47*	4s45p	^{1}P°	1	*49 246.98*
4s35p	^{1}P°	1	*49 205.95*	4s45d	^{1}D	2	49 248.52
4s35d	^{1}D	2	49 209.68	4s46p	^{3}P°	2	*49 249.37*
4s36p	^{3}P°	2	*49 211.34*	4s46p	^{1}P°	1	*49 249.61*
4s36p	^{1}P°	1	*49 211.72*	4s46d	^{1}D	2	49 251.05
4s36d	^{1}D	2	49 215.11	4s47p	^{3}P°	2	*49 251.87*
4s37p	^{3}P°	2	*49 216.61*	4s47p	^{1}P°	1	*49 252.08*
4s37p	^{1}P°	1	*49 217.02*	4s47d	^{1}D	2	49 253.40
4s37d	^{1}D	2	49 220.10	4s48p	^{3}P°	2	*49 254.22*
4s38p	^{3}P°	2	*49 221.51*	4s48p	^{1}P°	1	*49 254.41*
4s38p	^{1}P°	1	*49 221.87*	4s48d	^{1}D	2	49 255.64
4s38d	^{1}D	2	49 224.70	4s49p	^{3}P°	2	*49 256.42*
4s39p	^{3}P°	2	*49 226.02*	4s49p	^{1}P°	1	*49 256.56*
4s39p	^{1}P°	1	*49 226.35*	4s49d	^{1}D	2	49 257.74
4s39d	^{1}D	2	49 228.92	4s50p	^{3}P°	2	*49 258.45*
4s40p	^{3}P°	2	*49 230.13*	4s50p	^{1}P°	1	*49 258.60*
4s40p	^{1}P°	1	*49 230.45*	4s50d	^{1}D	2	49 259.68
4s40d	^{1}D	2	49 232.81	4s51p	^{3}P°	2	*49 260.36*
4s41p	^{3}P°	2	*49 234.00*	4s51p	^{1}P°	1	*49 260.51*
4s41p	^{1}P°	1	*49 234.28*	4s51d	^{1}D	2	49 261.51
				4s52p	^{3}P°	2	*49 262.15*

Ca I: Ordered by term values—Continued

Configuration	Term	J	Level (cm^{-1})
$4s52p$	$^1P^\circ$	1	*49 262.30*
$4s52d$	^1D	2	49 263.31
$4s53p$	$^3P^\circ$	2	*49 263.85*
$4s53p$	$^1P^\circ$	1	*49 263.99*
$4s53d$	^1D	2	49 264.77
$4s54p$	$^3P^\circ$	2	*49 265.44*
$4s54p$	$^1P^\circ$	1	*49 265.59*
$4s54d$	^1D	2	49 266.36
$4s55p$	$^3P^\circ$	2	*49 266.99*
$4s55p$	$^1P^\circ$	1	*49 267.10*
$4s55d$	^1D	2	49 267.84
$4s56p$	$^3P^\circ$	2	*49 268.40*
$4s56p$	$^1P^\circ$	1	*49 268.52*
$4s56d$	^1D	2	49 269.33
$4s57p$	$^3P^\circ$	2	*49 269.77*
$4s57p$	$^1P^\circ$	1	*49 269.88*
$4s57d$	^1D	2	49 270.40
$4s58p$	$^3P^\circ$	2	*49 271.01*
$4s58p$	$^1P^\circ$	1	*49 271.14*
$4s58d$	^1D	2	49 271.79
$4s59p$	$^3P^\circ$	2	*49 272.24*
$4s59p$	$^1P^\circ$	1	*49 272.35*
$4s59d$	^1D	2	49 273.09
$4s60p$	$^3P^\circ$	2	*49 273.37*
$4s60p$	$^1P^\circ$	1	*49 273.50*
$4s60d$	^1D	2	49 274.29
$4s61p$	$^1P^\circ$	1	*49 274.60*
$4s61d$	^1D	2	49 275.58
$4s62p$	$^1P^\circ$	1	*49 275.62*
$4s62d$	^1D	2	49 275.87
$4s63p$	$^1P^\circ$	1	*49 276.61*
$4s64p$	$^1P^\circ$	1	*49 277.55*
$4s65p$	$^1P^\circ$	1	*49 278.44*

Configuration	Term	J	Level (cm^{-1})
$4s66p$	$^1P^\circ$	1	*49 279.30*
$4s67p$	$^1P^\circ$	1	*49 280.10*
$4s68p$	$^1P^\circ$	1	*49 280.88*
$4s69p$	$^1P^\circ$	1	*49 281.62*
$4s70p$	$^1P^\circ$	1	*49 282.34*
$4s71p$	$^1P^\circ$	1	*49 283.01*
$4s72p$	$^1P^\circ$	1	*49 283.67*
$4s73p$	$^1P^\circ$	1	*49 284.30*
$4s74p$	$^1P^\circ$	1	*49 284.88*
$4s75p$	$^1P^\circ$	1	*49 285.46*
$4s76p$	$^1P^\circ$	1	*49 286.00*
$4s77p$	$^1P^\circ$	1	*49 286.54*
$4s78p$	$^1P^\circ$	1	*49 287.05*
$4s79p$	$^1P^\circ$	1	*49 287.57*
Ca II ($^2S_{1/2}$)	***Limit***		**49 305.96**
$3d\,4d$	^3D	1	51 351.74
		2	51 369.38
		3	51 396.32
$3d\,4d$	^3S	1	51 571.7
$3d\,5p$	$^3D^\circ$	1	*51 709.5*
		2	*51 734.6*
		3	*51 767.0*
$3d\,5p$	$^3P^\circ$	1	*51 908.*
$3d\,5p$	$^1P^\circ$	1	*53 100.*
$3d\,4d$	^3P	0	54 282.3
		1	54 288.74
		2	54 304.6
$3d4f$	$^3D^\circ$	1	*55 902.8*
$3d4f$	$^3P^\circ$	1	*55 946.6*
$3d4f$	$^1P^\circ$	1	*55 982.3*
$3d\,6p$	$^3D^\circ$	1	*56 254.*
$3d\,5d$	^3D	2	56 469.0
$3d\,6p$	$^3P^\circ$	1	*56 532.63*
$3d\,5d$	^3S	1	56 558.9
$3d\,6p$	$^1P^\circ$	1	*56 651.*
$4p5s$	$^3P^\circ$	1	*57 462.*
$3d\,5d$	^3P	0	57 611.2
		1	57 617.9
		2	57 638.4
$4p5s$	$^1P^\circ$	1	*57 960.*
$3d5f$	$^3D^\circ$	1	*58 431.31*
$3d5f$	$^3P^\circ$	1	*58 491.91*

Ca I: Ordered by term values—Continued

Configuration	Term	J	Level (cm⁻¹)
3d5f	¹P°	1	58 505.89
3d 7p	³D°	1	58 798.92
3d 7p	³P°	1	59 010.87
3d 7p	¹P°	1	59 197.
3d 6d	³P	1	59 368.
		2	59 391.
3d6f	³D°	1	59 802.21
3d6f	³P°	1	59 862.26
3d6f	¹P°	1	59 878.52
3d 8p	³D°	1	60 046.13
3d 8p	³P°	1	60 150.26
3d 8p	¹P°	1	60 300.
3d7f	³D°	1	60 632.18
3d7f	³P°	1	60 690.27
3d7f	¹P°	1	60 709.54
3d 9p	³D°	1	60 807.28
3d 9p	³P°	1	60 869.28
3d 9p	¹P°	1	60 973.6
3d8f	³D°	1	61 172.54
3d8f	³P°	1	61 228.65
3d8f	¹P°	1	61 251.39
3d 10p	³D°	1	61 306.65
3d 10p	³P°	1	61 345.74
3d 10p	¹P°	1	61 428.1
3d9f	³D°	1	61 543.95
3d9f	³P°	1	61 596.69
3d9f	¹P°	1	61 622.60
3d 11p	³D°	1	61 652.25
3d 11p	³P°	1	61 676.62
3d 11p	¹P°	1	61 747.2
3d 10f	³D°	1	61 810.68
3d 10f	³P°	1	61 859.22
3d 10f	¹P°	1	61 888.22
3d 12p	³D°	1	61 901.04
3d 12p	³P°	1	61 916.38
3d 12p	¹P°	1	61 980.49
3d 11f	³D°	1	62 009.17
3d 11f	³P°	1	62 052.49
3d 13p	³D°	1	62 084.92
3d 11f	¹P°	1	62 084.92
3d 13p	³P°	1	62 097.08
3d 13p	¹P°	1	62 154.62
3d 12f	³D°	1	62 161.61
3d 12f	³P°	1	62 198.92
3d 14p	³D°	1	62 223.68
3d 12f	¹P°	1	62 234.47
3d 14p	³P°	1	62 237.12
3d 13f	³D°	1	62 279.33
3d 14p	¹P°	1	62 288.02
3d 13f	³P°	1	62 312.63
3d 15p	³D°	1	62 331.04
3d 13f	¹P°	1	62 346.47
3d 15p	³P°	1	62 351.93
3d 14f	³D°	1	62 375.29
3d 15p	¹P°	1	62 392.01
3d 14f	³P°	1	62 403.22
3d 16p	³D°	1	62 416.47
3d 14f	¹P°	1	62 433.38
3d 16p	³P°	1	62 443.64
3d 15f	³D°	1	62 453.85
3d 15f	³P°	1	62 472.14
3d 16p	¹P°	1	62 478.26
3d 17p	³D°	1	62 486.45
3d 15f	¹P°	1	62 506.62
3d 17p	³P°	1	62 511.97
3d 16f	³D°	1	62 520.06
3d 16f	³P°	1	62 533.90

Ca I: Ordered by term values—Continued

Configuration	Term	J	Level (cm⁻¹)	Configuration	Term	J	Level (cm⁻¹)
3d 18p	$^3D°$	1	62 539.39	3d 22f	$^3D°$	1	62 720.41
3d 17p	$^1P°$	1	62 548.16	3d 21p	$^1P°$	1	62 721.80
4p4d	$^3D°$?	1	62 552.97	3d 22f	$^3P°$	1	62 729.19
4p4d	$^3P°$?	1	62 557.45	3d 24p	$^3D°$	1	62 734.25
4p4d	$^1P°$?	1	62 561.72	3d 22p	$^3P°$	1	62 736.10
3d 17f	$^3D°$	1	62 565.68	3d 20f	$^1P°$	1	62 736.10
3d 16f	$^1P°$	1	62 572.66	3d 23f	$^3D°$	1	62 743.11
3d 17f	$^3P°$	1	62 578.91	3d 23f	$^3P°$	1	62 748.53
3d 18p	$^3P°$	1	62 584.50	3d 22p	$^1P°$	1	62 750.58
3d 19p	$^3D°$	1	62 587.83	3d 25p	$^3D°$	1	62 753.60
3d 18p	$^1P°$	1	62 602.72	3d 23p	$^3P°$	1	62 762.86
3d 18f	$^3D°$	1	62 610.75	3d 21f	$^1P°$	1	62 762.86
3d 18f	$^3P°$	1	62 617.02	3d 24f	$^3P°$	1	62 764.10
3d 17f	$^1P°$	1	62 625.37	3d 24f	$^3D°$	1	62 768.10
3d 20p	$^3D°$	1	62 626.03	3d 26p	$^3D°$	1	62 769.47
3d 19p	$^3P°$	1	62 628.76	3d 23p	$^1P°$	1	62 774.75
3d 19f	$^3D°$	1	62 641.52	3d 25f	$^3P°$	1	62 780.30
3d 19p	$^1P°$	1	62 648.37	3d 27p	$^3D°$	1	62 783.86
3d 19f	$^3P°$	1	62 653.99	3d 22f	$^1P°$	1	62 785.02
3d 21p	$^3D°$	1	62 660.15	3d 24p	$^3P°$	1	62 787.31
3d 20p	$^3P°$	1	62 671.51	3d 26f	$^3D°$	1	62 790.08
3d 18f	$^1P°$	1	62 671.51	3d 26f	$^3P°$	1	62 794.19
3d 20f	$^3D°$	1	62 675.56	3d 24p	$^1P°$	1	62 795.55
3d 20f	$^3P°$	1	62 683.89	3d 28p	$^3D°$	1	62 797.46
3d 22p	$^3D°$	1	62 686.88	3d 23f	$^1P°$	1	62 804.38
3d 20p	$^1P°$	1	62 690.32	3d 27f	$^3P°$	1	62 806.02
3d 19f	$^1P°$	1	62 704.43	3d 25p	$^3P°$	1	62 807.90
3d 21f	$^3D°$	1	62 704.43	3d 29p	$^3D°$	1	62 808.51
3d 21f	$^3P°$	1	62 707.25	3d 28f	$^3D°$	1	62 812.00
3d 21p	$^3P°$	1	62 711.37	3d 25p	$^1P°$	1	62 814.13
3d 23p	$^3D°$	1	62 713.24				

Ca I: Ordered by term values—Continued

Configuration	Term	J	Level (cm⁻¹)	Configuration	Term	J	Level (cm⁻¹)
3d 28f	$^3P^\circ$	1	62 816.51	3d 30p	$^3P^\circ$	1	62 875.40
3d 30p	$^3D^\circ$	1	62 818.76	3d 37f	$^3P^\circ$	1	62 875.40
3d 24f	$^1P^\circ$	1	62 820.31	3d 39p	$^3D^\circ$	1	62 876.98
3d 26p	$^3P^\circ$	1	62 824.17			1	62 878.40
3d 29f	$^3P^\circ$	1	62 824.17	3d 30p	$^1P^\circ$	1	62 879.48
3d 31p	$^3D^\circ$	1	62 827.75	3d 38f	$^3P^\circ$	1	62 880.04
3d 26p	$^1P^\circ$	1	62 830.67	3d 40p	$^3D^\circ$	1	62 881.24
3d 30f	$^3D^\circ$	1	62 832.31	3d 31p	$^3P^\circ$	1	62 884.77
3d 30f	$^3P^\circ$	1	62 834.11	3d 41p	$^3D^\circ$	1	62 884.77
3d 32p	$^3D^\circ$	1	62 836.22			1	62 886.45
3d 25f	$^1P^\circ$	1	62 836.85	3d 31p	$^1P^\circ$	1	62 889.00
3d 27p	$^3P^\circ$	1	62 838.45	3d 42p	$^3D^\circ$	1	62 889.00
3d 31f	$^3P^\circ$	1	62 840.23	3d 43p	$^3D^\circ$	1	62 891.65
3d 33p	$^3D^\circ$	1	62 843.72	3d 32p	$^3P^\circ$	1	62 893.66
3d 27p	$^1P^\circ$	1	62 845.27	3d 44p	$^3D^\circ$	1	62 894.65
3d 32f	$^3P^\circ$	1	62 848.77	3d 32p	$^1P^\circ$	1	62 897.57
3d 34p	$^3D^\circ$	1	62 850.62	3d 45p	$^3D^\circ$	1	62 897.57
3d 26f	$^1P^\circ$	1	62 852.33	3d 46p	$^3D^\circ$	1	62 900.09
3d 28p	$^3P^\circ$	1	62 853.79	3d 33p	$^3P^\circ$	1	62 901.85
3d 33f	$^3P^\circ$	1	62 853.79	3d 47p	$^3D^\circ$	1	62 902.75
3d 35p	$^3D^\circ$	1	62 856.56	3d 33p	$^1P^\circ$	1	62 904.95
3d 28p	$^1P^\circ$	1	62 858.11	3d 48p	$^3D^\circ$	1	62 904.95
3d 34f	$^3P^\circ$	1	62 861.06	3d 49p	$^3D^\circ$	1	62 906.98
3d 36p	$^3D^\circ$	1	62 862.60	3d 50p	$^3D^\circ$	1	62 908.88
3d 29p	$^3P^\circ$	1	62 863.99	3d 51p	$^3D^\circ$	1	62 910.88
3d 35f	$^3P^\circ$	1	62 865.39	3d 34p	$^1P^\circ$	1	62 911.51
3d 37p	$^3D^\circ$	1	62 867.87	3d 52p	$^3D^\circ$	1	62 912.67
3d 29p	$^1P^\circ$	1	62 869.38	3d 53p	$^3D^\circ$	1	62 914.47
3d 36f	$^3P^\circ$	1	62 871.46	3d 54p	$^3D^\circ$	1	62 915.91
3d 38p	$^3D^\circ$	1	62 872.69	3d 35p	$^1P^\circ$	1	62 917.83
				3d 55p	$^3D^\circ$	1	62 917.83
				3d 56p	$^3D^\circ$	1	62 918.80
				3d 57p	$^3D^\circ$	1	62 920.32

Ca I: Ordered by term values—Continued

Configuration	Term	*J*	Level (cm^{-1})
$3d\,58p$	$^3D^\circ$	1	*62 921.43*
$3d\,36p$	$^1P^\circ$	1	*62 923.62*
$3d\,35f$	$^1P^\circ$	1	*62 926.36*
$3d\,37p$	$^1P^\circ$	1	*62 928.81*
$3d\,36f$	$^1P^\circ$	1	*62 931.29*
$3d\,38p$	$^1P^\circ$	1	*62 933.61*
$3d\,37f$	$^1P^\circ$	1	*62 935.88*
$3d\,39p$	$^1P^\circ$	1	*62 938.02*
$3d\,38f$	$^1P^\circ$	1	*62 939.79*
$3d\,40p$	$^1P^\circ$	1	*62 942.10*
$3d\,39f$	$^1P^\circ$	1	*62 943.85*
$3d\,41p$	$^1P^\circ$	1	*62 945.88*
$3d\,42p$	$^1P^\circ$	1	*62 949.34*
$3d\,43p$	$^1P^\circ$	1	*62 952.58*
$3d\,44p$	$^1P^\circ$	1	*62 955.57*
Ca II ($^2D_{3/2}$)	***Limit***		**62 956.15**
$3d\,45p$	$^1P^\circ$	1	*62 958.38*
$3d\,46p$	$^1P^\circ$	1	*62 961.01*
$3d\,47p$	$^1P^\circ$	1	*62 963.43*
$3d\,48p$	$^1P^\circ$	1	*62 965.72*
$3d\,49p$	$^1P^\circ$	1	*62 967.84*
$3d\,50p$	$^1P^\circ$	1	*62 969.89*
$3d\,51p$	$^1P^\circ$	1	*62 971.78*
$3d\,52p$	$^1P^\circ$	1	*62 973.55*
$3d\,53p$	$^1P^\circ$	1	*62 975.23*
$3d\,54p$	$^1P^\circ$	1	*62 976.81*
$3d\,55p$	$^1P^\circ$	1	*62 978.26*
$3d\,56p$	$^1P^\circ$	1	*62 979.72*
$3d\,57p$	$^1P^\circ$	1	*62 981.03*
$3d\,58p$	$^1P^\circ$	1	*62 982.35*
$3d\,59p$	$^1P^\circ$	1	*62 983.48*
$3d\,60p$	$^1P^\circ$	1	*62 984.63*
$3d\,61p$	$^1P^\circ$	1	*62 985.70*
Ca II ($^2D_{5/2}$)	***Limit***		**63 016.84**
$3p^5\,4s^2\,3d$	$^3P^\circ$	1	*200 096*
$3p^5\,4s^2\,3d$	$^3D^\circ$	1	*218 991*
$3p^5\,4s^2\,3d$	$^1P^\circ$	1	*253 310*
$3p^5\,4s^2\,4d$	$^3P^\circ$	1	*255 022*
$3p^5(^2P^\circ_{3/2})4s^2\,5s$	$^2[3/2]^\circ$	1	*257 737*
$3p^5(^2P^\circ_{1/2})4s^2\,5s$	$^2[1/2]^\circ$	1	*260 193*
$3p^5(^2P^\circ_{3/2})4s^2\,6s$	$^2[3/2]^\circ$	1	*267 417*

Configuration	Term	*J*	Level (cm^{-1})
$3p^5\,4s^2\,4d$	$^3D^\circ$	1	*267 956*
$3p^5(^2P^\circ_{1/2})4s^2\,6s$	$^2[1/2]^\circ$	1	*269 706*
$3p^5\,4s^2\,4d$	$^1P^\circ$	1	*270 640*
$3p^5(^2P^\circ_{3/2})4s^2\,5d$	$^2[3/2]^\circ$	1	*270 889*
$3p^5(^2P^\circ_{3/2})4s^2\,7s$	$^2[3/2]^\circ$	1	*271 245*
$3p^5(^2P^\circ_{3/2})4s^2\,6d$	$^2[3/2]^\circ$	1	*273 134*
$3p^5(^2P^\circ_{1/2})4s^2\,7s$	$^2[1/2]^\circ$	1	*273 598*
$3p^5(^2P^\circ_{3/2})4s^2\,7d$	$^2[3/2]^\circ$	1	*273 959*
$3p^5(^2P^\circ_{1/2})4s^2\,5d$	$^2[3/2]^\circ$	1	*274 040*
$3p^5(^2P^\circ_{3/2})4s^2\,9s$	$^2[3/2]^\circ$	1	*274 276*
$3p^5(^2P^\circ_{3/2})4s^2\,8d$	$^2[3/2]^\circ$	1	*274 652*
$3p^5(^2P^\circ_{3/2})4s^2\,10s$	$^2[3/2]^\circ$	1	*274 777*
$3p^5(^2P^\circ_{3/2})4s^2\,9d$	$^2[3/2]^\circ$	1	*275 272*
$3p^5(^2P^\circ_{3/2})4s^2\,10d$	$^2[3/2]^\circ$	1	*275 503*
$3p^5(^2P^\circ_{3/2})4s^2\,11d$	$^2[3/2]^\circ$	1	*275 726*
$3p^5(^2P^\circ_{3/2})4s^2\,12d$	$^2[3/2]^\circ$	1	*275 898*
$3p^5(^2P^\circ_{3/2})4s^2\,13d$	$^2[3/2]^\circ$	1	*276 038*
$3p^5(^2P^\circ_{3/2})4s^2\,14d$	$^2[3/2]^\circ$	1	*276 138*
$3p^5(^2P^\circ_{3/2})4s^2\,15d$	$^2[3/2]^\circ$	1	*276 214*
$3p^5(^2P^\circ_{3/2})4s^2\,16d$	$^2[3/2]^\circ$	1	*276 283*
$3p^5(^2P^\circ_{1/2})4s^2\,7d$	$^2[3/2]^\circ$	1	*276 631*
Ca II $3p^5 4s^2\,^2P^\circ_{3/2}$	***Limit***		**276 750**
$3p^5(^2P^\circ_{1/2})4s^2\,8d$	$^2[3/2]^\circ$	1	*277 430*
$3p^5(^2P^\circ_{1/2})4s^2\,9d$	$^2[3/2]^\circ$	1	*277 917*
$3p^5(^2P^\circ_{1/2})4s^2\,11s$	$^2[1/2]^\circ$	1	*277 991*
$3p^5(^2P^\circ_{1/2})4s^2\,10d$	$^2[3/2]^\circ$	1	*278 228*
$3p^5(^2P^\circ_{1/2})4s^2\,12s$	$^2[1/2]^\circ$	1	*278 302*
$3p^5(^2P^\circ_{1/2})4s^2\,11d$	$^2[3/2]^\circ$	1	*278 469*
$3p^5(^2P^\circ_{1/2})4s^2\,13s$	$^2[1/2]^\circ$	1	*278 534*
$3p^5(^2P^\circ_{1/2})4s^2\,12d$	$^2[3/2]^\circ$	1	*278 647*

Ca I: Ordered by term values—Continued

Configuration	Term	J	Level (cm^{-1})	Configuration	Term	J	Level (cm^{-1})
$3p^5(^2P^\circ_{1/2})4s^2\,14s$	$^2[1/2]^\circ$	1	*278 702*	$3p^5(^2P^\circ_{1/2})4s^2\,16d$	$^2[3/2]^\circ$	1	*279 050*
$3p^5(^2P^\circ_{1/2})4s^2\,13d$	$^2[3/2]^\circ$	1	*278 796*	$3p^5(^2P^\circ_{1/2})4s^2\,17d$	$^2[3/2]^\circ$	1	*279 117*
$3p^5(^2P^\circ_{1/2})4s^2\,14d$	$^2[3/2]^\circ$	1	*278 900*	Ca II $3p^54s^2\,^2P^\circ_{1/2}$	***Limit***		**279 530**
$3p^5(^2P^\circ_{1/2})4s^2\,15d$	$^2[3/2]^\circ$	1	*278 983*				

Ca I: Ordered by series

Configuration	Term	J	Level (cm^{-1})
$4s^2$	^1S	0	0.000
*****	***	*	*******
4s4p	$^3P^\circ$	0	15 157.901
		1	15 210.063
		2	15 315.943
4s5p	$^3P^\circ$	0	36 547.688
		1	36 554.749
		2	36 575.119
4s6p	$^3P^\circ$	0	42 514.845
		1	42 518.708
		2	42 526.591
4s7p	$^3P^\circ$	0	44 955.67
		1	44 957.655
		2	44 961.757
4s8p	$^3P^\circ$	0	46 284.12
		1	46 285.23
		2	46 287.63
4s9p	$^3P^\circ$	1	47 085.38
		2	47 086.99
4s10p	$^3P^\circ$	1	47 604.75
		2	47 605.77
4s11p	$^3P^\circ$	1	47 960.87
		2	47 961.53
4s12p	$^3P^\circ$	1	48 215.81
		2	48 216.36
4s13p	$^3P^\circ$	1	48 404.57
		2	48 404.95
4s14p	$^3P^\circ$	1	48 548.30
		2	48 548.51
4s15p	$^3P^\circ$	2	48 660.23
4s16p	$^3P^\circ$	2	48 749.04
4s17p	$^3P^\circ$	2	48 820.60
4s18p	$^3P^\circ$	2	48 879.31
4s19p	$^3P^\circ$	2	48 927.93
4s20p	$^3P^\circ$	2	48 968.67
4s21p	$^3P^\circ$	2	49 003.21
4s22p	$^3P^\circ$	2	49 032.70
4s23p	$^3P^\circ$	2	49 058.02
4s24p	$^3P^\circ$	2	49 080.04
4s25p	$^3P^\circ$	2	49 099.25
4s26p	$^3P^\circ$	2	49 116.07
4s27p	$^3P^\circ$	2	49 130.94
4s28p	$^3P^\circ$	2	49 144.19
4s29p	$^3P^\circ$	2	49 155.90
4s30p	$^3P^\circ$	2	49 166.43
4s31p	$^3P^\circ$	2	49 175.87
4s32p	$^3P^\circ$	2	49 184.37

Configuration	Term	J	Level (cm^{-1})
4s33p	$^3P^\circ$	2	49 192.08
4s34p	$^3P^\circ$	2	49 199.09
4s35p	$^3P^\circ$	2	49 205.47
4s36p	$^3P^\circ$	2	49 211.34
4s37p	$^3P^\circ$	2	49 216.61
4s38p	$^3P^\circ$	2	49 221.51
4s39p	$^3P^\circ$	2	49 226.02
4s40p	$^3P^\circ$	2	49 230.13
4s41p	$^3P^\circ$	2	49 234.00
4s42p	$^3P^\circ$	2	49 237.55
4s43p	$^3P^\circ$	2	49 240.81
4s44p	$^3P^\circ$	2	49 243.87
4s45p	$^3P^\circ$	2	49 246.74
4s46p	$^3P^\circ$	2	49 249.37
4s47p	$^3P^\circ$	2	49 251.87
4s48p	$^3P^\circ$	2	49 254.22
4s49p	$^3P^\circ$	2	49 256.42
4s50p	$^3P^\circ$	2	49 258.45
4s51p	$^3P^\circ$	2	49 260.36
4s52p	$^3P^\circ$	2	49 262.15
4s53p	$^3P^\circ$	2	49 263.85
4s54p	$^3P^\circ$	2	49 265.44
4s55p	$^3P^\circ$	2	49 266.99
4s56p	$^3P^\circ$	2	49 268.40
4s57p	$^3P^\circ$	2	49 269.77
4s58p	$^3P^\circ$	2	49 271.01
4s59p	$^3P^\circ$	2	49 272.24
4s60p	$^3P^\circ$	2	49 273.37
Ca II ($^2S_{1/2}$)	**Limit**		**49 305.96**
4s4p	$^1P^\circ$	1	23 652.304
4s5p	$^1P^\circ$	1	36 731.615
4s6p	$^1P^\circ$	1	41 679.008
4s7p	$^1P^\circ$	1	45 425.358
4s8p	$^1P^\circ$	1	46 479.813
4s9p	$^1P^\circ$	1	47 184.370
4s10p	$^1P^\circ$	1	47 662.10
4s11p	$^1P^\circ$	1	47 997.49
4s12p	$^1P^\circ$	1	48 240.53
4s13p	$^1P^\circ$	1	48 422.09
4s14p	$^1P^\circ$	1	48 561.10
4s15p	$^1P^\circ$	1	48 669.83
4s16p	$^1P^\circ$	1	48 756.45
4s17p	$^1P^\circ$	1	48 826.54
4s18p	$^1P^\circ$	1	48 884.06
4s19p	$^1P^\circ$	1	48 931.82
4s20p	$^1P^\circ$	1	48 971.93
4s21p	$^1P^\circ$	1	49 005.92
4s22p	$^1P^\circ$	1	49 034.98
4s23p	$^1P^\circ$	1	49 060.02
4s24p	$^1P^\circ$	1	49 081.75
4s25p	$^1P^\circ$	1	49 100.72
4s26p	$^1P^\circ$	1	49 117.38
4s27p	$^1P^\circ$	1	49 132.09
4s28p	$^1P^\circ$	1	49 145.15
4s29p	$^1P^\circ$	1	49 156.78
4s30p	$^1P^\circ$	1	49 167.20
4s31p	$^1P^\circ$	1	49 176.58
4s32p	$^1P^\circ$	1	49 185.02

Ca I: Ordered by series—Continued

Configuration	Term	J	Level (cm^{-1})
4s33*p*	$^1P^\circ$	1	*49 192.68*
4s34*p*	$^1P^\circ$	1	*49 199.62*
4s35*p*	$^1P^\circ$	1	*49 205.95*
4s36*p*	$^1P^\circ$	1	*49 211.72*
4s37*p*	$^1P^\circ$	1	*49 217.02*
4s38*p*	$^1P^\circ$	1	*49 221.87*
4s39*p*	$^1P^\circ$	1	*49 226.35*
4s40*p*	$^1P^\circ$	1	*49 230.45*
4s41*p*	$^1P^\circ$	1	*49 234.28*
4s42*p*	$^1P^\circ$	1	*49 237.82*
4s43*p*	$^1P^\circ$	1	*49 241.09*
4s44*p*	$^1P^\circ$	1	*49 244.13*
4s45*p*	$^1P^\circ$	1	*49 246.98*
4s46*p*	$^1P^\circ$	1	*49 249.61*
4s47*p*	$^1P^\circ$	1	*49 252.08*
4s48*p*	$^1P^\circ$	1	*49 254.41*
4s49*p*	$^1P^\circ$	1	*49 256.56*
4s50*p*	$^1P^\circ$	1	*49 258.60*
4s51*p*	$^1P^\circ$	1	*49 260.51*
4s52*p*	$^1P^\circ$	1	*49 262.30*
4s53*p*	$^1P^\circ$	1	*49 263.99*
4s54*p*	$^1P^\circ$	1	*49 265.59*
4s55*p*	$^1P^\circ$	1	*49 267.10*
4s56*p*	$^1P^\circ$	1	*49 268.52*
4s57*p*	$^1P^\circ$	1	*49 269.88*
4s58*p*	$^1P^\circ$	1	*49 271.14*
4s59*p*	$^1P^\circ$	1	*49 272.35*
4s60*p*	$^1P^\circ$	1	*49 273.50*
4s61*p*	$^1P^\circ$	1	*49 274.60*
4s62*p*	$^1P^\circ$	1	*49 275.62*
4s63*p*	$^1P^\circ$	1	*49 276.61*
4s64*p*	$^1P^\circ$	1	*49 277.55*
4s65*p*	$^1P^\circ$	1	*49 278.44*
4s66*p*	$^1P^\circ$	1	*49 279.30*
4s67*p*	$^1P^\circ$	1	*49 280.10*
4s68*p*	$^1P^\circ$	1	*49 280.88*
4s69*p*	$^1P^\circ$	1	*49 281.62*
4s70*p*	$^1P^\circ$	1	*49 282.34*
4s71*p*	$^1P^\circ$	1	*49 283.01*
4s72*p*	$^1P^\circ$	1	*49 283.67*
4s73*p*	$^1P^\circ$	1	*49 284.30*
4s74*p*	$^1P^\circ$	1	*49 284.88*
4s75*p*	$^1P^\circ$	1	*49 285.46*
4s76*p*	$^1P^\circ$	1	*49 286.00*
4s77*p*	$^1P^\circ$	1	*49 286.54*
4s78*p*	$^1P^\circ$	1	*49 287.05*
4s79*p*	$^1P^\circ$	1	*49 287.57*
Ca II ($^2S_{1/2}$)	***Limit***		**49 305.96**
4s3*d*	^3D	1	20 335.360
		2	20 349.260
		3	20 371.000
4s4*d*	^3D	1	37 748.197
		2	37 751.867
		3	37 757.449

Configuration	Term	J	Level (cm^{-1})
4s5*d*	^3D	1	42 743.002
		2	42 744.716
		3	42 747.387
4s6*d*	^3D	1	45 049.073
		2	45 050.419
		3	45 052.374
4s7*d*	^3D	1	46 301.973
		2	46 303.649
		3	46 306.059
4s8*d*	^3D	1	47 036.225
		2	47 040.007
		3	47 045.241
4s9*d*	^3D	1	47 752.655
		2	47 757.286
		3	47 765.697
4s10*d*	^3D	1	48 031.58
		2	48 033.23
		3	48 036.212
4s11*d*	^3D	1	48 258.30
		2	48 258.98
		3	48 260.25
4s12*d*	^3D	1	48 433.23
		2	48 433.65
		3	48 434.36
4s13*d*	^3D	1	48 568.95
		2	48 569.16
		3	48 569.59
4s14*d*	^3D	1	48 675.68
		2	48 675.87
		3	48 676.13
4s15*d*	^3D	1	48 761.11
		2	48 761.21
		3	48 761.31
4s16*d*	^3D	2	48 830.41
		1	48 830.44
		3	48 830.64
4s17*d*	^3D	3	48 887.58
		2	48 887.68
Ca II ($^2S_{1/2}$)	***Limit***		**49 305.96**
4s3*d*	^1D	2	21 849.634
4s4*d*	^1D	2	37 298.287
4s5*d*	^1D	2	42 919.053
4s6*d*	^1D	2	44 989.830
4s7*d*	^1D	2	46 200.13
4s8*d*	^1D	2	46 948.98

Ca I: Ordered by series—Continued

Configuration	Term	*J*	Level (cm^{-1})	Configuration	Term	*J*	Level (cm^{-1})
4*s*9*d*	^{1}D	2	47 812.39	4*s*8*s*	^{3}S	1	45 738.684
4*s*10*d*	^{1}D	2	48 083.41	4*s*9*s*	^{3}S	1	46 748.283
4*s*11*d*	^{1}D	2	48 290.85	4*s*10*s*	^{3}S	1	47 382.048
4*s*12*d*	^{1}D	2	48 451.73	4*s*11*s*	^{3}S	1	47 806.17
4*s*13*d*	^{1}D	2	48 578.32	4*s*12*s*	^{3}S	1	48 103.93
4*s*14*d*	^{1}D	2	48 678.97	4*s*13*s*	^{3}S	1	48 321.00
4*s*15*d*	^{1}D	2	48 760.14	4*s*14*s*	^{3}S	1	48 484.12
4*s*16*d*	^{1}D	2	48 827.05	4*s*15*s*	^{3}S	1	48 609.75
4*s*17*d*	^{1}D	2	48 882.37	4*s*16*s*	^{3}S	1	48 708.67
4*s*18*d*	^{1}D	2	48 928.79	4*s*17*s*	^{3}S	1	48 787.89
4*s*19*d*	^{1}D	2	48 968.10	4*s*18*s*	^{3}S	1	48 852.18
4*s*20*d*	^{1}D	2	49 001.66				
4*s*21*d*	^{1}D	2	49 030.55	Ca II (^{2}S$_{1/2}$)	***Limit***		**49 305.96**
4*s*22*d*	^{1}D	2	49 055.62				
4*s*23*d*	^{1}D	2	49 077.48	4*s*5*s*	^{1}S	0	33 317.264
4*s*24*d*	^{1}D	2	49 096.52	4*s*6*s*	^{1}S	0	40 690.435
4*s*25*d*	^{1}D	2	49 113.41	4*s*7*s*	^{1}S	0	44 276.538
4*s*26*d*	^{1}D	2	49 128.34	4*s*8*s*	^{1}S	0	45 887.200
4*s*27*d*	^{1}D	2	49 141.63	4*s*9*s*	^{1}S	0	46 835.055
4*s*28*d*	^{1}D	2	49 153.49	4*s*10*s*	^{1}S	0	47 437.471
4*s*29*d*	^{1}D	2	49 164.12	4*s*11*s*	^{1}S	0	47 843.76
4*s*30*d*	^{1}D	2	49 173.70	4*s*12*s*	^{1}S	0	48 130.75
4*s*31*d*	^{1}D	2	49 182.36	4*s*13*s*	^{1}S	0	48 340.75
4*s*32*d*	^{1}D	2	49 190.17	4*s*14*s*	^{1}S	0	48 499.14
4*s*33*d*	^{1}D	2	49 197.30	4*s*15*s*	^{1}S	0	48 621.53
4*s*34*d*	^{1}D	2	49 203.78	4*s*16*s*	^{1}S	0	48 718.02
4*s*35*d*	^{1}D	2	49 209.68	4*s*17*s*	^{1}S	0	48 795.46
4*s*36*d*	^{1}D	2	49 215.11	4*s*18*s*	^{1}S	0	48 858.59
4*s*37*d*	^{1}D	2	49 220.10	4*s*19*s*	^{1}S	0	48 910.65
4*s*38*d*	^{1}D	2	49 224.70	4*s*20*s*	^{1}S	0	48 954.13
4*s*39*d*	^{1}D	2	49 228.92	4*s*21*s*	^{1}S	0	48 990.83
4*s*40*d*	^{1}D	2	49 232.81	4*s*22*s*	^{1}S	0	49 022.02
4*s*41*d*	^{1}D	2	49 236.45	4*s*23*s*	^{1}S	0	49 048.85
4*s*42*d*	^{1}D	2	49 239.80	4*s*24*s*	^{1}S	0	49 071.99
4*s*43*d*	^{1}D	2	49 242.93	4*s*25*s*	^{1}S	0	49 092.19
4*s*44*d*	^{1}D	2	49 245.80	4*s*26*s*	^{1}S	0	49 109.85
4*s*45*d*	^{1}D	2	49 248.52	4*s*27*s*	^{1}S	0	49 125.44
4*s*46*d*	^{1}D	2	49 251.05	4*s*28*s*	^{1}S	0	49 139.31
4*s*47*d*	^{1}D	2	49 253.40	4*s*29*s*	^{1}S	0	49 151.59
4*s*48*d*	^{1}D	2	49 255.64	4*s*30*s*	^{1}S	0	49 162.47
4*s*49*d*	^{1}D	2	49 257.74	4*s*31*s*	^{1}S	0	49 172.43
4*s*50*d*	^{1}D	2	49 259.68	4*s*32*s*	^{1}S	0	49 181.49
4*s*51*d*	^{1}D	2	49 261.51				
4*s*52*d*	^{1}D	2	49 263.31	Ca II (^{2}S$_{1/2}$)	***Limit***		**49 305.96**
4*s*53*d*	^{1}D	2	49 264.77				
4*s*54*d*	^{1}D	2	49 266.36	3*d* 4*p*	^{3}F°	2	*35 730.454*
4*s*55*d*	^{1}D	2	49 267.84			3	*35 818.713*
4*s*56*d*	^{1}D	2	49 269.33			4	*35 896.889*
4*s*57*d*	^{1}D	2	49 270.40				
4*s*58*d*	^{1}D	2	49 271.79	3*d* 4*p*	^{1}D°	2	*35 835.413*
4*s*59*d*	^{1}D	2	49 273.09				
4*s*60*d*	^{1}D	2	49 274.29	3*d* 4*p*	^{3}D°	1	*38 192.392*
4*s*61*d*	^{1}D	2	49 275.58			2	*38 219.118*
4*s*62*d*	^{1}D	2	49 275.87			3	*38 259.124*
Ca II (^{2}S$_{1/2}$)	***Limit***		**49 305.96**	3*d* 4*p*	^{3}P°	0	*39 333.382*
						1	*39 335.322*
4*s*5*s*	^{3}S	1	31 539.495			2	*39 340.080*
4*s*6*s*	^{3}S	1	40 474.241				
4*s*7*s*	^{3}S	1	43 980.767	3*d* 4*p*	^{1}F°	3	*40 537.893*

Ca I: Ordered by series—Continued

Configuration	Term	J	Level (cm^{-1})
$3d\,4p$	$^1P^{\circ}$	1	*43 933.477*
$3d\,5p$	$^3D^{\circ}$	1	*51 709.5*
		2	*51 734.6*
		3	*51 767.0*
$3d\,5p$	$^3P^{\circ}$	1	*51 908.*
$3d\,5p$	$^1P^{\circ}$	1	*53 100.*
$3d\,6p$	$^3D^{\circ}$	1	*56 254.*
$3d\,7p$	$^3D^{\circ}$	1	*58 798.92*
$3d\,8p$	$^3D^{\circ}$	1	*60 046.13*
$3d\,9p$	$^3D^{\circ}$	1	*60 807.28*
$3d\,10p$	$^3D^{\circ}$	1	*61 306.65*
$3d\,11p$	$^3D^{\circ}$	1	*61 652.25*
$3d\,12p$	$^3D^{\circ}$	1	*61 901.04*
$3d\,13p$	$^3D^{\circ}$	1	*62 084.92*
$3d\,14p$	$^3D^{\circ}$	1	*62 223.68*
$3d\,15p$	$^3D^{\circ}$	1	*62 331.04*
$3d\,16p$	$^3D^{\circ}$	1	*62 416.47*
$3d\,17p$	$^3D^{\circ}$	1	*62 486.45*
$3d\,18p$	$^3D^{\circ}$	1	*62 539.39*
$3d\,19p$	$^3D^{\circ}$	1	*62 587.83*
$3d\,20p$	$^3D^{\circ}$	1	*62 626.03*
$3d\,21p$	$^3D^{\circ}$	1	*62 660.15*
$3d\,22p$	$^3D^{\circ}$	1	*62 686.88*
$3d\,23p$	$^3D^{\circ}$	1	*62 713.24*
$3d\,24p$	$^3D^{\circ}$	1	*62 734.25*
$3d\,25p$	$^3D^{\circ}$	1	*62 753.60*
$3d\,26p$	$^3D^{\circ}$	1	*62 769.47*
$3d\,27p$	$^3D^{\circ}$	1	*62 783.86*
$3d\,28p$	$^3D^{\circ}$	1	*62 797.46*
$3d\,29p$	$^3D^{\circ}$	1	*62 808.51*
$3d\,30p$	$^3D^{\circ}$	1	*62 818.76*
$3d\,31p$	$^3D^{\circ}$	1	*62 827.75*
$3d\,32p$	$^3D^{\circ}$	1	*62 836.22*
$3d\,33p$	$^3D^{\circ}$	1	*62 843.72*
$3d\,34p$	$^3D^{\circ}$	1	*62 850.62*
$3d\,35p$	$^3D^{\circ}$	1	*62 856.56*
$3d\,36p$	$^3D^{\circ}$	1	*62 862.60*
$3d\,37p$	$^3D^{\circ}$	1	*62 867.87*
$3d\,38p$	$^3D^{\circ}$	1	*62 872.69*
$3d\,39p$	$^3D^{\circ}$	1	*62 876.98*
$3d\,40p$	$^3D^{\circ}$	1	*62 881.24*
$3d\,41p$	$^3D^{\circ}$	1	*62 884.77*
$3d\,42p$	$^3D^{\circ}$	1	*62 889.00*
$3d\,43p$	$^3D^{\circ}$	1	*62 891.65*
$3d\,44p$	$^3D^{\circ}$	1	*62 894.65*
$3d\,45p$	$^3D^{\circ}$	1	*62 897.57*
$3d\,46p$	$^3D^{\circ}$	1	*62 900.09*
$3d\,47p$	$^3D^{\circ}$	1	*62 902.75*
$3d\,48p$	$^3D^{\circ}$	1	*62 904.95*
$3d\,49p$	$^3D^{\circ}$	1	*62 906.98*
$3d\,50p$	$^3D^{\circ}$	1	*62 908.88*
$3d\,51p$	$^3D^{\circ}$	1	*62 910.88*
$3d\,52p$	$^3D^{\circ}$	1	*62 912.67*
$3d\,53p$	$^3D^{\circ}$	1	*62 914.47*
$3d\,54p$	$^3D^{\circ}$	1	*62 915.91*
$3d\,55p$	$^3D^{\circ}$	1	*62 917.83*
$3d\,56p$	$^3D^{\circ}$	1	*62 918.80*
$3d\,57p$	$^3D^{\circ}$	1	*62 920.32*
$3d\,58p$	$^3D^{\circ}$	1	*62 921.43*
Ca II ($^2D_{3/2}$)	***Limit***		**62 956.15**
$3d\,6p$	$^3P^{\circ}$	1	*56 532.63*
$3d\,7p$	$^3P^{\circ}$	1	*59 010.87*
$3d\,8p$	$^3P^{\circ}$	1	*60 150.26*
$3d\,9p$	$^3P^{\circ}$	1	*60 869.28*
$3d\,10p$	$^3P^{\circ}$	1	*61 345.74*
$3d\,11p$	$^3P^{\circ}$	1	*61 676.62*
$3d\,12p$	$^3P^{\circ}$	1	*61 916.38*
$3d\,13p$	$^3P^{\circ}$	1	*62 097.08*
$3d\,14p$	$^3P^{\circ}$	1	*62 237.12*
$3d\,15p$	$^3P^{\circ}$	1	*62 351.93*
$3d\,16p$	$^3P^{\circ}$	1	*62 443.64*
$3d\,17p$	$^3P^{\circ}$	1	*62 511.97*
$3d\,18p$	$^3P^{\circ}$	1	*62 584.50*
$3d\,19p$	$^3P^{\circ}$	1	*62 628.76*
$3d\,20p$	$^3P^{\circ}$	1	*62 671.51*
$3d\,21p$	$^3P^{\circ}$	1	*62 711.37*
$3d\,22p$	$^3P^{\circ}$	1	*62 736.10*
$3d\,23p$	$^3P^{\circ}$	1	*62 762.86*
$3d\,24p$	$^3P^{\circ}$	1	*62 787.31*
$3d\,25p$	$^3P^{\circ}$	1	*62 807.90*
$3d\,26p$	$^3P^{\circ}$	1	*62 824.17*
$3d\,27p$	$^3P^{\circ}$	1	*62 838.45*
$3d\,28p$	$^3P^{\circ}$	1	*62 853.79*
$3d\,29p$	$^3P^{\circ}$	1	*62 863.99*
$3d\,30p$	$^3P^{\circ}$	1	*62 875.40*
$3d\,31p$	$^3P^{\circ}$	1	*62 884.77*
$3d\,32p$	$^3P^{\circ}$	1	*62 893.66*
$3d\,33p$	$^3P^{\circ}$	1	*62 901.85*
Ca II ($^2D_{5/2}$)	***Limit***		**63 016.84**
$3d\,6p$	$^1P^{\circ}$	1	*56 651.*
$3d\,7p$	$^1P^{\circ}$	1	*59 197.*
$3d\,8p$	$^1P^{\circ}$	1	*60 300.*
$3d\,9p$	$^1P^{\circ}$	1	*60 973.6*
$3d\,10p$	$^1P^{\circ}$	1	*61 428.1*
$3d\,11p$	$^1P^{\circ}$	1	*61 747.2*
$3d\,12p$	$^1P^{\circ}$	1	*61 980.49*
$3d\,13p$	$^1P^{\circ}$	1	*62 154.62*
$3d\,14p$	$^1P^{\circ}$	1	*62 288.02*
$3d\,15p$	$^1P^{\circ}$	1	*62 392.01*
$3d\,16p$	$^1P^{\circ}$	1	*62 478.26*
$3d\,17p$	$^1P^{\circ}$	1	*62 548.16*
$3d\,18p$	$^1P^{\circ}$	1	*62 602.72*
$3d\,19p$	$^1P^{\circ}$	1	*62 648.37*
$3d\,20p$	$^1P^{\circ}$	1	*62 690.32*
$3d\,21p$	$^1P^{\circ}$	1	*62 721.80*
$3d\,22p$	$^1P^{\circ}$	1	*62 750.58*
$3d\,23p$	$^1P^{\circ}$	1	*62 774.75*
$3d\,24p$	$^1P^{\circ}$	1	*62 795.55*
$3d\,25p$	$^1P^{\circ}$	1	*62 814.13*
$3d\,26p$	$^1P^{\circ}$	1	*62 830.67*

Ca I: Ordered by series—Continued

Configuration	Term	J	Level (cm^{-1})
3d 27p	$^1P^\circ$	1	*62 845.27*
3d 28p	$^1P^\circ$	1	*62 858.11*
3d 29p	$^1P^\circ$	1	*62 869.38*
3d 30p	$^1P^\circ$	1	*62 879.48*
3d 31p	$^1P^\circ$	1	*62 889.00*
3d 32p	$^1P^\circ$	1	*62 897.57*
3d 33p	$^1P^\circ$	1	*62 904.95*
3d 34p	$^1P^\circ$	1	*62 911.51*
3d 35p	$^1P^\circ$	1	*62 917.83*
3d 36p	$^1P^\circ$	1	*62 923.62*
3d 37p	$^1P^\circ$	1	*62 928.81*
3d 38p	$^1P^\circ$	1	*62 933.61*
3d 39p	$^1P^\circ$	1	*62 938.02*
3d 40p	$^1P^\circ$	1	*62 942.10*
3d 41p	$^1P^\circ$	1	*62 945.88*
3d 42p	$^1P^\circ$	1	*62 949.34*
3d 43p	$^1P^\circ$	1	*62 952.58*
3d 44p	$^1P^\circ$	1	*62 955.57*
3d 45p	$^1P^\circ$	1	*62 958.38*
3d 46p	$^1P^\circ$	1	*62 961.01*
3d 47p	$^1P^\circ$	1	*62 963.43*
3d 48p	$^1P^\circ$	1	*62 965.72*
3d 49p	$^1P^\circ$	1	*62 967.84*
3d 50p	$^1P^\circ$	1	*62 969.89*
3d 51p	$^1P^\circ$	1	*62 971.78*
3d 52p	$^1P^\circ$	1	*62 973.55*
3d 53p	$^1P^\circ$	1	*62 975.23*
3d 54p	$^1P^\circ$	1	*62 976.81*
3d 55p	$^1P^\circ$	1	*62 978.26*
3d 56p	$^1P^\circ$	1	*62 979.72*
3d 57p	$^1P^\circ$	1	*62 981.03*
3d 58p	$^1P^\circ$	1	*62 982.35*
3d 59p	$^1P^\circ$	1	*62 983.48*
3d 60p	$^1P^\circ$	1	*62 984.63*
3d 61p	$^1P^\circ$	1	*62 985.70*
Ca II ($^2D_{5/2}$)	***Limit***		**63 016.84**
$4p^2$	^3P	0	38 417.543
		1	38 464.808
		2	38 551.558
$4p^2$	^1D	2	40 719.847
$4p^2$	^1S	0	41 786.276
*****	***	*	*******
4s4f	$^3F^\circ$	2	*42 170.214*
		3	*42 170.558*
		4	*42 171.026*
4s5f	$^3F^\circ$	2	*44 762.620*
		3	*44 762.839*
		4	*44 763.118*
4s6f	$^3F^\circ$	2	*46 164.644*
		3	*46 164.785*
		4	*46 164.971*
4s7f	$^3F^\circ$	2	*47 006.194*
		3	*47 006.280*
		4	*47 006.400*
4s8f	$^3F^\circ$	2	*47 550.214*
		3	*47 550.271*
		4	*47 550.371*
4s9f	$^3F^\circ$	2	*47 921.87*
		3	*47 921.981*
		4	*47 922.033*
4s10f	$^3F^\circ$	2	*48 187.045*
		3	*48 187.075*
		4	*48 187.118*
4s11f	$^3F^\circ$	2	*48 382.70*
		3	*48 382.781*
		4	*48 382.801*
4s12f	$^3F^\circ$	3,4	*48 531.04*
4s13f	$^3F^\circ$	4	*48 646.38*
Ca II ($^2S_{1/2}$)	***Limit***		**49 305.96**
4s4f	$^1F^\circ$	3	*42 343.587*
4s5f	$^1F^\circ$	3	*44 804.878*
4s6f	$^1F^\circ$	3	*46 182.399*
4s7f	$^1F^\circ$	3	*47 015.141*
4s8f	$^1F^\circ$	3	*47 555.23*
4s9f	$^1F^\circ$	3	*47 924.947*
4s10f	$^1F^\circ$	3	*48 188.990*
4s11f	$^1F^\circ$	3	*48 384.039*
4s12f	$^1F^\circ$	3	*48 532.139*
4s13f	$^1F^\circ$	3	*48 647.30*
4s14f	$^1F^\circ$	3	*48 738.54*
4s15f	$^1F^\circ$	3	*48 812.09*
4s16f	$^1F^\circ$	3	*48 872.20*
4s17f	$^1F^\circ$	3	*48 921.95*
4s18f	$^1F^\circ$	3	*48 963.67*
4s19f	$^1F^\circ$	3	*48 998.89*
4s20f	$^1F^\circ$	3	*49 028.93*
4s21f	$^1F^\circ$	3	*49 054.80*
4s22f	$^1F^\circ$	3	*49 077.20*
4s23f	$^1F^\circ$	3	*49 096.74*
4s24f	$^1F^\circ$	3	*49 113.85*
4s25f	$^1F^\circ$	3	*49 129.00*
4s26f	$^1F^\circ$	3	*49 142.38*
4s27f	$^1F^\circ$	3	*49 154.29*
4s28f	$^1F^\circ$	3	*49 164.99*
Ca II ($^2S_{1/2}$)	***Limit***		**49 305.96**
$3d^2$	^3F	2	43 474.827
		3	43 489.119
		4	43 508.088

Ca I: Ordered by series—Continued

Configuration	Term	J	Level (cm⁻¹)	Configuration	Term	J	Level (cm⁻¹)
$3d^2$	^{3}P	0	48 524.093	3d 26f	^{3}D°	1	*62 790.08*
		1	48 537.623	3d 28f	^{3}D°	1	*62 812.00*
		2	48 563.522	3d 30f	^{3}D°	1	*62 832.31*
				Ca II ($^2D_{3/2}$)	*Limit*		**62 956.15**
*****	***	*	*******				
				3d4f	^{3}P°	1	*55 946.6*
3d 5s	^{1}D	2	47 449.083	3d5f	^{3}P°	1	*58 491.91*
				3d6f	^{3}P°	1	*59 862.26*
3d 5s	^{3}D	1	47 456.452	3d7f	^{3}P°	1	*60 690.27*
		2	47 466.014	3d8f	^{3}P°	1	*61 228.65*
		3	47 475.915	3d9f	^{3}P°	1	*61 596.69*
				3d 10f	^{3}P°	1	*61 859.22*
*****	***	*	*******	3d 11f	^{3}P°	1	*62 052.49*
				3d 12f	^{3}P°	1	*62 198.92*
3d 4d	^{3}D	1	51 351.74	3d 13f	^{3}P°	1	*62 312.63*
		2	51 369.88	3d 14f	^{3}P°	1	*62 403.22*
		3	51 396.32	3d 15f	^{3}P°	1	*62 472.14*
				3d 16f	^{3}P°	1	*62 533.90*
3d 4d	^{3}S	1	51 571.7	3d 17f	^{3}P°	1	*62 578.91*
				3d 18f	^{3}P°	1	*62 617.02*
3d 4d	^{3}P	0	54 282.3	3d 19f	^{3}P°	1	*62 653.99*
		1	54 288.74	3d 20f	^{3}P°	1	*62 683.89*
		2	54 304.6	3d 21f	^{3}P°	1	*62 707.25*
				3d 22f	^{3}P°	1	*62 729.19*
3d 5d	^{3}D	2	56 469.0	3d 23f	^{3}P°	1	*62 748.53*
				3d 24f	^{3}P°	1	*62 764.10*
3d 5d	^{3}S	1	56 558.9	3d 25f	^{3}P°	1	*62 780.30*
				3d 26f	^{3}P°	1	*62 794.19*
3d 5d	^{3}P	0	57 611.2	3d 27f	^{3}P°	1	*62 806.02*
		1	57 617.9	3d 28f	^{3}P°	1	*62 816.51*
		2	57 638.4	3d 29f	^{3}P°	1	*62 824.17*
				3d 30f	^{3}P°	1	*62 834.11*
3d 6d	^{3}P	1	59 368.	3d 31f	^{3}P°	1	*62 840.23*
		2	59 391.	3d 32f	^{3}P°	1	*62 848.77*
				3d 33f	^{3}P°	1	*62 853.79*
*****	***	*	*******	3d 34f	^{3}P°	1	*62 861.06*
				3d 35f	^{3}P°	1	*62 865.39*
3d4f	^{3}D°	1	*55 902.8*	3d 36f	^{3}P°	1	*62 871.46*
3d5f	^{3}D°	1	*58 431.31*	3d 37f	^{3}P°	1	*62 875.40*
3d6f	^{3}D°	1	*59 802.21*	3d 38f	^{3}P°	1	*62 880.04*
3d7f	^{3}D°	1	*60 632.18*				
3d8f	^{3}D°	1	*61 172.54*	Ca II ($^2D_{3/2}$)	*Limit*		**62 956.15**
3d9f	^{3}D°	1	*61 543.95*				
3d 10f	^{3}D°	1	*61 810.68*	3d4f	^{1}P°	1	*55 982.3*
3d 11f	^{3}D°	1	*62 009.17*	3d5f	^{1}P°	1	*58 505.89*
3d 12f	^{3}D°	1	*62 161.61*	3d6f	^{1}P°	1	*59 878.52*
3d 13f	^{3}D°	1	*62 279.33*	3d7f	^{1}P°	1	*60 709.54*
3d 14f	^{3}D°	1	*62 375.29*	3d8f	^{1}P°	1	*61 251.39*
3d 15f	^{3}D°	1	*62 453.85*	3d9f	^{1}P°	1	*61 622.60*
3d 16f	^{3}D°	1	*62 520.06*	3d 10f	^{1}P°	1	*61 888.22*
3d 17f	^{3}D°	1	*62 565.68*	3d 11f	^{1}P°	1	*62 084.92*
3d 18f	^{3}D°	1	*62 610.75*	3d 12f	^{1}P°	1	*62 234.47*
3d 19f	^{3}D°	1	*62 641.52*	3d 13f	^{1}P°	1	*62 346.47*
3d 20f	^{3}D°	1	*62 675.56*	3d 14f	^{1}P°	1	*62 433.38*
3d 21f	^{3}D°	1	*62 704.43*	3d 15f	^{1}P°	1	*62 506.62*
3d 22f	^{3}D°	1	*62 720.41*	3d 16f	^{1}P°	1	*62 572.66*
3d 23f	^{3}D°	1	*62 743.11*	3d 17f	^{1}P°	1	*62 625.37*
3d 24f	^{3}D°	1	*62 768.10*	3d 18f	^{1}P°	1	*62 671.51*

Ca I: Ordered by series—Continued

Configuration	Term	J	Level (cm^{-1})
$3d\,19f$	$^1P^\circ$	1	*62 704.43*
$3d\,20f$	$^1P^\circ$	1	*62 736.10*
$3d\,21f$	$^1P^\circ$	1	*62 762.86*
$3d\,22f$	$^1P^\circ$	1	*62 785.02*
$3d\,23f$	$^1P^\circ$	1	*62 804.38*
$3d\,24f$	$^1P^\circ$	1	*62 820.31*
$3d\,25f$	$^1P^\circ$	1	*62 836.85*
$3d\,26f$	$^1P^\circ$	1	*62 852.33*
$3d\,35f$	$^1P^\circ$	1	*62 926.36*
$3d\,36f$	$^1P^\circ$	1	*62 931.29*
$3d\,37f$	$^1P^\circ$	1	*62 935.88*
$3d\,38f$	$^1P^\circ$	1	*62 939.79*
$3d\,39f$	$^1P^\circ$	1	*62 943.85*
Ca II ($^2D_{5/2}$)	***Limit***		**63 016.84**
$4p5s$	$^3P^\circ$	1	*57 462.*
$4p5s$	$^1P^\circ$	1	*57 960.*
*****	***	*	*******
$4p4d$	$^3D^\circ$?	1	*62 552.97*
$4p4d$	$^3P^\circ$?	1	*62 557.45*
$4p4d$	$^1P^\circ$?	1	*62 561.72*
*****	***	*	*******
		1	*62 878.40*
		1	*62 886.45*
*****	***	*	*******
$3p^5\,4s^2\,3d$	$^3P^\circ$	1	*200 096*
$3p^5\,4s^2\,3d$	$^3D^\circ$	1	*218 991*
$3p^5\,4s^2\,3d$	$^1P^\circ$	1	*253 310*
$3p^5\,4s^2\,4d$	$^3P^\circ$	1	*255 022*
$3p^5\,4s^2\,4d$	$^3D^\circ$	1	*267 956*
$3p^5\,4s^2\,4d$	$^1P^\circ$	1	*270 640*
$3p^5(^2P^\circ_{3/2})4s^2\,5s$	$^2[3/2]^\circ$	1	*257 737*
$3p^5(^2P^\circ_{3/2})4s^2\,6s$	$^2[3/2]^\circ$	1	*267 417*
$3p^5(^2P^\circ_{3/2})4s^2\,7s$	$^2[3/2]^\circ$	1	*271 245*
$3p^5(^2P^\circ_{3/2})4s^2\,9s$	$^2[3/2]^\circ$	1	*274 276*
$3p^5(^2P^\circ_{3/2})4s^2\,10s$	$^2[3/2]^\circ$	1	*274 777*
Ca II $3p^54s^2\,^2P^\circ_{3/2}$	***Limit***		**276 750**
$3p^5(^2P^\circ_{1/2})4s^2\,5s$	$^2[1/2]^\circ$	1	*260 193*
$3p^5(^2P^\circ_{1/2})4s^2\,6s$	$^2[1/2]^\circ$	1	*269 706*
$3p^5(^2P^\circ_{1/2})4s^2\,7s$	$^2[1/2]^\circ$	1	*273 598*
$3p^5(^2P^\circ_{1/2})4s^2\,11s$	$^2[1/2]^\circ$	1	*277 991*
$3p^5(^2P^\circ_{1/2})4s^2\,12s$	$^2[1/2]^\circ$	1	*278 302*
$3p^5(^2P^\circ_{1/2})4s^2\,13s$	$^2[1/2]^\circ$	1	*278 534*
$3p^5(^2P^\circ_{1/2})4s^2\,14s$	$^2[1/2]^\circ$	1	*278 702*
Ca II $3p^54s^2\,^2P^\circ_{1/2}$	***Limit***		**279 530**
$3p^5(^2P^\circ_{3/2})4s^2\,5d$	$^2[3/2]^\circ$	1	*270 889*
$3p^5(^2P^\circ_{3/2})4s^2\,6d$	$^2[3/2]^\circ$	1	*273 134*
$3p^5(^2P^\circ_{3/2})4s^2\,7d$	$^2[3/2]^\circ$	1	*273 959*
$3p^5(^2P^\circ_{3/2})4s^2\,8d$	$^2[3/2]^\circ$	1	*274 652*
$3p^5(^2P^\circ_{3/2})4s^2\,9d$	$^2[3/2]^\circ$	1	*275 272*
$3p^5(^2P^\circ_{3/2})4s^2\,10d$	$^2[3/2]^\circ$	1	*275 503*
$3p^5(^2P^\circ_{3/2})4s^2\,11d$	$^2[3/2]^\circ$	1	*275 726*
$3p^5(^2P^\circ_{3/2})4s^2\,12d$	$^2[3/2]^\circ$	1	*275 898*
$3p^5(^2P^\circ_{3/2})4s^2\,13d$	$^2[3/2]^\circ$	1	*276 028*
$3p^5(^2P^\circ_{3/2})4s^2\,14d$	$^2[3/2]^\circ$	1	*276 138*
$3p^5(^2P^\circ_{3/2})4s^2\,15d$	$^2[3/2]^\circ$	1	*276 214*
$3p^5(^2P^\circ_{3/2})4s^2\,16d$	$^2[3/2]^\circ$	1	*276 283*
Ca II $3p^54s^2\,^2P^\circ_{3/2}$	***Limit***		**276 750**
$3p^5(^2P^\circ_{1/2})4s^2\,5d$	$^2[3/2]^\circ$	1	*274 040*
$3p^5(^2P^\circ_{1/2})4s^2\,7d$	$^2[3/2]^\circ$	1	*276 631*
$3p^5(^2P^\circ_{1/2})4s^2\,8d$	$^2[3/2]^\circ$	1	*277 430*
$3p^5(^2P^\circ_{1/2})4s^2\,9d$	$^2[3/2]^\circ$	1	*277 917*
$3p^5(^2P^\circ_{1/2})4s^2\,10d$	$^2[3/2]^\circ$	1	*278 228*
$3p^5(^2P^\circ_{1/2})4s^2\,11d$	$^2[3/2]^\circ$	1	*278 469*
$3p^5(^2P^\circ_{1/2})4s^2\,12d$	$^2[3/2]^\circ$	1	*278 647*
$3p^5(^2P^\circ_{1/2})4s^2\,13d$	$^2[3/2]^\circ$	1	*278 796*
$3p^5(^2P^\circ_{1/2})4s^2\,14d$	$^2[3/2]^\circ$	1	*278 900*
$3p^5(^2P^\circ_{1/2})4s^2\,15d$	$^2[3/2]^\circ$	1	*278 983*
$3p^5(^2P^\circ_{1/2})4s^2\,16d$	$^2[3/2]^\circ$	1	*279 050*
$3p^5(^2P^\circ_{1/2})4s^2\,17d$	$^2[3/2]^\circ$	1	*279 117*
Ca II $3p^54s^2\,^2P^\circ_{1/2}$	***Limit***		**279 530**

Ca II

$Z = 20$

K I isoelectronic sequence

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

Ionization energy = 95 751.87 ± 0.03 (11.87181 ± .000004 eV)

The strong resonance doublet of this spectrum, the Fraunhofer H and K lines, is used to measure the velocity of recession of galaxies in the farthest reaches of space and thereby provides us with the dimensions and age of the universe.

The analysis in its present state was nearly completed by Saunders and Russell (1925). The spectrum was re-observed between 3000 and 12 000 Å by Edlén and Risberg (1956), who recalculated the level values from their new grating measurements and the interferometric measurements of Wagman (1937) and found the 5*g*, 9*s*, and 10*s* terms. G. Risberg (1968) added 10*d*, 8*f*, 8*h*, and 10*h* and revised the $6p\ {}^2P^\circ_{1/2}$ level.

The 9–10*f* and 11–16*d* terms are derived from unpublished observations of Shenstone (1930) in the region 2890 to 3220 Å.

Edlén and Risberg derived the quoted ionization energy from the *ng* series.

The $3p^5 4s^2\ {}^2P^\circ$ term was obtained from the limit of the $3p^5 4s^2 ns$ and *nd* series in Ca I by Mansfield and Newsom (1977).

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Ca II

Configuration	Term	J	Level (cm⁻¹)
$3p^6(^1S_0)4s$	^2S	1/2	0.00
$3p^6(^1S_0)3d$	^2D	3/2	13 650.19
		5/2	13 710.88
$3p^6(^1S_0)4p$	$^2P^\circ$	1/2	*25 191.51*
		3/2	*25 414.40*
$3p^6(^1S_0)5s$	^2S	1/2	52 166.93
$3p^6(^1S_0)4d$	^2D	3/2	56 839.25
		5/2	56 858.46
$3p^6(^1S_0)5p$	$^2P^\circ$	1/2	*60 533.02*
		3/2	*60 611.28*
$3p^6(^1S_0)4f$	$^2F^\circ$	5/2,7/2	*68 056.91*
$3p^6(^1S_0)6s$	^2S	1/2	70 677.62
$3p^6(^1S_0)5d$	^2D	3/2	72 722.23
		5/2	72 730.93
$3p^6(^1S_0)6p$	$^2P^\circ$	1/2	*74 484.92*
		3/2	*74 521.75*
$3p^6(^1S_0)5f$	$^2F^\circ$	5/2,7/2	*78 034.39*
$3p^6(^1S_0)5g$	^2G	7/2,9/2	78 164.72
$3p^6(^1S_0)7s$	^2S	1/2	79 448.28
$3p^6(^1S_0)6d$	^2D	3/2	80 521.53
		5/2	80 526.16
$3p^6(^1S_0)6f$	$^2F^\circ$	5/2,7/2	*83 458.08*
$3p^6(^1S_0)6g$	^2G	7/2,9/2	83 540.00
$3p^6(^1S_0)8s$	^2S	1/2	84 300.89
$3p^6(^1S_0)7d$	^2D	3/2	84 933.65
		5/2	84 936.41
$3p^6(^1S_0)7f$	$^2F^\circ$	5/2,7/2	*86 727.06*
$3p^6(^1S_0)7g$	^2G	7/2,9/2	86 781.14
$3p^6(^1S_0)9s$	^2S	1/2	87 267.86
$3p^6(^1S_0)8d$	^2D	3/2	87 671.93
		5/2	87 673.72
$3p^6(^1S_0)8f$	$^2F^\circ$	5/2,7/2	*88 847.31*
$3p^6(^1S_0)8g$	^2G	7/2,9/2	88 884.54
$3p^6(^1S_0)8h$	$^2H^\circ$	9/2,11/2	*88 890.64*

Ca II—Continued

Configuration	Term	J	Level (cm^{-1})	Configuration	Term	J	Level (cm^{-1})
$3p^6(^1S_0)10s$	^2S	$\frac{1}{2}$	89 214.13	$3p^6(^1S_0)11d$	^2D	$\frac{3}{2},\frac{5}{2}$	91 672.0
$3p^6(^1S_0)9d$	^2D	$\frac{3}{2}$	89 487.93	$3p^6(^1S_0)12d$	^2D	$\frac{3}{2},\frac{5}{2}$	92 359.0
		$\frac{5}{2}$	89 489.13	$3p^6(^1S_0)13d$	^2D	$\frac{3}{2},\frac{5}{2}$	92 883.0
$3p^6(^1S_0)9f$	$^2F^\circ$	$\frac{5}{2},\frac{7}{2}$	*90 300.0*	$3p^6(^1S_0)14d$	^2D	$\frac{3}{2},\frac{5}{2}$	93 297.6
$3p^6(^1S_0)9g$	^2G	$\frac{7}{2},\frac{9}{2}$	90 326.45	$3p^6(^1S_0)15d$	^2D	$\frac{3}{2},\frac{5}{2}$	93 626.9
$3p^6(^1S_0)10d$	^2D	$\frac{3}{2}$	90 753.92				
		$\frac{5}{2}$	90 754.80	$3p^6(^1S_0)16d$	^2D	$\frac{3}{2},\frac{5}{2}$	93 894.5
$3p^6(^1S_0)10f$	$^2F^\circ$	$\frac{5}{2},\frac{7}{2}$	*91 338.0*	Ca III ($^1S_0$)	*Limit*		95 751.87
$3p^6(^1S_0)10h$	$^2H^\circ$	$\frac{9}{2},\frac{11}{2}$	*91 361.00*	$3p^5\,4s^2$	$^2P^\circ$	$\frac{3}{2}$	*227 444*
						$\frac{1}{2}$	*230 224*

Ca III

Z = 20

Ar I isoelectronic sequence

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

Ionization energy = 410 642 ± 2 cm^{-1} (50.9135 ± .0002 eV)

The first observations and analysis of Ca III were carried out by Bowen (1928). He measured the spectrum in the range 400–4000 Å and determined levels in the configurations $3p^5 3d$, $4d$, $4s$, $4p$, and $5s$. A much more extensive analysis has since been completed by Borgström (1968, 1971), who has remeasured the spectrum from 440 to 9640 Å. His designations and level values are given here. He has also determined the ionization energy from the ng series.

Hansen, Persson, and Borgström (1975) found the $3s3p^6 3d$ configuration, which strongly interacts with the $3p^5 nf$ series, and added two levels to $3p^5 6p$. They reported the percentage compositions given here for the $3s^2 3p^5 5p$, $6p$, $4f$, $5f$, $6f$ and $3s3p^6 3d$ configurations. The percentages for $3p^5 4p$ in LS coupling are from Borgström (1971).

The two ${}^1P^\circ_1$ levels from $3s3p^6 4p$ and $5p$ were determined by Kastner, Crooker, Behring, and Cohen (1977).

Schmitz, Breuckmann, and Mehlhorn (1976) reported the discovery of $3p^4 4s^2$ but their identification has been shown by Pejcev, Ottley, Rassi and Ross (1978) to be incorrect.

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Ca III

Configuration	Term	J	Level (cm^{-1})	Leading percentages
$3s^2 3p^6$	^1S	0	0.00	
$3s^2 3p^5 3d$	$^3P^\circ$	0	*203 373.22*	
		1	*203 851.95*	
		2	*204 842.64*	
$3s^2 3p^5 3d$	$^3F^\circ$	4	*212 310.04*	
		3	*213 379.40*	
		2	*214 334.06*	
$3s^2 3p^5 3d$	$^1D^\circ$	2	*225 826.22*	
$3s^2 3p^5 3d$	$^3D^\circ$	3	*226 333.56*	
		2	*227 388.56*	
		1	*227 432.11*	
$3s^2 3p^5 3d$	$^1F^\circ$	3	*228 413.95*	
$3s^2 3p^5 4s$	$^3P^\circ$	2	*242 547.19*	
		1	*243 930.44*	
		0	*245 611.88*	
$3s^2 3p^5 4s$	$^1P^\circ$	1	*247 696.39*	
$3s^2 3p^5 4p$	^3S	1	272 188.70	98

Ca III—Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages		
$3s^2 3p^5 4p$	^{3}D	3	277 022.40	100		
		2	277 380.86	77		
		1	278 621.01	83		
$3s^2 3p^5 3d$	^{1}P°	1	*279 353.64*			
$3s^2 3p^5 4p$	^{1}D	2	279 741.80	57		
$3s^2 3p^5 4p$	^{1}P	1	281 139.55	57		
$3s^2 3p^5 4p$	^{3}P	2	281 882.24	63		
		0	282 075.15	98		
		1	282 571.43	64		
$3s^2 3p^5 4p$	^{1}S	0	290 934.30	98		
$3s^2 3p^5 4d$	^{3}P°	0	*322 663.28*			
		1	*323 003.56*			
		2	*323 655.06*			
$3s^2 3p^5 4d$	^{3}F°	4	*324 110.24*			
		3	*324 660.47*			
		2	*325 467.67*			
$3s^2 3p^5 4d$	^{1}F°	3	*326 186.32*			
$3s^2 3p^5 (^2P^\circ_{3/2}) 5s$	$^2[3/2]^\circ$	2	*327 922.87*			
		1	*328 582.45*			
$3s^2 3p^5 4d$	^{3}D°	1	*327 962.11*			
		3	*328 588.76*			
		2	*328 606.78*			
$3s^2 3p^5 4d$	^{1}D°	2	*328 090.99*			
$3s^2 3p^5 (^2P^\circ_{1/2}) 5s$	$^2[1/2]^\circ$	0	*331 048.86*			
		1	*331 403.20*			
$3s^2 3p^5 4d$	^{1}P°	1	*336 749.11*			
$3s^2 3p^5 (^2P^\circ_{3/2}) 5p$	$^2[1/2]$	1	339 198.09	91	9	$(^2P^\circ_{1/2})\ ^2[1/2]$
		0	343 110.24	75	25	
$3s^2 3p^5 (^2P^\circ_{3/2}) 5p$	$^2[5/2]$	3	340 580.15	100		
		2	340 748.72	90	8	$(^2P^\circ_{3/2})\ ^2[3/2]$
$3s^2 3p^5 (^2P^\circ_{3/2}) 5p$	$^2[3/2]$	1	341 349.19	96	4	$(^2P^\circ_{1/2})\ ^2[3/2]$
		2	341 601.46	90	9	$(^2P^\circ_{3/2})\ ^2[5/2]$
$3s^2 3p^5 (^2P^\circ_{1/2}) 5p$	$^2[3/2]$	1	343 784.96	95	4	$(^2P^\circ_{3/2})\ ^2[3/2]$
		2	344 149.81	97		
$3s^2 3p^5 (^2P^\circ_{1/2}) 5p$	$^2[1/2]$	1	344 257.92	90	9	$(^2P^\circ_{3/2})\ ^2[1/2]$
		0	346 692.34	75	25	
$3s^2 3p^5 (^2P^\circ_{3/2}) 4f$	$^2[3/2]$	1	346 732.19	99		
		2	346 896.26	90	8	$(^2P^\circ_{3/2})\ ^2[5/2]$

Ca III—Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages		
$3s^2 3p^5(^2P^\circ_{3/2})4f$	$^2[9/2]$	5	347 344.37	100		
		4	347 383.51	100		
$3s^2 3p^5(^2P^\circ_{3/2})4f$	$^2[5/2]$	3	347 417.05	93	6	$(^2P^\circ_{1/2})\ ^2[5/2]$
		2	347 758.22	88	9	$(^2P^\circ_{3/2})\ ^2[3/2]$
$3s^2 3p^5(^2P^\circ_{3/2})4f$	$^2[7/2]$	3	348 028.13	97		
		4	348 051.86	97		
$3s^2 3p^5(^2P^\circ_{1/2})4f$	$^2[5/2]$	3	350 741.19	93	7	$(^2P^\circ_{3/2})\ ^2[5/2]$
		2	350 900.04	96	4	$(^2P^\circ_{3/2})\ ^2[5/2]$
$3s^2 3p^5(^2P^\circ_{1/2})4f$	$^2[7/2]$	3	350 779.47	97		
		4	350 805.32	98		
$3s^2 3p^5(^2P^\circ_{3/2})5d$	$^2[1/2]^\circ$	0	*358 940.91*			
		1	*359 156.83*			
$3s^2 3p^5(^2P^\circ_{3/2})5d$	$^2[3/2]^\circ$	2	*359 520.60*			
		1	*361 794.08*			
$3s^2 3p^5(^2P^\circ_{3/2})5d$	$^2[7/2]^\circ$	4	*359 543.08*			
		3	*359 800.57*			
$3s^2 3p^5(^2P^\circ_{3/2})5d$	$^2[5/2]^\circ$	2	*360 207.16*			
		3	*360 388.68*			
$3s^2 3p^5(^2P^\circ_{3/2})6s$	$^2[3/2]^\circ$	2	*361 154.07*			
		1	*361 353.31*			
$3s^2 3p^5(^2P^\circ_{1/2})5d$	$^2[5/2]^\circ$	2	*362 893.47*			
		3	*363 118.75*			
$3s^2 3p^5(^2P^\circ_{1/2})5d$	$^2[3/2]^\circ$	2	*363 021.27*			
		1	*365 363.88*			
$3s^2 3p^5(^2P^\circ_{1/2})6s$	$^2[1/2]^\circ$	0	*364 229.89*			
		1	*364 343.85*			
$3s3p^6 3d$	^3D	1	366 778.85	65	31	$3p^5(^2P^\circ_{3/2})5f\ ^2[3/2]$
		2	366 926.33	55	17	$3p^5(^2P^\circ_{3/2})6p\ ^2[5/2]$
		3	367 472.91	53	24	$3p^5(^2P^\circ_{3/2})6p\ ^2[5/2]$
$3s^2 3p^5(^2P^\circ_{3/2})6p$	$^2[5/2]$	3	367 026.65	75	18	$3s3p^6 3d\ ^3D$
$3s^2 3p^5(^2P^\circ_{3/2})5f$	$^2[9/2]$	5	370 141.77	100		
		4	370 172.43	100		
$3s^2 3p^5(^2P^\circ_{3/2})5f$	$^2[5/2]$	2	370 304.54?	58	34	$3p^5(^2P^\circ_{3/2})5f\ ^2[3/2]$
		3	371 059.95?	80	17	$3s3p^6 3d\ ^3D$
$3s^2 3p^5(^2P^\circ_{1/2})6p$	$^2[3/2]$	2	370 454.04	93	6	$3p^5(^2P^\circ_{3/2})5f\ ^2[5/2]$
$3s^2 3p^5(^2P^\circ_{3/2})5f$	$^2[7/2]$	3	370 515.86	99		
		4	370 533.07	99		
$3s^2 3p^5(^2P^\circ_{3/2})5g$	$^2[5/2]^\circ$	2	*370 901.88*			
		3	*370 903.12*			

Ca III—Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages		
$3s^2 3p^5(^2P^\circ_{3/2})5g$	$^2[11/2]^\circ$	6	*370 957.52*			
		5	*370 957.65*			
$3s^2 3p^5(^2P^\circ_{3/2})5g$	$^2[7/2]^\circ$	3	*371 061.30*			
		4	*371 061.37*			
$3s^2 3p^5(^2P^\circ_{3/2})5g$	$^2[9/2]^\circ$	4	*371 120.69*			
		5	*371 121.06*			
$3s^2 3p^5(^2P^\circ_{3/2})5f$	$^2[3/2]$	2	371 274.48?	42	29	$3p^5(^2P^\circ_{3/2})5f\ ^2[5/2]$
		1	371 447.58?	67	31	$3s3p^6 3d\ ^3D$
$3s^2 3p^5(^2P^\circ_{1/2})5f$	$^2[7/2]$	3	373 401.87	99		
		4	373 425.51	99		
$3s^2 3p^5(^2P^\circ_{1/2})5f$	$^2[5/2]$	2	373 626.85	92	4	$3s3p^6 3d\ ^3D$
		3	373 880.37	91	9	
$3s^2 3p^5(^2P^\circ_{1/2})5g$	$^2[9/2]^\circ$	4	*374 138.90*			
		5	*374 139.31*			
$3s^2 3p^5(^2P^\circ_{1/2})5g$	$^2[7/2]^\circ$	4	*374 143.44*			
		3	*374 143.84*			
$3s^2 3p^5(^2P^\circ_{3/2})6d$	$^2[7/2]^\circ$	4	*376 808.60*			
		3	*376 883.36*			
$3s3p^6 3d$	^1D	2	377 168.1	93		
$3s^2 3p^5(^2P^\circ_{3/2})6d$	$^2[5/2]^\circ$	2	*380 152.21*			
		3	*380 230.50*			
$3s^2 3p^5(^2P^\circ_{3/2})6g$	$^2[9/2]^\circ$	5	*382 190.20*			
		4	*383 189.82*			
$3s^2 3p^5(^2P^\circ_{3/2})6f$	$^2[9/2]$	5	382 565.1	100		
		4	382 587.9	100		
$3s^2 3p^5(^2P^\circ_{3/2})6f$	$^2[7/2]$	3	382 784.7	100		
		4	382 798.5	99		
$3s^2 3p^5(^2P^\circ_{3/2})6f$	$^2[5/2]$	3	382 791.5	99		
		2	382 852.3	79	19	$(^2P^\circ_{3/2})\ ^2[3/2]$
$3s^2 3p^5(^2P^\circ_{3/2})6g$	$^2[5/2]^\circ$	2	*383 061.33*			
		3	*383 063.78*			
$3s^2 3p^5(^2P^\circ_{3/2})6g$	$^2[11/2]^\circ$	6	*383 094.79*			
		5	*383 095.10*			
$3s^2 3p^5(^2P^\circ_{3/2})6g$	$^2[7/2]^\circ$	4	*383 156.51*			
		3	*383 157.11*			
$3s^2 3p^5(^2P^\circ_{1/2})6f$	$^2[7/2]$	3	385 757.6	100		
		4	385 775.5	100		
$3s^2 3p^5(^2P^\circ_{1/2})6f$	$^2[5/2]$	3	385 867.2	99		
		2	385 906.9	99		

Ca III—Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages
$3s^2 3p^5(^2P^\circ_{1/2})6g$	$^2[9/2]^\circ$	4	*386 248.39*	
		5	*386 248.68*	
$3s^2 3p^5(^2P^\circ_{1/2})6g$	$^2[7/2]^\circ$	4	*386 249.78*	
		3	*386 250.31*	
$3s^2 3p^5(^2P^\circ_{3/2})7f$	$^2[9/2]$	5	390 054.0	
$3s^2 3p^5(^2P^\circ_{3/2})7f$	$^2[7/2]$	4	390 207.6	
$3s^2 3p^5(^2P^\circ_{3/2})7g$	$^2[5/2]^\circ$	3	*390 392.62*	
$3s^2 3p^5(^2P^\circ_{3/2})7g$	$^2[11/2]^\circ$	6	*390 411.58*	
		5	*390 411.99*	
$3s^2 3p^5(^2P^\circ_{3/2})7g$	$^2[7/2]^\circ$	3	*390 451.97*	
$3s^2 3p^5(^2P^\circ_{3/2})7g$	$^2[9/2]^\circ$	4	*390 471.79*	
		5	*390 472.32*	
$3s^2 3p^5(^2P^\circ_{1/2})7f$	$^2[7/2]$	4	393 224.9	
$3s^2 3p^5(^2P^\circ_{1/2})7g$	$^2[9/2]^\circ$	5	*393 551.86*	
		4	*393 561.59*	
$3s^2 3p^5(^2P^\circ_{1/2})7g$	$^2[7/2]^\circ$	4	*393 552.31*	
		3	*393 552.81*	
Ca IV ($^2P^\circ_{3/2}$)	***Limit***		**410 642**	
$3s3p^6 4p$	$^1P^\circ$	1	*431 100*	
$3s3p^6 5p$	$^1P^\circ$	1	*492 850*	

Ca IV

$Z=20$

Cl I isoelectronic sequence

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

Ionization energy = 542 600 cm^{-1} (67.27 eV)

The initial work on the analysis was by Bowen (1928), who identified the ground term, the $3s3p^6\ ^2S$ level, and the $3p^4(^3P)4s\ ^2P_{3/2}$ level. Kruger and Phillips (1937) also identified the $3p^44s$ terms from their observations below 350 Å.

Levels of $3p^43d\ ^4D$, ^2D and ^2F terms and the $3p^44p$ and $5s$ levels were reported by Tsien (1939), who worked with the line list of Ekefors (1931). Svensson and Ekberg (1968), also using Ekefors' list, established the $3p^4(^3P)3d\ ^2P$ term.

A new analysis based on a new set of observations was provided by Smitt (1978), whose work is still in progress. He estimates an accuracy of ±2 cm^{-1} for the levels relative to the ground term and less than ±1 cm^{-1} for the ground term splitting. The new analysis provides three times the number of previously known levels as well as some changes of designation and J-values. All levels compiled here are from this work except for the $3p^45s\ ^2D$ term retained from Tsien.

The ionization energy was obtained by extrapolation by Lotz (1967).

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Ca IV

Configuration	Term	J	Level (cm^{-1})	Configuration	Term	J	Level (cm^{-1})
$3s^2 3p^5$	$^2P^\circ$	3/2	*0.0*	$3s^2 3p^4(^1D)3d$	^2F	5/2	252 286
		1/2	*3 118.2*			7/2	252 903
$3s3p^6$	^2S	1/2	152 439.6	$3s^2 3p^4(^1S)3d$	^2D	3/2	269 974
$3s^2 3p^4(^3P)3d$	^4D	7/2	201 505			5/2	270 532
		5/2	201 747	$3s^2 3p^4(^3P)4s$	^4P	5/2	291 456
		3/2	202 031			3/2	292 864
		1/2	202 254			1/2	294 292
$3s^2 3p^4(^3P)3d$	^4F	9/2	218 383	$3s^2 3p^4(^1D)3d$	^2S	1/2	293 009
		7/2	219 467	$3s^2 3p^4(^3P)3d$	^2P	3/2	293 872
		5/2	220 240			1/2	295 133
		3/2	220 741	$3s^2 3p^4(^3P)3d$	^2D	5/2	301 218
$3s^2 3p^4(^1D)3d$	^2P	1/2	219 991			3/2	303 850
		3/2	221 945	$3s^2 3p^4(^3P)4s$	^2P	3/2	301 718
$3s^2 3p^4(^3P)3d$	^4P	1/2	227 214			1/2	303 604
		3/2	227 825	$3s^2 3p^4(^1D)4s$	^2D	5/2	312 517
		5/2	228 694			3/2	312 650
$3s^2 3p^4(^1D)3d$	^2D	3/2	228 436	$3s^2 3p^4(^3P)4p$	$^4P^\circ$	5/2	*330 693*
		5/2	230 119			3/2	*331 173*
$3s^2 3p^4(^3P)3d$	^2F	7/2	231 288			1/2	*331 969*
		5/2	233 851				
$3s^2 3p^4(^1D)3d$	^2G	9/2	234 498				
		7/2	234 642				

Ca IV—Continued

Configuration	Term	J	Level (cm^{-1})	Configuration	Term	J	Level (cm^{-1})
$3s^2 3p^4(^3P)4p$	$^4D°$	7/2	*335 122*	$3s^2 3p^4(^1D)4p$	$^2P°$	3/2	*359 575*
		5/2	*335 901*			1/2	*361 170*
		3/2	*336 958*				
		1/2	*337 452*	$3s3p^5(^3P°)3d$	$^4F°$	9/2	*367 174*
						7/2	*367 971*
$3s^2 3p^4(^1S)4s$	^2S	1/2	337 214			5/2	*368 660*
						3/2	*369 197*
$3s^2 3p^4(^3P)4p$	$^2D°$	5/2	*338 250*				
		3/2	*340 377*	$3s^2 3p^4(^1S)4p$	$^2P°$	1/2	*379 774*
						3/2	*380 043*
$3s^2 3p^4(^3P)4p$	$^2P°$	1/2	*338 300*				
		3/2	*338 959*	$3s3p^5(^3P°)3d$	$^4D°$	7/2	*382 641*
						5/2	*382 974*
$3s^2 3p^4(^3P)4p$	$^2S°$	1/2	*342 567*			3/2	*383 125*
						1/2	*383 176*
$3s^2 3p^4(^3P)4p$	$^4S°$	3/2	*342 915*				
				$3s^2 3p^4(^1D)5s$	^2D	5/2	399 755
$3s^2 3p^4(^1D)4p$	$^2F°$	5/2	*352 154*			3/2	400 956
		7/2	*352 616*				
				Ca V $(^3P_2)$	***Limit***		**542 600**
$3s^2 3p^4(^1D)4p$	$^2D°$	3/2	*357 941*				
		5/2	*358 306*				

Ca V

Z=20

S I isoelectronic sequence

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

Ionization energy = 681 600 cm^{-1} (84.50 eV)

Spectra of calcium from 1035-135 Å were obtained by Ekefors (1931) and were supplemented by longer exposures below 600 Å by Bowen (1934). From the combined line-lists Bowen derived levels of the configurations $3s^23p^4$, $3s3p^5$, $3s^23p^33d$, $3s^23p^34s$, and $3s^23p^35s$. By means of isoelectronic comparisons Svensson and Ekberg (1968) revised and extended the $3p^33d$ configuration.

New measurements of the transition array $3s^23p^4$–$3s3p^5$ by Smitt, Svensson, and Outred (1976) led to improved values for the levels of these configurations.

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

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Ca V

Configuration	Term	J	Level (cm^{-1})
$3s^2 3p^4$	^{3}P	2	0.0
		1	2 404.7
		0	3 275.6
$3s^2 3p^4$	^{1}D	2	18 830.3
$3s^2 3p^4$	^{1}S	0	43 836.5
$3s3p^5$	^{3}P°	2	*154 670.8*
		1	*156 760.2*
		0	*157 900.5*
$3s3p^5$	^{1}P°	1	*197 844.5*
$3s^2 3p^3(^2D°)3d$	^{1}D°	2	*254 124*
$3s^2 3p^3(^2D°)3d$	^{1}F°	3	*283 955*
$3s^2 3p^3(^2D°)3d$	^{3}S°	1	*293 785*
$3s^2 3p^3(^2P°)3d$	^{3}P°	2	*298 214*
		1	*299 534*
		0	*300 594*
$3s^2 3p^3(^2D°)3d$	^{1}P°	1	*302 184*
$3s^2 3p^3(^2P°)3d$	^{3}D°	3	*308 188*
		2	*309 831*
		1	*310 943*
$3s^2 3p^3(^2P°)3d$	^{1}D°	2	*318 741*

Configuration	Term	J	Level (cm^{-1})
$3s^2 3p^3(^2P°)3d$	^{1}F°	3	*329 229*
$3s^2 3p^3(^4S°)4s$	^{3}S°	1	*350 914*
$3s^2 3p^3(^2P°)3d$	^{1}P°	1	*353 220*
$3s^2 3p^3(^2D°)4s$	^{3}D°	1	*369 590*
		2	*369 696*
		3	*369 959*
$3s^2 3p^3(^2D°)4s$	^{1}D°	2	*374 728*
$3s^2 3p^3(^2P°)4s$	^{3}P°	0	*387 039*
		1	*387 226*
		2	*387 652*
$3s^2 3p^3(^2P°)4s$	^{1}P°	1	*392 283*
$3s^2 3p^3(^4S°)5s$	^{3}S°	1	*501 127*
$3s^2 3p^3(^2D°)5s$	^{3}D°	1	*524 651*
		2	*524 770*
		3	*525 053*
$3s^2 3p^3(^2D°)5s$	^{1}D°	2	*526 523*
$3s^2 3p^3(^2P°)5s$	^{3}P°	1	*542 249*
		2	*542 650*
$3s^2 3p^3(^2P°)5s$	^{1}P°	1	*544 143*
Ca VI ($^4S°_{3/2}$)	*Limit*		**681 600**

Ca VI

$Z=20$

P I isoelectronic sequence

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

Ionization energy = 877 400 cm^{-1} (108.78 eV)

The present compilation is obtained from the work of Ekberg and Svensson (1970) and Smitt, Svensson, and Outred (1976). The level values for the $3s^23p^3$ and $3s3p^4$ configurations are taken from the latter paper. They have an uncertainty of about ± 2cm^{-1}. We have combined these values with the measurements and classifications given by Ekberg and Svensson to derive new level values for the $3p^23d$ and $4s$ configurations. The uncertainty of these upper levels is about ± 10 cm^{-1}. Since no intersystem transitions have been observed, all of the doublets have an added systematic error x, relative to the ground term $^4S^\circ$. The value of x depends on the accuracy of calculations by Smitt, Svensson and Outred and is expected to be less than ± 20 cm^{-1}.

Most of the wavelengths used by Ekberg and Svensson are taken from Bowen (1934) or Ekefors (1931).

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

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Ca VI

Configuration	Term	J	Level (cm^{-1})	Configuration	Term	J	Level (cm^{-1})
$3s^2\,3p^3$	$^4S^\circ$	3/2	*0.0*	$3s^2\,3p^2(^1D)3d$	^2P	1/2	331 968+x
						3/2	333 324+x
$3s^2\,3p^3$	$^2D^\circ$	3/2	*26 835.1*+x				
		5/2	*27 246.6*+x	$3s^2\,3p^2(^1D)3d$	^2F	5/2	336 219+x
						7/2	336 631+x
$3s^2\,3p^3$	$^2P^\circ$	1/2	*44 586.7*+x				
		3/2	*45 142.7*+x	$3s^2\,3p^2(^1S)3d$	^2D	5/2	348 819+x
						3/2	349 645+x
$3s3p^4$	^4P	5/2	155 786.5				
		3/2	157 767.5	$3s^2\,3p^2(^3P)4s$	^4P	1/2	433 849
		1/2	158 830.5			3/2	435 286
						5/2	437 392
$3s3p^4$	^2D	3/2	193 247.0+x				
		5/2	193 444.8+x	$3s^2\,3p^2(^3P)4s$	^2P	1/2	442 256+x
						3/2	444 724+x
$3s3p^4$	^2P	3/2	222 749.7+x				
		1/2	224 773.3+x	$3s^2\,3p^2(^1D)4s$	^2D	5/2	457 294+x
						3/2	457 358+x
$3s3p^4$	^2S	1/2	233 712.8+x				
				$3s^2\,3p^2(^1S)4s$	^2S	1/2	483 882+x
$3s^2\,3p^2(^3P)3d$	^2P	3/2	294 630+x				
		1/2	297 083+x	Ca VII ($^3P_0$)	*Limit*		**877 400**
$3s^2\,3p^2(^1D)3d$	^2D	5/2	320 919+x				
		3/2	321 411+x				

Ca VII

$Z=20$

Si I isoelectronic sequence

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

Ionization energy = 1 026 000 cm^{-1} (127.2 eV)

The level values for $3s^23p^2$ and $3s3p^3$ are taken from Smitt, Svensson, and Outred (1976). Ekberg and Svensson (1970) revised and extended the interpretation of the $3p^2$–$3p3d$, $4s$ arrays published by several earlier workers. We have combined these new classifications with the $3p^2$ levels given by Smitt et al. Ekberg and Svensson have obtained the value for the ionization energy by extrapolation.

References

Ekberg, J. O., and Svensson, L. A. (1970), Physica Scripta **2**, 283.
Smitt, R., Svensson, L. A., and Outred, M. (1976), Physica Scripta **13**, 293.

Ca VII

Configuration	Term	J	Level (cm^{-1})	Configuration	Term	J	Level (cm^{-1})
$3s^2\,3p^2$	^{3}P	0	0.0	$3s3p^3$	^{1}P°	1	*252 489.9*
		1	1 624.9				
		2	4 071.4	$3s^2\,3p3d$	^{3}P°	2	*286 224*
						1	*288 160*
$3s^2\,3p^2$	^{1}D	2	21 864.0			0	*289 004*
$3s^2\,3p^2$	^{1}S	0	48 981.4	$3s^2\,3p3d$	^{3}D°	1	*295 138*
						2	*295 772*
$3s3p^3$	^{3}D°	1	*160 157.5*			3	*296 132*
		2	*160 220.3*				
		3	*160 529.2*	$3s^2\,3p3d$	^{1}F°	3	*324 885*
$3s3p^3$	^{3}P°	0	*185 356.6*	$3s^2\,3p3d$	^{1}P°	1	*333 501*
		1	*185 392.9*				
		2	*185 412.2*	$3s^2\,3p4s$	^{3}P°	0	*490 059*
						1	*490 919*
$3s3p^3$	^{1}D°	2	*203 616.1*			2	*494 262*
$3s3p^3$	^{3}S°	1	*245 240.5*	$3s^2\,3p4s$	^{1}P°	1	*498 683*
				Ca VIII (^{2}P°$_{1/2}$)	*Limit*		1 026 000

Ca VIII

$Z=20$

Al I isoelectronic sequence

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

Ionization energy = 1 187 600 ± 1000 cm^{-1} (147.24 ± 0.1 eV)

The doublet terms of $3s^2 3p$ and $3s3p^2$ are from Smitt, Svensson, and Outred (1976). The uncertainty of their measurements is about 2 cm^{-1}.

The remaining terms are derived from the measurements and classifications of Ekberg and Svensson (1970). They obtained the position of the quartets by extrapolation.

The ionization energy was determined by Ekberg and Svensson from the $nf\ ^2F^\circ$ series.

References

Ekberg, J. O. and Svensson, L. A. (1970), Physica Scripta **2**, 283.
Smitt, R., Svensson, L. A., and Outred, M. (1976), Physica Scripta **13**, 293.

Ca VIII

Configuration	Term	J	Level (cm^{-1})
$3s^2 3p$	$^2P^\circ$	1/2 3/2	*0.0* *4 308.3*
$3s3p^2$	^4P	1/2 3/2 5/2	129 100+x 130 678+x 133 042+x
$3s3p^2$	^2D	3/2 5/2	171 572.2 171 830.7
$3s3p^2$	^2S	1/2	216 584.9
$3s3p^2$	^2P	1/2 3/2	231 016.3 233 592.8
$3s^2 3d$	^2D	3/2 5/2	282 356 282 577
$3p^3$	$^4S^\circ$	3/2	*345 274*+x
$3s3p3d$	$^4P^\circ$	5/2 3/2	*408 227*+x *409 291*+x
$3s3p3d$	$^4D^\circ$	1/2 3/2 5/2 7/2	*411 816*+x *412 388*+x *412 772*+x *412 881*+x
$3s^2 4s$	^2S	1/2	547 322
$3s3p4s$	$^4P^\circ$	1/2 3/2 5/2	*688 747*+x *690 128*+x *692 833*+x
$3s^2 4d$	^2D	3/2 5/2	698 232 698 420
$3s^2 4f$	$^2F^\circ$	5/2 7/2	*743 288* *743 330*
$3s^2 5d$	^2D	3/2 5/2	885 693 885 750
$3s^2 5f$	$^2F^\circ$	5/2 7/2	*905 052* *905 087*
$3s^2 6d$	^2D	3/2 5/2	979 749 980 089
$3s^2 6f$	$^2F^\circ$	5/2 7/2	*991 023* *991 028*
$3s^2 7f$	$^2F^\circ$	7/2 5/2	*1 043 207* *1 043 275*
Ca IX ($^1S_0$)	*Limit*		**1 187 600**

Ca IX

$Z=20$

Mg I isoelectronic sequence

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

Ionization energy = 1 519 000 ± 1000 cm^{-1} (188.3 ± 0.1 eV)

Most of the levels for this spectrum are taken from Ekberg (1971). The identification of the two combinations with $3s5f\ ^1F^\circ_3$ has been revised by Edlén and Bodén (1976). Ekberg obtained his intersystem connection with two faint lines, but regards this as tentative.

The $3p^2\ ^1S$ term and the $3p3d$ configuration are from Fawcett (1970). The $3p4f$ configuration is from Fawcett (1976).

The ionization energy was calculated by Ekberg from the first three members of the $3snf\ ^3F^\circ$ series ($n=4$, 5, and 6).

References

Edlén, B., and Bodén, E. (1976), Physica Scripta **14**, 31.
Ekberg, J. O. (1971), Physica Scripta **4**, 101.
Fawcett, B. C. (1970), J. Phys. **B3**, 1732.
Fawcett, B. C. (1976), J. Opt. Soc. Am. **66**, 632.

Ca IX

Configuration	Term	J	Level (cm^{-1})
$3s^2$	^1S	0	0
$3s3p$	$^3P^\circ$	0	*141 612*
		1	*143 111*
		2	*146 348*
$3s3p$	$^1P^\circ$	1	*214 482*
$3p^2$	^1D	2	336 245
$3p^2$	^3P	0	338 399
		1	340 308
		2	343 908
$3p^2$	^1S	0	398 900
$3s3d$	^3D	1	410 514
		2	410 627
		3	410 841
$3s3d$	^1D	2	467 631
$3p3d$	$^3F^\circ$	2	*562 150*
		3	*564 160*
		4	*566 630*
$3p3d$	$^1D^\circ$	2	*571 900*
$3p3d$	$^3D^\circ$	2	*599 640*
		3	*601 140*
$3p3d$	$^1P^\circ$	1	*618 520*
$3s4s$	^3S	1	758 974
$3s4s$	^1S	0	774 480
$3s4p$	$^1P^\circ$	1	*832 314*
$3s4d$	^3D	1	915 636
		2	915 750
		3	915 964
$3s4d$	^1D	2	921 921
$3p4s$	$^3P^\circ$	0	*939 907*
		1	*941 094*
		2	*944 814*
$3s4f$	$^3F^\circ$	2–4	*953 030*
$3s4f$	$^1F^\circ$	3	*963 050*
$3p4p$	^3D	2	1 003 670
		3	1 007 010
$3p4p$	^3P	0	1 009 330
		1	1 010 470
		2	1 012 820
$3p4p$	^3S	1	1 014 060
$3s5s$	^3S	1	1 067 240
$3s5s$	^1S	0	1 076 110
$3s5p$	$^1P^\circ$	1	*1 097 570*
$3p4f$	^3G	5	1 125 440
$3p4f$	^3F	3	1 125 620
		4	1 128 930

Ca IX—Continued

Configuration	Term	J	Level (cm^{-1})	Configuration	Term	J	Level (cm^{-1})
$3s5d$	^{1}D	2	1 139 810	$3s6d$	^{3}D	1	1 258 080
$3s5d$	^{3}D	1	1 143 670			2	1 258 260
		3	1 144 290			3	1 258 450
$3s5f$	^{3}F°	2–4	*1 158 110*	$3s6d$	^{1}D	2	1 260 390
$3s5f$	^{1}F°	3	*1 162 610*	$3s6f$	^{3}F°	2–4	*1 269 050*
$3s6s$	^{3}S	1	1 218 220	$3s7p$	^{1}P°	1	*1 315 300*
$3s6p$	^{1}P°	1	*1 235 330*	$3s7d$	^{3}D	1–3	1 329 760
				$3s8d$	^{3}D	1–3	1 374 830
				Ca X ($^2S_{1/2}$)	***Limit***		**1 519 000**

Ca x

$Z=20$

Na I isoelectronic sequence

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

Ionization energy = 1 704 047 ± 3 cm⁻¹ (211.277 ± .001 eV)

The recent publications by Edlén and Bodén (1976), by Fawcett (1976), and by Cohen and Behring (1976) provide considerable extensions of the early work of Kruger and Phillips (1939) on this spectrum. We have quoted level values from Edlén and Bodén and added the higher *nf* series members (n=10-11) from Cohen and Behring. The measurements of the high members of the *nf* series by Fawcett do not agree well with the Ritz formulae given by Edlén and Bodén.

The ionization energy is derived by Edlén (1978) from a polarization formula applied to the *nf* series.

References

Cohen, L., and Behring, W. E. (1976), J. Opt. Soc. Am. **66**, 899.
Edlén, B. (1978), Physica Scripta **17**, 565.
Edlén, B., and Bodén, E. (1976), Physica Scripta **14**, 31.
Fawcett, B. C. (1976), J. Opt. Soc. Am. **66**, 632.
Kruger, P. G., and Phillips, L. W. (1939), Phys. Rev. **55**, 352.

Ca x

Configuration	Term	J	Level (cm⁻¹)	Configuration	Term	J	Level (cm⁻¹)
$2p^6(^1S)3s$	^2S	1/2	0	$2p^6(^1S)6d$	^2D	3/2	1 389 840
						5/2	1 389 870
$2p^6(^1S)3p$	$^2P^\circ$	1/2	*174 213*				
		3/2	*179 287*	$2p^6(^1S)6f$	$^2F^\circ$	5/2	*1 398 330*
						7/2	*1 398 440*
$2p^6(^1S)3d$	^2D	3/2	417 112				
		5/2	417 522	$2p^6(^1S)7s$	^2S	1/2	1 448 710
$2p^6(^1S)4s$	^2S	1/2	832 790	$2p^6(^1S)7p$	$^2P^\circ$	1/2, 3/2	*1 459 920*
$2p^6(^1S)4p$	$^2P^\circ$	1/2	*899 290*	$2p^6(^1S)7d$	^2D	3/2	1 474 040
		3/2	*901 200*			5/2	1 474 090
$2p^6(^1S)4d$	^2D	3/2	987 300				
		5/2	987 490	$2p^6(^1S)7f$	$^2F^\circ$	5/2	*1 479 470*
						7/2	*1 479 540*
$2p^6(^1S)4f$	$^2F^\circ$	5/2	*1 016 100*				
		7/2	*1 016 150*	$2p^6(^1S)8s$	^2S	1/2	1 511 780
$2p^6(^1S)5s$	^2S	1/2	1 174 710	$2p^6(^1S)8p$	$^2P^\circ$	1/2, 3/2	*1 519 200*
$2p^6(^1S)5p$	$^2P^\circ$	1/2	*1 206 850*	$2p^6(^1S)8d$	^2D	3/2	1 528 490
		3/2	*1 207 760*			5/2	1 528 510
$2p^6(^1S)5d$	^2D	3/2	1 248 920	$2p^6(^1S)8f$	$^2F^\circ$	5/2	*1 532 290*
		5/2	1 249 030			7/2	*1 532 390*
$2p^6(^1S)5f$	$^2F^\circ$	5/2	*1 263 690*				
		7/2	*1 263 720*	$2p^6(^1S)9p$	$^2P^\circ$	1/2, 3/2	*1 559 260*
$2p^6(^1S)6s$	^2S	1/2	1 348 380	$2p^6(^1S)9d$	^2D	3/2, 5/2	1 565 730
$2p^6(^1S)6p$	$^2P^\circ$	1/2	*1 366 360*	$2p^6(^1S)9f$	$^2F^\circ$	5/2	*1 568 390*
		3/2	*1 366 890*			7/2	*1 568 420*

Ca x—Continued

Configuration	Term	J	Level (cm^{-1})	Configuration	Term	J	Level (cm^{-1})
$2p^6(^1S)10d$	^2D	5/2	1 592 260	$2p^6(^1S)11f$	$^2F°$	7/2	*1 613 480*
						5/2	*1 613 600*
$2p^6(^1S)10f$	$^2F°$	7/2	*1 594 230*				
		5/2	*1 594 330*	Ca XI ($^1S_0$)	***Limit***		**1 704 047**

Ca XI

$Z=20$

Ne I isoelectronic sequence

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

Ionization energy = 4 774 000 cm^{-1} (591.9 eV)

Only resonance lines between 25 and 36 Å are classified by this rare-gas-type system of energy levels. Edlén and Tyrén (1936) identified 11 transitions and extrapolated to obtain an ionization potential which agrees well with the present value.

We use *jj*-coupling designations for the $2p^5ns$ levels and *jl*-coupling designations for the $2p^5nd$ levels.

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 $n=3$ and 4 with the change in quantum defect Δn^* taken from Ti XIII. Our value agrees exactly with Lotz's (1967) value.

References

Edlén, B., and Tyrén, F. (1936), Z. Phys. **101**, 206.
Kastner, S. O., Behring, W. E., and Cohen, L. (1975), Astrophys. J. **199**, 777.
Lotz, W. J. (1967), J. Opt. Soc. Am. **57**, 873.

Ca XI

Configuration	Term	J	Level (cm^{-1})	Configuration	Term	J	Level (cm^{-1})
$2s^22p^6$	^1S	0	0	$2s2p^63p$	$^3P^\circ$	1	*3 692 900*
$2s^22p^5(^2P^\circ_{3/2})3s$	$(3/2,1/2)^\circ$	1	*2 810 880*	$2s2p^63p$	$^1P^\circ$	1	*3 708 900*
$2s^22p^5(^2P^\circ_{1/2})3s$	$(1/2,1/2)^\circ$	1	*2 839 940*	$2s^22p^5(^2P^\circ_{3/2})4s$	$(3/2,1/2)^\circ$	1	*3 753 900*
$2s^22p^5(^2P^\circ_{3/2})3d$	$^2[1/2]^\circ$	1	*3 199 300*	$2s^22p^5(^2P^\circ_{1/2})4s$	$(1/2,1/2)^\circ$	1	*3 781 900*
$2s^22p^5(^2P^\circ_{3/2})3d$	$^2[3/2]^\circ$	1	*3 239 700*	$2s^22p^5(^2P^\circ_{3/2})4d$	$^2[3/2]^\circ$	1	*3 919 000*
$2s^22p^5(^2P^\circ_{1/2})3d$	$^2[3/2]^\circ$	1	*3 284 300*	$2s^22p^5(^2P^\circ_{1/2})4d$	$^2[3/2]^\circ$	1	*3 948 400*
				Ca XII $(^2P^\circ_{3/2})$	***Limit***		**4 774 000**

Ca XII

Z = 20

F I isoelectronic sequence

Ground state: $1s^22s^22p^5\ {}^2P°_{3/2}$

Ionization energy = 5 301 000 cm^{-1} (657.2 eV)

The first work on this spectrum was by Edlén and Tyrén (1936), who classified 10 lines of the $2s^22p^5$–$2s^22p^43s$ and $3d$ transition arrays between 27 and 33 Å. This work was extended by Feldman, Doschek, Cowan, and Cohen (1973), from whose wavelengths the $3s$ and $3d$ levels are determined. Fawcett, Burgess, and Peacock (1967) identified the $2s^22p^5$–$2s2p^6$ doublet at ∽ 140 Å. The $2s^22p^5\ {}^2P°$ term interval is obtained from the solar flare line at 3327.5 Å (in air) identified by Edlén (1942, 1976).

The $2s2p^53s\ {}^2P°$ term is from Feldman et al. (1973).

The ionization energy was obtained by extrapolation by Lotz (1967).

References

Edlén, B. (1942), Z. Astrophys. **22**, 30.

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Edlén, B., and Tyrén, F. (1936), Z. Phys. **101**, 206.

Fawcett, B. C., Burgess, D. D., and Peacock, N. J. (1967), Proc. Phys. Soc. **91**, 970.

Feldman, U., Doschek, G. A., Cowan, R. D., and Cohen, L. (1973), J. Opt. Soc. Am. **63**, 1445.

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

Ca XII

Configuration	Term	J	Level (cm^{-1})
$2s^2 2p^5$	$^2P°$	3/2	*0*
		1/2	*30 044*
$2s2p^6$	^2S	1/2	709 000
$2s^2 2p^4(^3P)3s$	^4P	5/2	3 062 300
		3/2	3 077 100
		1/2	3 089 300
$2s^2 2p^4(^3P)3s$	^2P	3/2	3 097 800
		1/2	3 114 800
$2s^2 2p^4(^1D)3s$	^2D	5/2	3 158 500
		3/2	3 159 300
$2s^2 2p^4(^1S)3s$	^2S	1/2	3 249 600
$2s^2 2p^4(^3P)3d$	^4P	1/2	3 475 800
		3/2	3 479 600
		5/2	3 489 400
$2s^2 2p^4(^3P)3d$	^4F	5/2	3 480 000
$2s^2 2p^4(^3P)3d$	^2P	1/2	3 486 700
		3/2	3 508 200
$2s^2 2p^4(^3P)3d$	^2D	3/2	3 494 600
		5/2	3 511 500
$2s^2 2p^4(^3P)3d$	^2F	5/2	3 494 900
$2s^2 2p^4(^1D)3d$	^2S	1/2	3 559 300
$2s^2 2p^4(^1D)3d$	^2F	5/2	3 562 800
$2s^2 2p^4(^1D)3d$	^2P	3/2	3 574 900
$2s^2 2p^4(^1D)3d$	^2D	5/2	3 574 900
		3/2	3 584 900
$2s^2 2p^4(^1S)3d$	^2D	5/2	3 647 900
		3/2	3 652 300
$2s2p^5(^3P°)3s$	$^2P°$	3/2	*3 738 000*
		1/2	*3 755 900*
Ca XIII ($^3P_2$)	***Limit***		**5 301 000**

Ca XIII

$Z=20$

O I isoelectronic sequence

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

Ionization energy = 5 861 000 cm⁻¹ (726.6 eV)

The observed spectrum of Ca XIII consists of the strong transition array $2s^2 2p^4$–$2s2p^5$, which lies between 130 and 170 Å, and the arrays $2p^4$–$2p^3 3s$ at 29 Å and $2p^4$–$2p^3 3d$ at 26 Å. The $2s2p^5\ ^3P^\circ$ is taken from Fawcett, Burgess, and Peacock (1967). Two lines assigned to the $^1P^\circ$ are inconsistent so the term value cannot be determined. The transition $2p^6\ ^1S_0$ to $2s2p^5\ ^1P^\circ_1$ lies at 169.49 Å, according to Fawcett, Galanti and Peacock (1974).

The configuration $2p^3 3s$ is from the observations of Doschek, Feldman, and Cohen (1973). Lines of the $2p^4$–$2p^3 3d$ array were classified by Fawcett and Hayes (1975). Subsequently, revisions of several line classifications were suggested by Bromage and Fawcett (1977) on the basis of new calculations. We regard these changes as tentative and therefore omit the corresponding levels.

Levels of the $2s^2 2p^4$ configuration are obtained from Edlén (1972). He gives a calculated value for the position of the $^1D_2$, on which we base the singlet system.

The ionization energy is from Lotz's (1967) extrapolation.

References

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Ca XIII

Configuration	Term	J	Level (cm⁻¹)	Configuration	Term	J	Level (cm⁻¹)
$2s^2 2p^4$	^3P	2	0	$2s^2 2p^3(^2P^\circ)3s$	$^1P^\circ$	1	*3 544 600+x*
		1	24 460				
		0	28 830	$2s^2 2p^3(^4S^\circ)3d$	$^3D^\circ$	2	*3 739 000*
						3	*3 743 000*
$2s^2 2p^4$	^1D	2	88 400+x				
				$2s^2 2p^3(^2D^\circ)3d$	$^3D^\circ$	1	*3 828 000*
$2s^2 2p^4$	^1S	0	178 560+x			2	*3 839 000*
$2s2p^5$	$^3P^\circ$	2	*618 260*	$2s^2 2p^3(^2D^\circ)3d$	$^3P^\circ$	2	*3 846 000*
		1	*638 260*				
		0	*650 160*	$2s^2 2p^3(^2D^\circ)3d$	$^3S^\circ$	1	*3 864 000*
$2s^2 2p^3(^4S^\circ)3s$	$^3S^\circ$	1	*3 374 600*	$2s^2 2p^3(^2P^\circ)3d$	$^3D^\circ$	1	*3 909 000*
						3	*3 917 000*
$s^2 2p^3(^2D^\circ)3s$	$^3D^\circ$	1	*3 452 700*			2	*3 924 000*
		2	*3 453 200*				
		3	*3 458 300*	Ca XIV ($^4S^\circ_{3/2}$)	*Limit*		5 861 000
$2s^2 2p^3(^2D^\circ)3s$	$^1D^\circ$	2	*3 474 800+x*				

Ca XIV

Z = 20

N I isoelectronic sequence

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

Ionization energy = 6 595 000 cm^{-1} (817.6 eV)

The levels of the configurations $2s^22p^3$, $2s2p^4$, and $2p^5$ are from the measurements and classifications of Kononov, Koshelev, Podobedova, and Churilov (1976). The position of the doublets relative to the ground state is based on the estimated position of $2s^22p^3\ ^2D^\circ_{5/2}$ by Eldén (1972).

The $2p^23d$ terms are from Fawcett and Hayes (1975); their percentage compositions were calculated by Bromage and Fawcett (1977).

The ionization energy is from Lotz's (1967) extrapolation.

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Ca XIV

Configuration	Term	J	Level (cm^{-1})	Leading percentages		
$2s^2 2p^3$	$^4S^\circ$	3/2	*0*			
$2s^2 2p^3$	$^2D^\circ$	3/2	*105 120+x*			
		5/2	*112 740+x*			
$2s^2 2p^3$	$^2P^\circ$	1/2	*171 640+x*			
		3/2	*182 570+x*			
$2s2p^4$	^4P	5/2	515 840			
		3/2	535 910			
		1/2	545 110			
$2s2p^4$	^2D	3/2	709 970+x			
		5/2	711 760+x			
$2s2p^4$	^2S	1/2	824 360+x			
$2s2p^4$	^2P	3/2	857 510+x			
		1/2	884 910+x			
$2p^5$	$^2P^\circ$	3/2	*1 347 180+x*			
		1/2	*1 379 450+x*			
$2s^2 2p^2(^3P)3d$	^2P	3/2	4 113 200+x	57	28	$(^3P)\ ^4D$
$2s^2 2p^2(^3P)3d$	^4P	5/2	4 143 700	76	19	$(^3P)\ ^4D$
		3/2	4 151 800	91		
$2s^2 2p^2(^3P)3d$	^2F	7/2	4 153 300+x	57	20	$(^1D)\ ^2F$
$2s^2 2p^2(^3P)3d$	^2D	5/2	4 198 100+x	78	14	$(^1D)\ ^2D$
$2s^2 2p^2(^1D)3d$	^2F	7/2	4 229 800+x	60	32	$(^3P)\ ^2F$
		5/2	4 242 800+x	48	21	

Ca XIV—Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages
$2s^2 2p^2(^1D)3d$	^2D	$5/2$	4 241 000+x	67 18 $(^1D)\ ^2F$
$2s^2 2p^2(^1D)3d$	^2P	$3/2$	4 250 400+x	90
Ca XV ($^3P_0$)	***Limit***		**6 595 000**	

Ca xv

$Z=20$

C I isoelectronic sequence

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

Ionization energy = 7 215 000 cm^{-1} (894.5 eV)

The levels of the $2s^22p^2$, $2s2p^3$, and $2p^4$ configurations were determined by Kononov, Koshelev, Podobedova, and Churilov (1976), from observations of a laser plasma between 130 and 270 Å. The fine-structure of the $2s^22p^2\ ^3P$ term is determined from the solar coronal lines 5444 Å and 5693.6 Å as given by Edlén (1972).

The levels of the higher configurations are from the measurements of Fawcett and Hayes (1975) and Bromage and Fawcett (1977).

No intersystem combinations have been observed in the laboratory. Edlén (1972) has extrapolated the position of $2p^2\ ^1D_2$ to 108 561 cm^{-1}. Sandlin, Brueckner, and Tousey (1977) have identified the $^3P_2$–$^1D_2$ forbidden transition in $2s^22p^2$ at 1375.95 Å in the solar corona. This put $^1D_2$ at 108 600 cm^{-1} above the ground state. We have used that value as the reference value for the singlet system.

The percentage compositions for the $2p3d$ configuration were calculated by Bromage and Fawcett.

The ionization energy is Lotz's (1967) extrapolation.

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Ca xv

Configuration	Term	J	Level (cm^{-1})	Leading percentages
$2s^2 2p^2$	^3P	0	0	
		1	17 559	
		2	35 923	
$2s^2 2p^2$	^1D	2	108 600	
$2s^2 2p^2$	^1S	0	197 620	
$2s2p^3$	$^3D°$	2	*496 680*	
		1	*497 590*	
		3	*500 240*	
$2s2p^3$	$^3P°$	0	*581 730*	
		1	*582 840*	
		2	*585 660*	
$2s2p^3$	$^3S°$	1	*728 910*	
$2s2p^3$	$^1D°$	2	*729 720*	
$2s2p^3$	$^1P°$	1	*814 370*	
$2p^4$	^3P	2	1 107 570	
		1	1 133 870	
		0	1 140 140	
$2p^4$	^1D	2	1 195 200	
$2p^4$	^1S	0	1 354 120	

Ca xv—Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages		
$2s^2 2p3d$	$^3F°$	2	*4 363 000*	74	25	$^1D°$
		3	*4 379 000*	88		
$2s^2 2p3d$	$^3D°$	1	*4 399 000*	78	15	$^3P°$
		2	*4 412 000*	45	24	$^1D°$
		3	*4 426 000*	88	10	$^3F°$
$2s^2 2p3d$	$^3P°$	1	*4 435 000*	82	17	$^3D°$
		2	4 435 000	61	36	
$2s^2 2p3d$	$^1P°$	1	*4 473 000*	92		
$2s^2 2p3d$	$^1F°$	3	*4 475 000*	96		
$2s2p^2(^4P)3d$	^3F	4	4 727 000			
Ca XVI ($^2P°_{1/2}$)	*Limit*		**7 215 000**			

Ca XVI

Z = 20

B I isoelectronic sequence

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

Ionization energy = 7 860 000 cm^{-1} (974 eV)

The low lying configurations $2s^2 2p$, $2s2p^2$, and $2p^3$ are from the observations of Kononov, Koshelev, Podobedova and Churilov (1975). We have assigned the lowest quartet level the value calculated by them, since there are no observed connections of the quartet terms with the doublet terms.

The high levels are from Fawcett and Hayes (1975) and the ionization energy is from the extrapolation of Lotz (1967).

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Ca XVI

Configuration	Term	J	Level (cm^{-1})	Configuration	Term	J	Level (cm^{-1})
$2s^2 2p$	$^2P^\circ$	1/2	*0*	$2s^2 3d$	^2D	3/2	4 662 000
		3/2	*36 600*			5/2	4 664 000
$2s2p^2$	^4P	1/2	269 000+x	$2s2p(^3P^\circ)3p$	^2P	1/2	4 773 000
		3/2	283 560+x			3/2	4 794 000
		5/2	301 790+x				
				$2s2p(^3P^\circ)3d$	$^4D^\circ$	3/2	*4 931 000+x*
$2s2p^2$	^2D	3/2	479 460			5/2	*4 935 000+x*
		5/2	481 960			7/2	*4 953 000+x*
$2s2p^2$	^2S	1/2	592 240	$2s2p(^3P^\circ)3d$	$^4P^\circ$	5/2	*4 964 000+x*
$2s2p^2$	^2P	1/2	633 890	$2s2p(^3P^\circ)3d$	$^2F^\circ$	5/2	*5 000 000*
		3/2	645 770			7/2	*5 022 000*
$2p^3$	$^4S^\circ$	3/2	*835 920+x*	$2s2p(^1P^\circ)3d$	$^2F^\circ$	7/2	*5 170 000*
$2p^3$	$^2D^\circ$	3/2	*940 060*	$2s2p(^1P^\circ)3d$	$^2D^\circ$	5/2	*5 198 000*
		5/2	*944 830*				
				Ca XVII ($^1S_0$)	***Limit***		**7 860 000**
$2p^3$	$^2P^\circ$	1/2	*1 053 000*				
		3/2	*1 062 090*				

Ca XVII

$Z=20$

Be I isoelectronic sequence

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

Ionization energy = 8 770 000 cm^{-1} (1087 eV)

The strong singlet resonance line $2s^2\ {}^1S_0$–$2s2p\ {}^1P^\circ_1$ at 192.8 Å has been observed in the laboratory by Kononov, Koshelev, Podobedova, and Churilov (1975), by Fawcett and Hayes (1975) and in solar flares. We used the wavelength of Kononov et al. to establish the value of the ${}^1P^\circ$ term.

The intersystem transition $2s^2\ {}^1S_0$–$2s2p\ {}^3P^\circ_1$ has not been observed in the laboratory but has been identified in a solar flare spectrum by Sandlin, Brueckner, Scherrer, and Tousey (1976). We have adopted their value to locate the triplet system relative to the singlets. The ${}^3P$ terms of $2s2p$ and $2p^2$ and the ${}^1S$ term of $2p^2$ are from Kononov et al. The $2p^2\ {}^1D$ is from Goldsmith, Oren, Crooker, and Cohen (1973).

The higher configurations are from Fawcett and Hayes. The ionization energy is from Lotz's (1967) extrapolation.

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Ca XVII

Configuration	Term	J	Level (cm^{-1})	Configuration	Term	J	Level (cm^{-1})
$2s^2$	${}^1S$	0	0	$2s3p$	${}^1P^\circ$	1	*5 113 000*
$2s2p$	${}^3P^\circ$	0	*258 290*	$2s3d$	${}^3D$	2	5 186 000
		1	*269 460*			3	5 190 000
		2	*296 950*	$2s3d$	${}^1D$	2	5 236 000
$2s2p$	${}^1P^\circ$	1	*518 620*	$2p3p$	${}^3D$	3	5 448 000
$2p^2$	${}^3P$	1	706 680	$2p3d$	${}^3D^\circ$	2	*5 533 000*
		2	726 450			3	*5 546 000*
$2p^2$	${}^1D$	2	801 710	$2p3d$	${}^1F^\circ$	3	*5 602 000*
$2p^2$	${}^1S$	0	967 330	Ca XVIII (${}^2S_{1/2}$)	*Limit*		8 770 000

Ca XVIII

$Z=20$

Li I isoelectronic sequence

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

Ionization energy = 9 332 000 cm^{-1} (1157.0 eV)

The $2s$–$3p$, $2s$–$4p$, $2s$–$5p$, $2p$–$3s$, $2p$–$3d$, $2p$–$4d$, $2p$–$5d$, and $2p$–$6d$ transitions were reported by Goldsmith, Feldman, Oren, and Cohen (1972). The value of the $2p\ ^2P^\circ$ term is from the $2s$–$2p$ transition observed at 300 Å in a solar flare by Widing and Purcell (1976).

Boiko, Faenov, and Pikuz (1978) confirmed the lines identified by Goldsmith et al. and added the $6p$, $7p$, $6d$, and $7d$ terms. The doubly excited levels were obtained from lines observed by Aglitskii, Boiko, Zakharov, Pikuz, and Faenov (1974) at 3.2 Å in a laser-produced plasma.

We derived the ionization energy from the nd Rydberg series ($n=4$ to 6).

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Ca XVIII

Configuration	Term	J	Level (cm^{-1})
$1s^2 2s$	^2S	1/2	0
$1s^2 2p$	$^2P^\circ$	1/2	*290 060*
		3/2	*330 920*
$1s^2 3s$	^2S	1/2	5 277 000
$1s^2 3p$	$^2P^\circ$	1/2	*5 338 000*
		3/2	*5 350 000*
$1s^2 3d$	^2D	3/2	5 381 000
		5/2	5 384 000
$1s^2 4p$	$^2P^\circ$	1/2,3/2	*7 101 000*
$1s^2 4d$	^2D	3/2	7 112 000
		5/2	7 116 000
$1s^2 5d$	^2D	5/2	7 912 000
		3/2	7 913 000
$1s^2 5p$	$^2P^\circ$	1/2,3/2	*7 914 000*
$1s^2 6p$	$^2P^\circ$	1/2,3/2	*8 341 000*
$1s^2 6d$	^2D	5/2	8 345 000
$1s^2 7p$	$^2P^\circ$	1/2,3/2	*8 605 000*
$1s^2 7d$	^2D	3/2,5/2	8 610 000
Ca XIX ($^1S_0$)	***Limit***		**9 332 000**
$1s(^2S)2s2p(^1P^\circ)$	$^2P^\circ$	3/2	*31 352 000*
$1s2p^2$	^2D	3/2	31 484 000
		5/2	31 486 000
$1s2p^2$	^2P	3/2	31 551 000
$1s2p3p$			36 784 000

Ca XIX

Z=20

He I isoelectronic sequence

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

Ionization energy = 41 369 120 ± 40 cm^{-1} (5129.16 ± 0.01 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 in the calculation is estimated by the authors to be one part in 10^{-6} or 10^{-7}. For comparison, the $1s^2$–$1s2p$ transition of this ion has been observed by Aglitskii et al. (1974) in a laser-produced plasma. They place $1s2p\ ^3P^\circ$ at 31 322 000 cm^{-1} and $1s2p\ ^1P^\circ_1$ at 31 480 000 cm^{-1}.

References

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Ca XIX

Configuration	Term	J	Level (cm^{-1})	Configuration	Term	J	Level (cm^{-1})
$1s^2$	^1S	0	0	1s3s	^1S	0	36 922 600
1s2s	^3S	1	31 145 160	1s3p	$^1P^\circ$	1	*36 965 520*
1s2p	$^3P^\circ$	0	*31 316 020*	1s4s	^3S	1	38 853 340
		1	*31 323 660*	1s4p	$^3P^\circ$	0	*38 872 900*
		2	*31 358 980*			1	*38 873 820*
						2	*38 878 300*
1s2s	^1S	0	31 330 780				
1s2p	$^1P^\circ$	1	*31 477 040*	1s4s	^1S	0	38 873 200
1s3s	^3S	1	36 873 600	1s4p	$^1P^\circ$	1	*38 891 350*
1s3p	$^3P^\circ$	0	*36 920 730*	Ca XX ($^2S_{1/2}$)	*Limit*		**41 369 120**
		1	*36 922 920*				
		2	*36 933 520*				

Ca XX

Z=20

H I isoelectronic sequence

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

Ionization energy=44 117 200 ± 200 cm^{-1} (5469.88 ± 0.02 eV)

The theoretical values calculated by Erikson (1977) for terms of this hydrogen-like ion are given below. No laboratory data were found. The binding energy of the 1s electron is given with an uncertainty of ± 200 cm^{-1}; the levels measured from the ground state taken as zero will also have this uncertainty.

Doschek (1972) reports wavelengths of several lines of this spectrum identified in solar flares.

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Ca XX

Configuration	Term	J	Level (cm^{-1})	Configuration	Term	J	Level (cm^{-1})
1s	^2S	½	0	4p	$^2P°$	½	*41 361 800*
						3/2	*41 369 200*
2p	$^2P°$	½	*33 069 700*				
		3/2	*33 129 100*	4s	^2S	½	41 362 100
2s	^2S	½	33 071 600	4d	^2D	3/2	41 369 200
						5/2	41 371 700
3p	$^2P°$	½	*39 213 800*				
		3/2	*39 231 400*	4f	$^2F°$	5/2	*41 371 700*
						7/2	*41 372 900*
3s	^2S	½	39 214 400				
					Limit		**44 117 200**
3d	^2D	3/2	39 231 400				
		5/2	39 237 200				