

# 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.

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## 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  $\text{cm}^{-1}$ . The conversion factor  $8065.479 \pm 0.021 \text{ cm}^{-1}/\text{eV}$ , 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  $\psi_1, \psi_2, \dots, \psi_n$ . 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  $\psi_A$  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  $\alpha_1^2 + \alpha_2^2 + \dots + \alpha_n^2 = 1$ . The squared quantities  $\alpha_1^2, \alpha_2^2, \dots$ , multiplied by 100, represent the percentage composi-

tion 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.

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## Energy Level Tables

## Ca I

Z=20

Ground state:  $1s^2 2s^2 2p^6 3s^2 3p^4 4s^2 \ ^1S_0$ Ionization energy =  $49\ 305.96 \pm 0.08 \text{ cm}^{-1}$  ( $6.11321 \pm 0.00002 \text{ eV}$ )

## 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  $3dnd$  ( $n=4-6$ ) 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
3d4p	$^1D$	2	1.007
	$^3F^\circ$	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 known series as follows:  $4snp \ ^1P^\circ_1$  to  $n=33$ ,  $3dnf \ ^1P^\circ_1$  to  $n=29$ ,  $3dnf \ ^3P^\circ_1$  to  $n=25$ ,  $3dnf \ ^3D^\circ_1$  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  $43\ 933 \text{ cm}^{-1}$  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  $41\ 786 \text{ cm}^{-1}$  and  $40\ 690 \text{ cm}^{-1}$  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  $49\ 305.99 \pm 0.12 \text{ cm}^{-1}$ .

Series in Ca I

Config.	Term	$n_{\max}$	References
1. $4snp$	$^3P^\circ$	60	Armstrong et al. (1979)
2. $4snp$	$^1P^\circ$	79	Brown et al. (1973)
3. $4snd$	$^3D$	17	Risberg (1968), Camus (1974)
4. $4snd$	$^1D$	62	Borgström and Rubbmark (1977), Armstrong et al. (1977)
5. $4sns$	$^3S$	18	Risberg (1968), Camus (1974)
6. $4sns$	$^1S$	32	Borgström and Rubbmark (1977), Armstrong et al. (1977)
7. $3dnp$	$^3D^\circ$	58	Brown et al. (1973)
8. $3dnp$	$^3P^\circ$	33	Brown et al. (1973)
9. $3dnp$	$^1P^\circ$	61	Brown et al. (1973)
10. $4snf$	$^3F^\circ$	13	Risberg (1968), Camus (1974)
11. $4snf$	$^1F^\circ$	28	Borgström and Rubbmark (1977)
12. $3dnf$	$^3D^\circ$	30	Brown et al. (1973)
13. $3dnf$	$^3P^\circ$	38	Brown et al. (1973)
14. $3dnf$	$^1P^\circ$	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  $3d^2D$  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  $46\,199.23\text{ cm}^{-1}$  for  $4s7d$ , rejecting the level  $46\,308.257$  given by Risberg. The level  $47\,449.083\text{ cm}^{-1}$  assigned by Risberg to  $3d^2^1D_2$  is renamed  $3d5s^1D_2$ . This designation was used by Risberg for the level  $48\,083.383\text{ cm}^{-1}$ , 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  $3p$  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  $49\,305.92 \pm 0.10\text{ cm}^{-1}$  which is within the error limits of the value of Brown et al.,  $49\,305.99 \pm 0.12\text{ cm}^{-1}$ . We have adopted the mean of the two values,  $49\,305.96 \pm 0.08\text{ cm}^{-1}$  as the best value. The uncertainty in the conversion factor,  $8065.479 \pm 0.021\text{ cm}^{-1}/\text{eV}$ , 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  $36\,731\text{ cm}^{-1}$ . Roth (1969) attributes to Racah his identification of this term with the level at  $41\,679\text{ cm}^{-1}$ . Friedrich and Trefftz (1969), on the basis of multi-configuration calculations, retained it at  $36\,731\text{ cm}^{-1}$ . Garton and Codling (1965), from intensity considerations, placed it at  $43\,933\text{ cm}^{-1}$ . 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  $4snp$  series. Among these levels the largest percentage of  $3dnp^1P^\circ_1$  (27%) is present in the level at  $43\,933\text{ cm}^{-1}$ . 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  $4snd^3D$  series, strongly perturbed by  $3d5s^3D$  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 <sup>-1</sup> )	Configuration	Term	$J$	Level (cm <sup>-1</sup> )
4s <sup>2</sup>	<sup>1</sup> S	0	0.000	3d 4p	<sup>3</sup> D°	1	38 192.392
4s4p	<sup>3</sup> P°	0	15 157.901			2	38 219.118
		1	15 210.063			3	38 259.124
		2	15 315.943	4p <sup>2</sup>	<sup>3</sup> P	0	38 417.543
3d 4s	<sup>3</sup> D	1	20 335.360			1	38 464.808
		2	20 349.260			2	38 551.558
		3	20 371.000	3d 4p	<sup>3</sup> P°	0	39 333.382
3d 4s	<sup>1</sup> D	2	21 849.634			1	39 335.322
4s4p	<sup>1</sup> P°	1	23 652.304			2	39 340.080
4s5s	<sup>3</sup> S	1	31 539.495	4s6s	<sup>3</sup> S	1	40 474.241
4s5s	<sup>1</sup> S	0	33 317.264	3d 4p	<sup>1</sup> F°	3	40 537.893
3d 4p	<sup>3</sup> F°	2	35 730.454	4s6s	<sup>1</sup> S	0	40 690.435
		3	35 818.713	4p <sup>2</sup>	<sup>1</sup> D	2	40 719.847
		4	35 896.889	4s6p	<sup>1</sup> P°	1	41 679.008
3d 4p	<sup>1</sup> D°	2	35 835.413	4p <sup>2</sup>	<sup>1</sup> S	0	41 786.276
4s5p	<sup>3</sup> P°	0	36 547.688	4s4f	<sup>3</sup> F°	2	42 170.214
		1	36 554.749			3	42 170.558
		2	36 575.119			4	42 171.026
4s5p	<sup>1</sup> P°	1	36 731.615	4s4f	<sup>1</sup> F°	3	42 343.587
4s4d	<sup>1</sup> D	2	37 298.287	4s6p	<sup>3</sup> P°	0	42 514.845
4s4d	<sup>3</sup> D	1	37 748.197			1	42 518.708
		2	37 751.867			2	42 526.591
		3	37 757.449				

Ca I: Ordered by term values—Continued

Configuration	Term	<i>J</i>	Level (cm <sup>-1</sup> )	Configuration	Term	<i>J</i>	Level (cm <sup>-1</sup> )		
4s5d	<sup>3</sup> D	1	42 743.002	4s7f	<sup>3</sup> F°	2	47 006.194		
		2	42 744.716			3	47 006.280		
		3	42 747.387			4	47 006.400		
4s5d	<sup>1</sup> D	2	42 919.053	4s7f	<sup>1</sup> F°	3	47 015.141		
3d <sup>2</sup>	<sup>3</sup> F	2	43 474.827	4s8d	<sup>3</sup> D	1	47 036.225		
		3	43 489.119			2	47 040.007		
		4	43 508.088			3	47 045.241		
3d 4p	<sup>1</sup> P°	1	43 933.477	4s9p	<sup>3</sup> P°	1	47 085.38		
4s7s	<sup>3</sup> S	1	43 980.767	4s9p		2	47 086.99		
4s7s		<sup>1</sup> S	0	44 276.538	4s10s	<sup>1</sup> P°	1	47 184.370	
4s5f	<sup>3</sup> F°	2	44 762.620	4s10s			<sup>3</sup> S	1	47 382.048
		3	44 762.839		<sup>1</sup> S	0		47 437.471	
		4	44 763.118						
4s5f	<sup>1</sup> F°	3	44 804.878	3d 5s	<sup>1</sup> D	2	47 449.083		
			44 804.878	3d 5s			<sup>3</sup> D	1	47 456.452
4s7p	<sup>3</sup> P°	0	44 955.67	4s8f	<sup>3</sup> F°	2		47 466.014	
		1	44 957.655			3		47 475.915	
		2	44 961.757			4s8f	<sup>1</sup> F°	2	47 550.214
4s6d	<sup>1</sup> D	2	44 989.830	4s8f	<sup>3</sup> P°			3	47 550.271
			45 049.073					4s10p	1
			45 050.419			2	47 605.77		
4s6d	<sup>3</sup> D	1	45 049.073	4s10p	<sup>1</sup> P°	1	47 662.10		
4s7p		<sup>1</sup> P°	1	45 425.358		4s9d	<sup>3</sup> D	1	47 752.655
				45 738.684				2	47 757.286
	45 887.200			3	47 765.697				
4s8s	<sup>3</sup> S	1	45 738.684	4s11s	<sup>3</sup> S	1	47 806.17		
4s8s	<sup>1</sup> S	0	45 887.200			4s9d	<sup>1</sup> D	2	47 812.39
4s6f	<sup>3</sup> F°	2	46 164.644					4s11s	<sup>1</sup> S
		3	46 164.785	4s9f	<sup>3</sup> F°				
		4	46 164.971			3	47 921.981		
4s6f	<sup>1</sup> F°	3	46 182.399	4s9f	<sup>1</sup> F°	3	47 922.033		
4s7d	<sup>1</sup> D	2	46 200.13			4s11p	<sup>3</sup> P°	1	47 960.87
			46 284.12					4s11p	2
			46 285.23	4s11p	<sup>1</sup> P°				
4s8p	<sup>3</sup> P°	0	46 284.12			4s11p	<sup>3</sup> D	1	48 031.58
4s7d		<sup>3</sup> D	1	46 301.973	4s10d			<sup>1</sup> D	2
	2		46 303.649	3		48 036.212			
	3		46 306.059	4s10d		2	48 083.41		
4s8p	<sup>1</sup> P°	1	46 479.813						
4s9s	<sup>3</sup> S	1	46 748.283	4s10d	<sup>3</sup> D	1	48 031.58		
4s9s	<sup>1</sup> S	0	46 835.055			2	48 033.23		
4s8d	<sup>1</sup> D	2	46 948.98			3	48 036.212		

Ca I: Ordered by term values—Continued

Configuration	Term	<i>J</i>	Level (cm <sup>-1</sup> )	Configuration	Term	<i>J</i>	Level (cm <sup>-1</sup> )
4s12s	<sup>3</sup> S	1	48 103.93	4s15s	<sup>3</sup> S	1	48 609.75
4s12s	<sup>1</sup> S	0	48 130.75	4s15s	<sup>1</sup> S	0	48 621.53
4s10f	<sup>3</sup> F°	2	48 187.045	4s13f	<sup>3</sup> F°	4	48 646.38
		3	48 187.075	4s13f	<sup>1</sup> F°	3	48 647.30
		4	48 187.118				
4s10f	<sup>1</sup> F°	3	48 188.990	4s15p	<sup>3</sup> P°	2	48 660.23
4s12p	<sup>3</sup> P°	1	48 215.81	4s15p	<sup>1</sup> P°	1	48 669.83
		2	48 216.36	4s14d	<sup>3</sup> D	1	48 675.68
4s12p	<sup>1</sup> P°	1	48 240.53			2	48 675.87
						3	48 676.13
4s11d	<sup>3</sup> D	1	48 258.30	4s14d	<sup>1</sup> D	2	48 678.97
		2	48 258.98				
		3	48 260.25	4s16s	<sup>3</sup> S	1	48 708.67
4s11d	<sup>1</sup> D	2	48 290.85	4s16s	<sup>1</sup> S	0	48 718.02
4s13s	<sup>3</sup> S	1	48 321.00	4s14f	<sup>1</sup> F°	3	48 738.54
4s13s	<sup>1</sup> S	0	48 340.75	4s16p	<sup>3</sup> P°	2	48 749.04
4s11f	<sup>3</sup> F°	2	48 382.70	4s16p	<sup>1</sup> P°	1	48 756.45
		3	48 382.781				
		4	48 382.801	4s15d	<sup>1</sup> D	2	48 760.14
4s11f	<sup>1</sup> F°	3	48 384.039	4s15d	<sup>3</sup> D	1	48 761.11
4s13p	<sup>3</sup> P°	1	48 404.57			2	48 761.21
		2	48 404.95			3	48 761.31
4s13p	<sup>1</sup> P°	1	48 422.09	4s17s	<sup>3</sup> S	1	48 787.89
4s12d	<sup>3</sup> D	1	48 433.23	4s17s	<sup>1</sup> S	0	48 795.46
		2	48 433.65	4s15f	<sup>1</sup> F°	3	48 812.09
		3	48 434.36				
4s12d	<sup>1</sup> D	2	48 451.73	4s17p	<sup>3</sup> P°	2	48 820.60
4s14s	<sup>3</sup> S	1	48 484.12	4s17p	<sup>1</sup> P°	1	48 826.54
4s14s	<sup>1</sup> S	0	48 499.14	4s16d	<sup>1</sup> D	2	48 827.05
3d <sup>2</sup>	<sup>3</sup> P	0	48 524.093	4s16d	<sup>3</sup> D	2	48 830.41
		1	48 537.623			1	48 830.44
		2	48 563.522			3	48 830.64
4s12f	<sup>3</sup> F°	3,4	48 531.04	4s18s	<sup>3</sup> S	1	48 852.18
4s12f	<sup>1</sup> F°	3	48 532.139	4s18s	<sup>1</sup> S	0	48 858.59
4s14p	<sup>3</sup> P°	1	48 548.30	4s16f	<sup>1</sup> F°	3	48 872.20
		2	48 548.51	4s18p	<sup>3</sup> P°	2	48 879.31
4s14p	<sup>1</sup> P°	1	48 561.10	4s17d	<sup>1</sup> D	2	48 882.37
4s13d	<sup>3</sup> D	1	48 568.95	4s18p	<sup>1</sup> P°	1	48 884.06
		2	48 569.16				
		3	48 569.59	4s17d	<sup>3</sup> D	3	48 887.58
4s13d	<sup>1</sup> D	2	48 578.32			2	48 887.68

Ca I: Ordered by term values—Continued

Configuration	Term	<i>J</i>	Level (cm <sup>-1</sup> )	Configuration	Term	<i>J</i>	Level (cm <sup>-1</sup> )
4s19s	<sup>1</sup> S	0	48 910.65	4s23f	<sup>1</sup> F°	3	49 096.74
4s17f	<sup>1</sup> F°	3	48 921.95	4s25p	<sup>3</sup> P°	2	49 099.25
4s19p	<sup>3</sup> P°	2	48 927.93	4s25p	<sup>1</sup> P°	1	49 100.72
4s18d	<sup>1</sup> D	2	48 928.79	4s26s	<sup>1</sup> S	0	49 109.85
4s19p	<sup>1</sup> P°	1	48 931.82	4s25d	<sup>1</sup> D	2	49 113.41
4s20s	<sup>1</sup> S	0	48 954.13	4s24f	<sup>1</sup> F°	3	49 113.85
4s18f	<sup>1</sup> F°	3	48 963.67	4s26p	<sup>3</sup> P°	2	49 116.07
4s19d	<sup>1</sup> D	2	48 968.10	4s26p	<sup>1</sup> P°	1	49 117.38
4s20p	<sup>3</sup> P°	2	48 968.67	4s27s	<sup>1</sup> S	0	49 125.44
4s20p	<sup>1</sup> P°	1	48 971.93	4s26d	<sup>1</sup> D	2	49 128.34
4s21s	<sup>1</sup> S	0	48 990.83	4s25f	<sup>1</sup> F°	3	49 129.00
4s19f	<sup>1</sup> F°	3	48 998.89	4s27p	<sup>3</sup> P°	2	49 130.94
4s20d	<sup>1</sup> D	2	49 001.66	4s27p	<sup>1</sup> P°	1	49 132.09
4s21p	<sup>3</sup> P°	2	49 003.21	4s28s	<sup>1</sup> S	0	49 139.31
4s21p	<sup>1</sup> P°	1	49 005.92	4s27d	<sup>1</sup> D	2	49 141.63
4s22s	<sup>1</sup> S	0	49 022.02	4s26f	<sup>1</sup> F°	3	49 142.38
4s20f	<sup>1</sup> F°	3	49 028.93	4s28p	<sup>3</sup> P°	2	49 144.19
4s21d	<sup>1</sup> D	2	49 030.55	4s28p	<sup>1</sup> P°	1	49 145.15
4s22p	<sup>3</sup> P°	2	49 032.70	4s29s	<sup>1</sup> S	0	49 151.59
4s22p	<sup>1</sup> P°	1	49 034.98	4s28d	<sup>1</sup> D	2	49 153.49
4s23s	<sup>1</sup> S	0	49 048.85	4s27f	<sup>1</sup> F°	3	49 154.29
4s21f	<sup>1</sup> F°	3	49 054.80	4s29p	<sup>3</sup> P°	2	49 155.90
4s22d	<sup>1</sup> D	2	49 055.62	4s29p	<sup>1</sup> P°	1	49 156.78
4s23p	<sup>3</sup> P°	2	49 058.02	4s30s	<sup>1</sup> S	0	49 162.47
4s23p	<sup>1</sup> P°	1	49 060.02	4s29d	<sup>1</sup> D	2	49 164.12
4s24s	<sup>1</sup> S	0	49 071.99	4s28f	<sup>1</sup> F°	3	49 164.99
4s22f	<sup>1</sup> F°	3	49 077.20	4s30p	<sup>3</sup> P°	2	49 166.43
4s23d	<sup>1</sup> D	2	49 077.48	4s30p	<sup>1</sup> P°	1	49 167.20
4s24p	<sup>3</sup> P°	2	49 080.04	4s31s	<sup>1</sup> S	0	49 172.43
4s24p	<sup>1</sup> P°	1	49 081.75	4s30d	<sup>1</sup> D	2	49 173.70
4s25s	<sup>1</sup> S	0	49 092.19	4s31p	<sup>3</sup> P°	2	49 175.87
4s24d	<sup>1</sup> D	2	49 096.52	4s31p	<sup>1</sup> P°	1	49 176.58

Ca I: Ordered by term values—Continued

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

Ca I: Ordered by term values—Continued

Configuration	Term	<i>J</i>	Level (cm <sup>-1</sup> )	Configuration	Term	<i>J</i>	Level (cm <sup>-1</sup> )
4s52p	<sup>1</sup> P°	1	49 262.30	4s66p	<sup>1</sup> P°	1	49 279.30
4s52d	<sup>1</sup> D	2	49 263.31	4s67p	<sup>1</sup> P°	1	49 280.10
4s53p	<sup>3</sup> P°	2	49 263.85	4s68p	<sup>1</sup> P°	1	49 280.88
4s53p	<sup>1</sup> P°	1	49 263.99	4s69p	<sup>1</sup> P°	1	49 281.62
4s53d	<sup>1</sup> D	2	49 264.77	4s70p	<sup>1</sup> P°	1	49 282.34
4s54p	<sup>3</sup> P°	2	49 265.44	4s71p	<sup>1</sup> P°	1	49 283.01
4s54p	<sup>1</sup> P°	1	49 265.59	4s72p	<sup>1</sup> P°	1	49 283.67
4s54d	<sup>1</sup> D	2	49 266.36	4s73p	<sup>1</sup> P°	1	49 284.30
4s55p	<sup>3</sup> P°	2	49 266.99	4s74p	<sup>1</sup> P°	1	49 284.88
4s55p	<sup>1</sup> P°	1	49 267.10	4s75p	<sup>1</sup> P°	1	49 285.46
4s55d	<sup>1</sup> D	2	49 267.84	4s76p	<sup>1</sup> P°	1	49 286.00
4s56p	<sup>3</sup> P°	2	49 268.40	4s77p	<sup>1</sup> P°	1	49 286.54
4s56p	<sup>1</sup> P°	1	49 268.52	4s78p	<sup>1</sup> P°	1	49 287.05
4s56d	<sup>1</sup> D	2	49 269.33	4s79p	<sup>1</sup> P°	1	49 287.57
4s57p	<sup>3</sup> P°	2	49 269.77	Ca II ( <sup>2</sup> S <sub>1/2</sub> )	<b>Limit</b>		<b>49 305.96</b>
4s57p	<sup>1</sup> P°	1	49 269.88	3d 4d	<sup>3</sup> D	1	51 351.74
4s57d	<sup>1</sup> D	2	49 270.40			2	51 369.38
4s58p	<sup>3</sup> P°	2	49 271.01	3d 4d		3	51 396.32
4s58p	<sup>1</sup> P°	1	49 271.14	3d 5p	<sup>3</sup> S	1	51 571.7
4s58d	<sup>1</sup> D	2	49 271.79				
4s59p	<sup>3</sup> P°	2	49 272.24	3d 5p	<sup>3</sup> D°	1	51 709.5
4s59p	<sup>1</sup> P°	1	49 272.35			2	51 734.6
4s59d	<sup>1</sup> D	2	49 273.09	3d 5p		3	51 767.0
4s60p	<sup>3</sup> P°	2	49 273.37				
4s60p	<sup>1</sup> P°	1	49 273.50	3d 4f	<sup>3</sup> P°	1	51 908.
4s60d	<sup>1</sup> D	2	49 274.29			1	53 100.
4s61p	<sup>1</sup> P°	1	49 274.60	3d 4f	<sup>3</sup> P	0	54 282.3
4s61d	<sup>1</sup> D	2	49 275.58			1	54 288.74
4s62p	<sup>1</sup> P°	1	49 275.62	3d 4f		2	54 304.6
4s62d	<sup>1</sup> D	2	49 275.87	3d 6p	<sup>3</sup> D°	1	55 902.8
4s63p	<sup>1</sup> P°	1	49 276.61				
4s64p	<sup>1</sup> P°	1	49 277.55	3d 5d	<sup>3</sup> P°	1	55 946.6
4s65p	<sup>1</sup> P°	1	49 278.44			1	55 982.3
				3d 6p	<sup>3</sup> D°	1	56 254.
						2	56 469.0
				4p5s	<sup>3</sup> P°	1	56 532.63
				3d 5d	<sup>3</sup> S	1	56 558.9
				4p5s	<sup>1</sup> P°	1	56 651.
				3d 5f	<sup>3</sup> P°	1	57 462.
				3d 5f	<sup>3</sup> P	0	57 611.2
						1	57 617.9
						2	57 638.4
					<sup>1</sup> P°	1	57 960.
					<sup>3</sup> D°	1	58 431.31
					<sup>3</sup> P°	1	58 491.91

## Ca I: Ordered by term values—Continued

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

Ca I. Ordered by term values—Continued

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

Ca I: Ordered by term values—Continued

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

**ENERGY LEVELS OF CALCIUM**  
Ca I: Ordered by term values—Continued

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Configuration	Term	<i>J</i>	Level (cm <sup>-1</sup> )	Configuration	Term	<i>J</i>	Level (cm <sup>-1</sup> )
3d 58p	<sup>3</sup> D°	1	62 921.43	3p <sup>5</sup> 4s <sup>2</sup> 4d	<sup>3</sup> D°	1	267 956
3d 36p	<sup>1</sup> P°	1	62 923.62	3p <sup>5</sup> ( <sup>2</sup> P <sub>1/2</sub> °) 4s <sup>2</sup> 6s	<sup>2</sup> [ <sup>1</sup> / <sub>2</sub> ]°	1	269 706
3d 35f	<sup>1</sup> P°	1	62 926.36	3p <sup>5</sup> 4s <sup>2</sup> 4d	<sup>1</sup> P°	1	270 640
3d 37p	<sup>1</sup> P°	1	62 928.81	3p <sup>5</sup> ( <sup>2</sup> P <sub>3/2</sub> °) 4s <sup>2</sup> 5d	<sup>2</sup> [ <sup>3</sup> / <sub>2</sub> ]°	1	270 889
3d 36f	<sup>1</sup> P°	1	62 931.29	3p <sup>5</sup> ( <sup>2</sup> P <sub>3/2</sub> °) 4s <sup>2</sup> 7s	<sup>2</sup> [ <sup>3</sup> / <sub>2</sub> ]°	1	271 245
3d 38p	<sup>1</sup> P°	1	62 933.61	3p <sup>5</sup> ( <sup>2</sup> P <sub>3/2</sub> °) 4s <sup>2</sup> 6d	<sup>2</sup> [ <sup>3</sup> / <sub>2</sub> ]°	1	273 134
3d 37f	<sup>1</sup> P°	1	62 935.88	3p <sup>5</sup> ( <sup>2</sup> P <sub>1/2</sub> °) 4s <sup>2</sup> 7s	<sup>2</sup> [ <sup>1</sup> / <sub>2</sub> ]°	1	273 598
3d 39p	<sup>1</sup> P°	1	62 938.02	3p <sup>5</sup> ( <sup>2</sup> P <sub>3/2</sub> °) 4s <sup>2</sup> 7d	<sup>2</sup> [ <sup>3</sup> / <sub>2</sub> ]°	1	273 959
3d 38f	<sup>1</sup> P°	1	62 939.79	3p <sup>5</sup> ( <sup>2</sup> P <sub>1/2</sub> °) 4s <sup>2</sup> 5d	<sup>2</sup> [ <sup>3</sup> / <sub>2</sub> ]°	1	274 040
3d 40p	<sup>1</sup> P°	1	62 942.10	3p <sup>5</sup> ( <sup>2</sup> P <sub>3/2</sub> °) 4s <sup>2</sup> 9s	<sup>2</sup> [ <sup>3</sup> / <sub>2</sub> ]°	1	274 276
3d 39f	<sup>1</sup> P°	1	62 943.85	3p <sup>5</sup> ( <sup>2</sup> P <sub>3/2</sub> °) 4s <sup>2</sup> 8d	<sup>2</sup> [ <sup>3</sup> / <sub>2</sub> ]°	1	274 652
3d 41p	<sup>1</sup> P°	1	62 945.88	3p <sup>5</sup> ( <sup>2</sup> P <sub>3/2</sub> °) 4s <sup>2</sup> 10s	<sup>2</sup> [ <sup>3</sup> / <sub>2</sub> ]°	1	274 777
3d 42p	<sup>1</sup> P°	1	62 949.34	3p <sup>5</sup> ( <sup>2</sup> P <sub>3/2</sub> °) 4s <sup>2</sup> 9d	<sup>2</sup> [ <sup>3</sup> / <sub>2</sub> ]°	1	275 272
3d 43p	<sup>1</sup> P°	1	62 952.58	3p <sup>5</sup> ( <sup>2</sup> P <sub>3/2</sub> °) 4s <sup>2</sup> 10d	<sup>2</sup> [ <sup>3</sup> / <sub>2</sub> ]°	1	275 503
3d 44p	<sup>1</sup> P°	1	62 955.57	3p <sup>5</sup> ( <sup>2</sup> P <sub>3/2</sub> °) 4s <sup>2</sup> 11d	<sup>2</sup> [ <sup>3</sup> / <sub>2</sub> ]°	1	275 726
Ca II ( <sup>2</sup> D <sub>3/2</sub> )	<i>Limit</i>		62 956.15	3p <sup>5</sup> ( <sup>2</sup> P <sub>3/2</sub> °) 4s <sup>2</sup> 12d	<sup>2</sup> [ <sup>3</sup> / <sub>2</sub> ]°	1	275 898
3d 45p	<sup>1</sup> P°	1	62 958.38	3p <sup>5</sup> ( <sup>2</sup> P <sub>3/2</sub> °) 4s <sup>2</sup> 13d	<sup>2</sup> [ <sup>3</sup> / <sub>2</sub> ]°	1	276 038
3d 46p	<sup>1</sup> P°	1	62 961.01	3p <sup>5</sup> ( <sup>2</sup> P <sub>3/2</sub> °) 4s <sup>2</sup> 14d	<sup>2</sup> [ <sup>3</sup> / <sub>2</sub> ]°	1	276 138
3d 47p	<sup>1</sup> P°	1	62 963.43	3p <sup>5</sup> ( <sup>2</sup> P <sub>3/2</sub> °) 4s <sup>2</sup> 15d	<sup>2</sup> [ <sup>3</sup> / <sub>2</sub> ]°	1	276 214
3d 48p	<sup>1</sup> P°	1	62 965.72	3p <sup>5</sup> ( <sup>2</sup> P <sub>3/2</sub> °) 4s <sup>2</sup> 16d	<sup>2</sup> [ <sup>3</sup> / <sub>2</sub> ]°	1	276 283
3d 49p	<sup>1</sup> P°	1	62 967.84	3p <sup>5</sup> ( <sup>2</sup> P <sub>1/2</sub> °) 4s <sup>2</sup> 7d	<sup>2</sup> [ <sup>3</sup> / <sub>2</sub> ]°	1	276 631
3d 50p	<sup>1</sup> P°	1	62 969.89	Ca II 3p <sup>5</sup> 4s <sup>2</sup> <sup>2</sup> P <sub>3/2</sub>	<i>Limit</i>		276 750
3d 51p	<sup>1</sup> P°	1	62 971.78	3p <sup>5</sup> ( <sup>2</sup> P <sub>1/2</sub> °) 4s <sup>2</sup> 8d	<sup>2</sup> [ <sup>3</sup> / <sub>2</sub> ]°	1	277 430
3d 52p	<sup>1</sup> P°	1	62 973.55	3p <sup>5</sup> ( <sup>2</sup> P <sub>1/2</sub> °) 4s <sup>2</sup> 9d	<sup>2</sup> [ <sup>3</sup> / <sub>2</sub> ]°	1	277 917
3d 53p	<sup>1</sup> P°	1	62 975.23	3p <sup>5</sup> ( <sup>2</sup> P <sub>1/2</sub> °) 4s <sup>2</sup> 11s	<sup>2</sup> [ <sup>1</sup> / <sub>2</sub> ]°	1	277 991
3d 54p	<sup>1</sup> P°	1	62 976.81	3p <sup>5</sup> ( <sup>2</sup> P <sub>1/2</sub> °) 4s <sup>2</sup> 10d	<sup>2</sup> [ <sup>3</sup> / <sub>2</sub> ]°	1	278 228
3d 55p	<sup>1</sup> P°	1	62 978.26	3p <sup>5</sup> ( <sup>2</sup> P <sub>1/2</sub> °) 4s <sup>2</sup> 12s	<sup>2</sup> [ <sup>1</sup> / <sub>2</sub> ]°	1	278 302
3d 56p	<sup>1</sup> P°	1	62 979.72	3p <sup>5</sup> ( <sup>2</sup> P <sub>1/2</sub> °) 4s <sup>2</sup> 11d	<sup>2</sup> [ <sup>3</sup> / <sub>2</sub> ]°	1	278 469
3d 57p	<sup>1</sup> P°	1	62 981.03	3p <sup>5</sup> ( <sup>2</sup> P <sub>1/2</sub> °) 4s <sup>2</sup> 13s	<sup>2</sup> [ <sup>1</sup> / <sub>2</sub> ]°	1	278 534
3d 58p	<sup>1</sup> P°	1	62 982.35	3p <sup>5</sup> ( <sup>2</sup> P <sub>1/2</sub> °) 4s <sup>2</sup> 12d	<sup>2</sup> [ <sup>3</sup> / <sub>2</sub> ]°	1	278 647
3d 59p	<sup>1</sup> P°	1	62 983.48				
3d 60p	<sup>1</sup> P°	1	62 984.63				
3d 61p	<sup>1</sup> P°	1	62 985.70				
Ca II ( <sup>2</sup> D <sub>5/2</sub> )	<i>Limit</i>		63 016.84				
3p <sup>5</sup> 4s <sup>2</sup> 3d	<sup>3</sup> P°	1	200 096				
3p <sup>5</sup> 4s <sup>2</sup> 3d	<sup>3</sup> D°	1	218 991				
3p <sup>5</sup> 4s <sup>2</sup> 3d	<sup>1</sup> P°	1	253 310				
3p <sup>5</sup> 4s <sup>2</sup> 4d	<sup>3</sup> P°	1	255 022				
3p <sup>5</sup> ( <sup>2</sup> P <sub>3/2</sub> °) 4s <sup>2</sup> 5s	<sup>2</sup> [ <sup>3</sup> / <sub>2</sub> ]°	1	257 737				
3p <sup>5</sup> ( <sup>2</sup> P <sub>1/2</sub> °) 4s <sup>2</sup> 5s	<sup>2</sup> [ <sup>1</sup> / <sub>2</sub> ]°	1	260 193				
3p <sup>5</sup> ( <sup>2</sup> P <sub>3/2</sub> °) 4s <sup>2</sup> 6s	<sup>2</sup> [ <sup>3</sup> / <sub>2</sub> ]°	1	267 417				

Ca I: Ordered by term values—Continued

Configuration	Term	<i>J</i>	Level (cm <sup>-1</sup> )	Configuration	Term	<i>J</i>	Level (cm <sup>-1</sup> )
$3p^5(^2P_{1/2}^{\circ})4s^2 14s$	$^2[1/2]^{\circ}$	1	278 702	$3p^5(^2P_{1/2}^{\circ})4s^2 16d$	$^2[3/2]^{\circ}$	1	279 050
$3p^5(^2P_{1/2}^{\circ})4s^2 13d$	$^2[3/2]^{\circ}$	1	278 796	$3p^5(^2P_{1/2}^{\circ})4s^2 17d$	$^2[3/2]^{\circ}$	1	279 117
$3p^5(^2P_{1/2}^{\circ})4s^2 14d$	$^2[3/2]^{\circ}$	1	278 900	Ca II $3p^5 4s^2 P_{1/2}^{\circ}$	<b>Limit</b>		279 530
$3p^5(^2P_{1/2}^{\circ})4s^2 15d$	$^2[3/2]^{\circ}$	1	278 983				

Ca I: Ordered by series

Configuration	Term	<i>J</i>	Level (cm <sup>-1</sup> )	Configuration	Term	<i>J</i>	Level (cm <sup>-1</sup> )
4s <sup>2</sup>	<sup>1</sup> S	0	0.000	4s33p	<sup>3</sup> P°	2	49 192.08
*****	***	*	*****	4s34p	<sup>3</sup> P°	2	49 199.09
4s4p	<sup>3</sup> P°	0	15 157.901	4s35p	<sup>3</sup> P°	2	49 205.47
		1	15 210.063	4s36p	<sup>3</sup> P°	2	49 211.34
		2	15 315.943	4s37p	<sup>3</sup> P°	2	49 216.61
4s5p	<sup>3</sup> P°	0	36 547.688	4s38p	<sup>3</sup> P°	2	49 221.51
		1	36 554.749	4s39p	<sup>3</sup> P°	2	49 226.02
		2	36 575.119	4s40p	<sup>3</sup> P°	2	49 230.13
4s6p	<sup>3</sup> P°	0	42 514.845	4s41p	<sup>3</sup> P°	2	49 234.00
		1	42 518.708	4s42p	<sup>3</sup> P°	2	49 237.55
		2	42 526.591	4s43p	<sup>3</sup> P°	2	49 240.81
4s7p	<sup>3</sup> P°	0	44 955.67	4s44p	<sup>3</sup> P°	2	49 243.87
		1	44 957.655	4s45p	<sup>3</sup> P°	2	49 246.74
		2	44 961.757	4s46p	<sup>3</sup> P°	2	49 249.37
4s8p	<sup>3</sup> P°	0	46 284.12	4s47p	<sup>3</sup> P°	2	49 251.87
		1	46 285.23	4s48p	<sup>3</sup> P°	2	49 254.22
		2	46 287.63	4s49p	<sup>3</sup> P°	2	49 256.42
4s9p	<sup>3</sup> P°	1	47 085.38	4s50p	<sup>3</sup> P°	2	49 258.45
		2	47 086.99	4s51p	<sup>3</sup> P°	2	49 260.36
4s10p	<sup>3</sup> P°	1	47 604.75	4s52p	<sup>3</sup> P°	2	49 262.15
		2	47 605.77	4s53p	<sup>3</sup> P°	2	49 263.85
4s11p	<sup>3</sup> P°	1	47 960.87	4s54p	<sup>3</sup> P°	2	49 265.44
		2	47 961.53	4s55p	<sup>3</sup> P°	2	49 266.99
4s12p	<sup>3</sup> P°	1	48 215.81	4s56p	<sup>3</sup> P°	2	49 268.40
		2	48 216.36	4s57p	<sup>3</sup> P°	2	49 269.77
4s13p	<sup>3</sup> P°	1	48 404.57	4s58p	<sup>3</sup> P°	2	49 271.01
		2	48 404.95	4s59p	<sup>3</sup> P°	2	49 272.24
4s14p	<sup>3</sup> P°	1	48 548.30	4s60p	<sup>3</sup> P°	2	49 273.37
		2	48 548.51	Ca II ( <sup>2</sup> S <sub>1/2</sub> )	<i>Limit</i>		49 305.96
4s15p	<sup>3</sup> P°	2	48 660.23	4s4p	<sup>1</sup> P°	1	23 652.304
4s16p	<sup>3</sup> P°	2	48 749.04	4s5p	<sup>1</sup> P°	1	36 731.615
4s17p	<sup>3</sup> P°	2	48 820.60	4s6p	<sup>1</sup> P°	1	41 679.008
4s18p	<sup>3</sup> P°	2	48 879.31	4s7p	<sup>1</sup> P°	1	45 425.358
4s19p	<sup>3</sup> P°	2	48 927.93	4s8p	<sup>1</sup> P°	1	46 479.813
4s20p	<sup>3</sup> P°	2	48 968.67	4s9p	<sup>1</sup> P°	1	47 184.370
4s21p	<sup>3</sup> P°	2	49 003.21	4s10p	<sup>1</sup> P°	1	47 662.10
4s22p	<sup>3</sup> P°	2	49 032.70	4s11p	<sup>1</sup> P°	1	47 997.49
4s23p	<sup>3</sup> P°	2	49 058.02	4s12p	<sup>1</sup> P°	1	48 240.53
4s24p	<sup>3</sup> P°	2	49 080.04	4s13p	<sup>1</sup> P°	1	48 422.09
4s25p	<sup>3</sup> P°	2	49 099.25	4s14p	<sup>1</sup> P°	1	48 561.10
4s26p	<sup>3</sup> P°	2	49 116.07	4s15p	<sup>1</sup> P°	1	48 669.83
4s27p	<sup>3</sup> P°	2	49 130.94	4s16p	<sup>1</sup> P°	1	48 756.45
4s28p	<sup>3</sup> P°	2	49 144.19	4s17p	<sup>1</sup> P°	1	48 826.54
4s29p	<sup>3</sup> P°	2	49 155.90	4s18p	<sup>1</sup> P°	1	48 884.06
4s30p	<sup>3</sup> P°	2	49 166.43	4s19p	<sup>1</sup> P°	1	48 931.82
4s31p	<sup>3</sup> P°	2	49 175.87	4s20p	<sup>1</sup> P°	1	48 971.93
4s32p	<sup>3</sup> P°	2	49 184.37	4s21p	<sup>1</sup> P°	1	49 005.92
				4s22p	<sup>1</sup> P°	1	49 034.98
				4s23p	<sup>1</sup> P°	1	49 060.02
				4s24p	<sup>1</sup> P°	1	49 081.75
				4s25p	<sup>1</sup> P°	1	49 100.72
				4s26p	<sup>1</sup> P°	1	49 117.38
				4s27p	<sup>1</sup> P°	1	49 132.09
				4s28p	<sup>1</sup> P°	1	49 145.15
				4s29p	<sup>1</sup> P°	1	49 156.78
				4s30p	<sup>1</sup> P°	1	49 167.20
				4s31p	<sup>1</sup> P°	1	49 176.58
				4s32p	<sup>1</sup> P°	1	49 185.02

Ca I: Ordered by series—Continued

Configuration	Term	<i>J</i>	Level (cm <sup>-1</sup> )	Configuration	Term	<i>J</i>	Level (cm <sup>-1</sup> )
4s33p	<sup>1</sup> P°	1	49 192.68	4s5d	<sup>3</sup> D	1	42 743.002
4s34p	<sup>1</sup> P°	1	49 199.62			2	42 744.716
4s35p	<sup>1</sup> P°	1	49 205.95			3	42 747.387
4s36p	<sup>1</sup> P°	1	49 211.72				
4s37p	<sup>1</sup> P°	1	49 217.02	4s6d	<sup>3</sup> D	1	45 049.073
4s38p	<sup>1</sup> P°	1	49 221.87			2	45 050.419
4s39p	<sup>1</sup> P°	1	49 226.35			3	45 052.374
4s40p	<sup>1</sup> P°	1	49 230.45				
4s41p	<sup>1</sup> P°	1	49 234.28	4s7d	<sup>3</sup> D	1	46 301.973
4s42p	<sup>1</sup> P°	1	49 237.82			2	46 303.649
4s43p	<sup>1</sup> P°	1	49 241.09			3	46 306.059
4s44p	<sup>1</sup> P°	1	49 244.13				
4s45p	<sup>1</sup> P°	1	49 246.98	4s8d	<sup>3</sup> D	1	47 036.225
4s46p	<sup>1</sup> P°	1	49 249.61			2	47 040.007
4s47p	<sup>1</sup> P°	1	49 252.08			3	47 045.241
4s48p	<sup>1</sup> P°	1	49 254.41				
4s49p	<sup>1</sup> P°	1	49 256.56	4s9d	<sup>3</sup> D	1	47 752.655
4s50p	<sup>1</sup> P°	1	49 258.60			2	47 757.286
4s51p	<sup>1</sup> P°	1	49 260.51			3	47 765.697
4s52p	<sup>1</sup> P°	1	49 262.30				
4s53p	<sup>1</sup> P°	1	49 263.99	4s10d	<sup>3</sup> D	1	48 031.58
4s54p	<sup>1</sup> P°	1	49 265.59			2	48 033.23
4s55p	<sup>1</sup> P°	1	49 267.10			3	48 036.212
4s56p	<sup>1</sup> P°	1	49 268.52				
4s57p	<sup>1</sup> P°	1	49 269.88	4s11d	<sup>3</sup> D	1	48 258.30
4s58p	<sup>1</sup> P°	1	49 271.14			2	48 258.98
4s59p	<sup>1</sup> P°	1	49 272.35			3	48 260.25
4s60p	<sup>1</sup> P°	1	49 273.50				
4s61p	<sup>1</sup> P°	1	49 274.60	4s12d	<sup>3</sup> D	1	48 433.23
4s62p	<sup>1</sup> P°	1	49 275.62			2	48 433.65
4s63p	<sup>1</sup> P°	1	49 276.61			3	48 434.36
4s64p	<sup>1</sup> P°	1	49 277.55				
4s65p	<sup>1</sup> P°	1	49 278.44	4s13d	<sup>3</sup> D	1	48 568.95
4s66p	<sup>1</sup> P°	1	49 279.30			2	48 569.16
4s67p	<sup>1</sup> P°	1	49 280.10			3	48 569.59
4s68p	<sup>1</sup> P°	1	49 280.88				
4s69p	<sup>1</sup> P°	1	49 281.62	4s14d	<sup>3</sup> D	1	48 675.68
4s70p	<sup>1</sup> P°	1	49 282.34			2	48 675.87
4s71p	<sup>1</sup> P°	1	49 283.01			3	48 676.13
4s72p	<sup>1</sup> P°	1	49 283.67				
4s73p	<sup>1</sup> P°	1	49 284.30	4s15d	<sup>3</sup> D	1	48 761.11
4s74p	<sup>1</sup> P°	1	49 284.88			2	48 761.21
4s75p	<sup>1</sup> P°	1	49 285.46			3	48 761.31
4s76p	<sup>1</sup> P°	1	49 286.00				
4s77p	<sup>1</sup> P°	1	49 286.54	4s16d	<sup>3</sup> D	2	48 830.41
4s78p	<sup>1</sup> P°	1	49 287.05			1	48 830.44
4s79p	<sup>1</sup> P°	1	49 287.57	4s17d	<sup>3</sup> D	3	48 830.64
						2	48 887.68
Ca II ( <sup>2</sup> S <sub>1/2</sub> )	<b>Limit</b>		<b>49 305.96</b>	Ca II ( <sup>2</sup> S <sub>1/2</sub> )	<b>Limit</b>		<b>49 305.96</b>
4s3d	<sup>3</sup> D	1	20 335.360	4s3d	<sup>1</sup> D	2	21 849.634
		2	20 349.260	4s4d	<sup>1</sup> D	2	37 298.287
		3	20 371.000	4s5d	<sup>1</sup> D	2	42 919.053
4s4d	<sup>3</sup> D	1	37 748.197	4s6d	<sup>1</sup> D	2	44 989.830
		2	37 751.867	4s7d	<sup>1</sup> D	2	46 200.13
		3	37 757.449	4s8d	<sup>1</sup> D	2	46 948.98

Ca I: Ordered by series—Continued

Configuration	Term	<i>J</i>	Level (cm <sup>-1</sup> )	Configuration	Term	<i>J</i>	Level (cm <sup>-1</sup> )
4s9d	<sup>1</sup> D	2	47 812.39	4s8s	<sup>3</sup> S	1	45 738.684
4s10d	<sup>1</sup> D	2	48 083.41	4s9s	<sup>3</sup> S	1	46 748.283
4s11d	<sup>1</sup> D	2	48 290.85	4s10s	<sup>3</sup> S	1	47 382.048
4s12d	<sup>1</sup> D	2	48 451.73	4s11s	<sup>3</sup> S	1	47 806.17
4s13d	<sup>1</sup> D	2	48 578.32	4s12s	<sup>3</sup> S	1	48 103.93
4s14d	<sup>1</sup> D	2	48 678.97	4s13s	<sup>3</sup> S	1	48 321.00
4s15d	<sup>1</sup> D	2	48 760.14	4s14s	<sup>3</sup> S	1	48 484.12
4s16d	<sup>1</sup> D	2	48 827.05	4s15s	<sup>3</sup> S	1	48 609.75
4s17d	<sup>1</sup> D	2	48 882.37	4s16s	<sup>3</sup> S	1	48 708.67
4s18d	<sup>1</sup> D	2	48 928.79	4s17s	<sup>3</sup> S	1	48 787.89
4s19d	<sup>1</sup> D	2	48 968.10	4s18s	<sup>3</sup> S	1	48 852.18
4s20d	<sup>1</sup> D	2	49 001.66				
4s21d	<sup>1</sup> D	2	49 030.55	Ca II ( <sup>2</sup> S <sub>1/2</sub> )	<i>Limit</i>		49 305.96
4s22d	<sup>1</sup> D	2	49 055.62				
4s23d	<sup>1</sup> D	2	49 077.48	4s5s	<sup>1</sup> S	0	33 317.264
4s24d	<sup>1</sup> D	2	49 096.52	4s6s	<sup>1</sup> S	0	40 690.435
4s25d	<sup>1</sup> D	2	49 113.41	4s7s	<sup>1</sup> S	0	44 276.538
4s26d	<sup>1</sup> D	2	49 128.34	4s8s	<sup>1</sup> S	0	45 887.200
4s27d	<sup>1</sup> D	2	49 141.63	4s9s	<sup>1</sup> S	0	46 835.055
4s28d	<sup>1</sup> D	2	49 153.49	4s10s	<sup>1</sup> S	0	47 437.471
4s29d	<sup>1</sup> D	2	49 164.12	4s11s	<sup>1</sup> S	0	47 843.76
4s30d	<sup>1</sup> D	2	49 173.70	4s12s	<sup>1</sup> S	0	48 130.75
4s31d	<sup>1</sup> D	2	49 182.36	4s13s	<sup>1</sup> S	0	48 340.75
4s32d	<sup>1</sup> D	2	49 190.17	4s14s	<sup>1</sup> S	0	48 499.14
4s33d	<sup>1</sup> D	2	49 197.30	4s15s	<sup>1</sup> S	0	48 621.53
4s34d	<sup>1</sup> D	2	49 203.78	4s16s	<sup>1</sup> S	0	48 718.02
4s35d	<sup>1</sup> D	2	49 209.68	4s17s	<sup>1</sup> S	0	48 795.46
4s36d	<sup>1</sup> D	2	49 215.11	4s18s	<sup>1</sup> S	0	48 858.59
4s37d	<sup>1</sup> D	2	49 220.10	4s19s	<sup>1</sup> S	0	48 910.65
4s38d	<sup>1</sup> D	2	49 224.70	4s20s	<sup>1</sup> S	0	48 954.13
4s39d	<sup>1</sup> D	2	49 228.92	4s21s	<sup>1</sup> S	0	48 990.83
4s40d	<sup>1</sup> D	2	49 232.81	4s22s	<sup>1</sup> S	0	49 022.02
4s41d	<sup>1</sup> D	2	49 236.45	4s23s	<sup>1</sup> S	0	49 048.85
4s42d	<sup>1</sup> D	2	49 239.80	4s24s	<sup>1</sup> S	0	49 071.99
4s43d	<sup>1</sup> D	2	49 242.93	4s25s	<sup>1</sup> S	0	49 092.19
4s44d	<sup>1</sup> D	2	49 245.80	4s26s	<sup>1</sup> S	0	49 109.85
4s45d	<sup>1</sup> D	2	49 248.52	4s27s	<sup>1</sup> S	0	49 125.44
4s46d	<sup>1</sup> D	2	49 251.05	4s28s	<sup>1</sup> S	0	49 139.31
4s47d	<sup>1</sup> D	2	49 253.40	4s29s	<sup>1</sup> S	0	49 151.59
4s48d	<sup>1</sup> D	2	49 255.64	4s30s	<sup>1</sup> S	0	49 162.47
4s49d	<sup>1</sup> D	2	49 257.74	4s31s	<sup>1</sup> S	0	49 172.43
4s50d	<sup>1</sup> D	2	49 259.68	4s32s	<sup>1</sup> S	0	49 181.49
4s51d	<sup>1</sup> D	2	49 261.51				
4s52d	<sup>1</sup> D	2	49 263.31	Ca II ( <sup>2</sup> S <sub>1/2</sub> )	<i>Limit</i>		49 305.96
4s53d	<sup>1</sup> D	2	49 264.77				
4s54d	<sup>1</sup> D	2	49 266.36	3d 4p	<sup>3</sup> F°	2	35 730.454
4s55d	<sup>1</sup> D	2	49 267.84			3	35 818.713
4s56d	<sup>1</sup> D	2	49 269.33			4	35 896.889
4s57d	<sup>1</sup> D	2	49 270.40				
4s58d	<sup>1</sup> D	2	49 271.79	3d 4p	<sup>1</sup> D°	2	35 835.413
4s59d	<sup>1</sup> D	2	49 273.09				
4s60d	<sup>1</sup> D	2	49 274.29	3d 4p	<sup>3</sup> D°	1	38 192.392
4s61d	<sup>1</sup> D	2	49 275.58			2	38 219.118
4s62d	<sup>1</sup> D	2	49 275.87			3	38 259.124
Ca II ( <sup>2</sup> S <sub>1/2</sub> )	<i>Limit</i>		49 305.96	3d 4p	<sup>3</sup> P°	0	39 333.382
						1	39 335.322
4s5s	<sup>3</sup> S	1	31 539.495			2	39 340.080
4s6s	<sup>3</sup> S	1	40 474.241				
4s7s	<sup>3</sup> S	1	43 980.767	3d 4p	<sup>1</sup> F°	3	40 537.893

Ca I: Ordered by series—Continued

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

Ca I: Ordered by series—Continued

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

Ca I: Ordered by series—Continued

Configuration	Term	<i>J</i>	Level (cm <sup>-1</sup> )	Configuration	Term	<i>J</i>	Level (cm <sup>-1</sup> )
3d <sup>2</sup>	<sup>3</sup> P	0	48 524.093	3d 26f	<sup>3</sup> D°	1	62 790.08
		1	48 537.623	3d 28f	<sup>3</sup> D°	1	62 812.00
		2	48 563.522	3d 30f	<sup>3</sup> D°	1	62 832.31
*****	***	*	*****	Ca II ( <sup>2</sup> D <sub>3/2</sub> )	<i>Limit</i>		62 956.15
3d 5s	<sup>1</sup> D	2	47 449.083	3d 4f	<sup>3</sup> P°	1	55 946.6
3d 5s	<sup>3</sup> D	1	47 456.452	3d 5f	<sup>3</sup> P°	1	58 491.91
		2	47 466.014	3d 6f	<sup>3</sup> P°	1	59 862.26
		3	47 475.915	3d 7f	<sup>3</sup> P°	1	60 690.27
*****	***	*	*****	3d 8f	<sup>3</sup> P°	1	61 228.65
3d 4d	<sup>3</sup> D	1	51 351.74	3d 9f	<sup>3</sup> P°	1	61 596.69
		2	51 369.38	3d 10f	<sup>3</sup> P°	1	61 859.22
		3	51 396.32	3d 11f	<sup>3</sup> P°	1	62 052.49
3d 4d	<sup>3</sup> S	1	51 571.7	3d 12f	<sup>3</sup> P°	1	62 198.92
3d 4d	<sup>3</sup> P	0	54 282.3	3d 13f	<sup>3</sup> P°	1	62 312.63
		1	54 288.74	3d 14f	<sup>3</sup> P°	1	62 403.22
		2	54 304.6	3d 15f	<sup>3</sup> P°	1	62 472.14
3d 5d	<sup>3</sup> D	2	56 469.0	3d 16f	<sup>3</sup> P°	1	62 533.90
		1	56 558.9	3d 17f	<sup>3</sup> P°	1	62 578.91
		0	57 611.2	3d 18f	<sup>3</sup> P°	1	62 617.02
3d 5d	<sup>3</sup> S	1	56 558.9	3d 19f	<sup>3</sup> P°	1	62 653.99
		0	57 611.2	3d 20f	<sup>3</sup> P°	1	62 683.89
		1	57 617.9	3d 21f	<sup>3</sup> P°	1	62 707.25
3d 5d	<sup>3</sup> P	2	57 638.4	3d 22f	<sup>3</sup> P°	1	62 729.19
		1	57 638.4	3d 23f	<sup>3</sup> P°	1	62 729.19
		0	57 611.2	3d 24f	<sup>3</sup> P°	1	62 748.53
3d 6d	<sup>3</sup> P	1	59 368.	3d 25f	<sup>3</sup> P°	1	62 764.10
		2	59 391.	3d 26f	<sup>3</sup> P°	1	62 780.30
		1	59 368.	3d 27f	<sup>3</sup> P°	1	62 794.19
*****	***	*	*****	3d 28f	<sup>3</sup> P°	1	62 806.02
3d 4f	<sup>3</sup> D°	1	55 902.8	3d 29f	<sup>3</sup> P°	1	62 816.51
3d 5f	<sup>3</sup> D°	1	58 431.31	3d 30f	<sup>3</sup> P°	1	62 824.17
3d 6f	<sup>3</sup> D°	1	59 802.21	3d 31f	<sup>3</sup> P°	1	62 834.11
3d 7f	<sup>3</sup> D°	1	60 632.18	3d 32f	<sup>3</sup> P°	1	62 840.23
3d 8f	<sup>3</sup> D°	1	61 172.54	3d 33f	<sup>3</sup> P°	1	62 848.77
3d 9f	<sup>3</sup> D°	1	61 543.95	3d 34f	<sup>3</sup> P°	1	62 853.79
3d 10f	<sup>3</sup> D°	1	61 810.68	3d 35f	<sup>3</sup> P°	1	62 861.06
3d 11f	<sup>3</sup> D°	1	62 009.17	3d 36f	<sup>3</sup> P°	1	62 865.39
3d 12f	<sup>3</sup> D°	1	62 161.61	3d 37f	<sup>3</sup> P°	1	62 871.46
3d 13f	<sup>3</sup> D°	1	62 279.33	3d 38f	<sup>3</sup> P°	1	62 875.40
3d 14f	<sup>3</sup> D°	1	62 375.29	Ca II ( <sup>2</sup> D <sub>3/2</sub> )	<i>Limit</i>		62 956.15
3d 15f	<sup>3</sup> D°	1	62 453.85	3d 4f	<sup>1</sup> P°	1	55 982.3
3d 16f	<sup>3</sup> D°	1	62 520.06	3d 5f	<sup>1</sup> P°	1	58 505.89
3d 17f	<sup>3</sup> D°	1	62 565.68	3d 6f	<sup>1</sup> P°	1	59 878.52
3d 18f	<sup>3</sup> D°	1	62 610.75	3d 7f	<sup>1</sup> P°	1	60 709.54
3d 19f	<sup>3</sup> D°	1	62 641.52	3d 8f	<sup>1</sup> P°	1	61 251.39
3d 20f	<sup>3</sup> D°	1	62 675.56	3d 9f	<sup>1</sup> P°	1	61 622.60
3d 21f	<sup>3</sup> D°	1	62 704.43	3d 10f	<sup>1</sup> P°	1	61 888.22
3d 22f	<sup>3</sup> D°	1	62 720.41	3d 11f	<sup>1</sup> P°	1	62 084.92
3d 23f	<sup>3</sup> D°	1	62 743.11	3d 12f	<sup>1</sup> P°	1	62 234.47
3d 24f	<sup>3</sup> D°	1	62 768.10	3d 13f	<sup>1</sup> P°	1	62 346.47
				3d 14f	<sup>1</sup> P°	1	62 433.38
				3d 15f	<sup>1</sup> P°	1	62 506.62
				3d 16f	<sup>1</sup> P°	1	62 572.66
				3d 17f	<sup>1</sup> P°	1	62 625.37
				3d 18f	<sup>1</sup> P°	1	62 671.51

## Ca I: Ordered by series—Continued

Configuration	Term	<i>J</i>	Level (cm <sup>-1</sup> )	Configuration	Term	<i>J</i>	Level (cm <sup>-1</sup> )
3d 19f	<sup>1</sup> P°	1	62 704.43	3p <sup>5</sup> ( <sup>2</sup> P <sub>3/2</sub> <sup>o</sup> )4s <sup>2</sup> 5s	<sup>2</sup> [ <sup>3</sup> / <sub>2</sub> ] <sup>o</sup>	1	257 737
3d 20f	<sup>1</sup> P°	1	62 736.10	3p <sup>5</sup> ( <sup>2</sup> P <sub>3/2</sub> <sup>o</sup> )4s <sup>2</sup> 6s	<sup>2</sup> [ <sup>3</sup> / <sub>2</sub> ] <sup>o</sup>	1	267 417
3d 21f	<sup>1</sup> P°	1	62 762.86	3p <sup>5</sup> ( <sup>2</sup> P <sub>3/2</sub> <sup>o</sup> )4s <sup>2</sup> 7s	<sup>2</sup> [ <sup>3</sup> / <sub>2</sub> ] <sup>o</sup>	1	271 245
3d 22f	<sup>1</sup> P°	1	62 785.02	3p <sup>5</sup> ( <sup>2</sup> P <sub>3/2</sub> <sup>o</sup> )4s <sup>2</sup> 9s	<sup>2</sup> [ <sup>3</sup> / <sub>2</sub> ] <sup>o</sup>	1	274 276
3d 23f	<sup>1</sup> P°	1	62 804.38	3p <sup>5</sup> ( <sup>2</sup> P <sub>3/2</sub> <sup>o</sup> )4s <sup>2</sup> 10s	<sup>2</sup> [ <sup>3</sup> / <sub>2</sub> ] <sup>o</sup>	1	274 777
3d 24f	<sup>1</sup> P°	1	62 820.31				
3d 25f	<sup>1</sup> P°	1	62 836.85	Ca II 3p <sup>5</sup> 4s <sup>2</sup> <sup>2</sup> P <sub>3/2</sub> <sup>o</sup>	<b>Limit</b>		<b>276 750</b>
3d 26f	<sup>1</sup> P°	1	62 852.33				
3d 35f	<sup>1</sup> P°	1	62 926.36	3p <sup>5</sup> ( <sup>2</sup> P <sub>1/2</sub> <sup>o</sup> )4s <sup>2</sup> 5s	<sup>2</sup> [ <sup>1</sup> / <sub>2</sub> ] <sup>o</sup>	1	260 193
3d 36f	<sup>1</sup> P°	1	62 931.29	3p <sup>5</sup> ( <sup>2</sup> P <sub>1/2</sub> <sup>o</sup> )4s <sup>2</sup> 6s	<sup>2</sup> [ <sup>1</sup> / <sub>2</sub> ] <sup>o</sup>	1	269 706
3d 37f	<sup>1</sup> P°	1	62 935.88	3p <sup>5</sup> ( <sup>2</sup> P <sub>1/2</sub> <sup>o</sup> )4s <sup>2</sup> 7s	<sup>2</sup> [ <sup>1</sup> / <sub>2</sub> ] <sup>o</sup>	1	273 598
3d 38f	<sup>1</sup> P°	1	62 939.79	3p <sup>5</sup> ( <sup>2</sup> P <sub>1/2</sub> <sup>o</sup> )4s <sup>2</sup> 11s	<sup>2</sup> [ <sup>1</sup> / <sub>2</sub> ] <sup>o</sup>	1	277 991
3d 39f	<sup>1</sup> P°	1	62 943.85	3p <sup>5</sup> ( <sup>2</sup> P <sub>1/2</sub> <sup>o</sup> )4s <sup>2</sup> 12s	<sup>2</sup> [ <sup>1</sup> / <sub>2</sub> ] <sup>o</sup>	1	278 302
Ca II ( <sup>2</sup> D <sub>5/2</sub> )	<b>Limit</b>		<b>63 016.84</b>	3p <sup>5</sup> ( <sup>2</sup> P <sub>1/2</sub> <sup>o</sup> )4s <sup>2</sup> 13s	<sup>2</sup> [ <sup>1</sup> / <sub>2</sub> ] <sup>o</sup>	1	278 534
				3p <sup>5</sup> ( <sup>2</sup> P <sub>1/2</sub> <sup>o</sup> )4s <sup>2</sup> 14s	<sup>2</sup> [ <sup>1</sup> / <sub>2</sub> ] <sup>o</sup>	1	278 702
4p5s	<sup>3</sup> P°	1	57 462.	Ca II 3p <sup>5</sup> 4s <sup>2</sup> <sup>2</sup> P <sub>1/2</sub> <sup>o</sup>	<b>Limit</b>		<b>279 530</b>
4p5s	<sup>1</sup> P°	1	57 960.				
*****	***	*	*****	3p <sup>5</sup> ( <sup>2</sup> P <sub>3/2</sub> <sup>o</sup> )4s <sup>2</sup> 5d	<sup>2</sup> [ <sup>3</sup> / <sub>2</sub> ] <sup>o</sup>	1	270 889
				3p <sup>5</sup> ( <sup>2</sup> P <sub>3/2</sub> <sup>o</sup> )4s <sup>2</sup> 6d	<sup>2</sup> [ <sup>3</sup> / <sub>2</sub> ] <sup>o</sup>	1	273 134
				3p <sup>5</sup> ( <sup>2</sup> P <sub>3/2</sub> <sup>o</sup> )4s <sup>2</sup> 7d	<sup>2</sup> [ <sup>3</sup> / <sub>2</sub> ] <sup>o</sup>	1	273 959
4p4d	<sup>3</sup> D°?	1	62 552.97	3p <sup>5</sup> ( <sup>2</sup> P <sub>3/2</sub> <sup>o</sup> )4s <sup>2</sup> 8d	<sup>2</sup> [ <sup>3</sup> / <sub>2</sub> ] <sup>o</sup>	1	274 652
				3p <sup>5</sup> ( <sup>2</sup> P <sub>3/2</sub> <sup>o</sup> )4s <sup>2</sup> 9d	<sup>2</sup> [ <sup>3</sup> / <sub>2</sub> ] <sup>o</sup>	1	275 272
4p4d	<sup>3</sup> P°?	1	62 557.45	3p <sup>5</sup> ( <sup>2</sup> P <sub>3/2</sub> <sup>o</sup> )4s <sup>2</sup> 10d	<sup>2</sup> [ <sup>3</sup> / <sub>2</sub> ] <sup>o</sup>	1	275 503
				3p <sup>5</sup> ( <sup>2</sup> P <sub>3/2</sub> <sup>o</sup> )4s <sup>2</sup> 11d	<sup>2</sup> [ <sup>3</sup> / <sub>2</sub> ] <sup>o</sup>	1	275 726
4p4d	<sup>1</sup> P°?	1	62 561.72	3p <sup>5</sup> ( <sup>2</sup> P <sub>3/2</sub> <sup>o</sup> )4s <sup>2</sup> 12d	<sup>2</sup> [ <sup>3</sup> / <sub>2</sub> ] <sup>o</sup>	1	275 898
				3p <sup>5</sup> ( <sup>2</sup> P <sub>3/2</sub> <sup>o</sup> )4s <sup>2</sup> 13d	<sup>2</sup> [ <sup>3</sup> / <sub>2</sub> ] <sup>o</sup>	1	276 038
				3p <sup>5</sup> ( <sup>2</sup> P <sub>3/2</sub> <sup>o</sup> )4s <sup>2</sup> 14d	<sup>2</sup> [ <sup>3</sup> / <sub>2</sub> ] <sup>o</sup>	1	276 138
*****	***	*	*****	3p <sup>5</sup> ( <sup>2</sup> P <sub>3/2</sub> <sup>o</sup> )4s <sup>2</sup> 15d	<sup>2</sup> [ <sup>3</sup> / <sub>2</sub> ] <sup>o</sup>	1	276 214
				3p <sup>5</sup> ( <sup>2</sup> P <sub>3/2</sub> <sup>o</sup> )4s <sup>2</sup> 16d	<sup>2</sup> [ <sup>3</sup> / <sub>2</sub> ] <sup>o</sup>	1	276 283
		1	62 878.40	Ca II 3p <sup>5</sup> 4s <sup>2</sup> <sup>2</sup> P <sub>3/2</sub> <sup>o</sup>	<b>Limit</b>		<b>276 750</b>
		1	62 886.45				
				3p <sup>5</sup> ( <sup>2</sup> P <sub>1/2</sub> <sup>o</sup> )4s <sup>2</sup> 5d	<sup>2</sup> [ <sup>3</sup> / <sub>2</sub> ] <sup>o</sup>	1	274 040
*****	***	*	*****	3p <sup>5</sup> ( <sup>2</sup> P <sub>1/2</sub> <sup>o</sup> )4s <sup>2</sup> 7d	<sup>2</sup> [ <sup>3</sup> / <sub>2</sub> ] <sup>o</sup>	1	276 631
				3p <sup>5</sup> ( <sup>2</sup> P <sub>1/2</sub> <sup>o</sup> )4s <sup>2</sup> 8d	<sup>2</sup> [ <sup>3</sup> / <sub>2</sub> ] <sup>o</sup>	1	277 430
3p <sup>5</sup> 4s <sup>2</sup> 3d	<sup>3</sup> P°	1	200 096	3p <sup>5</sup> ( <sup>2</sup> P <sub>1/2</sub> <sup>o</sup> )4s <sup>2</sup> 9d	<sup>2</sup> [ <sup>3</sup> / <sub>2</sub> ] <sup>o</sup>	1	277 917
				3p <sup>5</sup> ( <sup>2</sup> P <sub>1/2</sub> <sup>o</sup> )4s <sup>2</sup> 10d	<sup>2</sup> [ <sup>3</sup> / <sub>2</sub> ] <sup>o</sup>	1	278 228
3p <sup>5</sup> 4s <sup>2</sup> 3d	<sup>3</sup> D°	1	218 991	3p <sup>5</sup> ( <sup>2</sup> P <sub>1/2</sub> <sup>o</sup> )4s <sup>2</sup> 11d	<sup>2</sup> [ <sup>3</sup> / <sub>2</sub> ] <sup>o</sup>	1	278 469
				3p <sup>5</sup> ( <sup>2</sup> P <sub>1/2</sub> <sup>o</sup> )4s <sup>2</sup> 12d	<sup>2</sup> [ <sup>3</sup> / <sub>2</sub> ] <sup>o</sup>	1	278 647
3p <sup>5</sup> 4s <sup>2</sup> 3d	<sup>1</sup> P°	1	253 310	3p <sup>5</sup> ( <sup>2</sup> P <sub>1/2</sub> <sup>o</sup> )4s <sup>2</sup> 13d	<sup>2</sup> [ <sup>3</sup> / <sub>2</sub> ] <sup>o</sup>	1	278 796
				3p <sup>5</sup> ( <sup>2</sup> P <sub>1/2</sub> <sup>o</sup> )4s <sup>2</sup> 14d	<sup>2</sup> [ <sup>3</sup> / <sub>2</sub> ] <sup>o</sup>	1	278 900
3p <sup>5</sup> 4s <sup>2</sup> 4d	<sup>3</sup> P°	1	255 022	3p <sup>5</sup> ( <sup>2</sup> P <sub>1/2</sub> <sup>o</sup> )4s <sup>2</sup> 15d	<sup>2</sup> [ <sup>3</sup> / <sub>2</sub> ] <sup>o</sup>	1	278 983
				3p <sup>5</sup> ( <sup>2</sup> P <sub>1/2</sub> <sup>o</sup> )4s <sup>2</sup> 16d	<sup>2</sup> [ <sup>3</sup> / <sub>2</sub> ] <sup>o</sup>	1	279 050
3p <sup>5</sup> 4s <sup>2</sup> 4d	<sup>3</sup> D°	1	267 956	3p <sup>5</sup> ( <sup>2</sup> P <sub>1/2</sub> <sup>o</sup> )4s <sup>2</sup> 17d	<sup>2</sup> [ <sup>3</sup> / <sub>2</sub> ] <sup>o</sup>	1	279 117
				Ca II 3p <sup>5</sup> 4s <sup>2</sup> <sup>2</sup> P <sub>1/2</sub> <sup>o</sup>	<b>Limit</b>		<b>279 530</b>
3p <sup>5</sup> 4s <sup>2</sup> 4d	<sup>1</sup> P°	1	270 640				

## Ca II

Z = 20

K I isoelectronic sequence

Ground state:  $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 S_{1/2}$ Ionization energy =  $95\,751.87 \pm 0.03$  ( $11.87181 \pm 0.000004$  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 5g, 9s, and 10s terms. G. Risberg (1968) added 10d, 8f, 8h, and 10h and revised the  $6p^2 P^{\circ}_{1/2}$  level.

The 9-10f and 11-16d terms are derived from unpub-

lished 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  $3p^3 4s^2 ns$  and *nd* series in Ca I by Mansfield and Newsom (1977).

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## Ca II

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

## Ca II—Continued

Configuration	Term	<i>J</i>	Level (cm <sup>-1</sup> )	Configuration	Term	<i>J</i>	Level (cm <sup>-1</sup> )
3 <i>p</i> <sup>6</sup> ( <sup>1</sup> S <sub>0</sub> )10 <i>s</i>	<sup>2</sup> S	1/2	89 214.13	3 <i>p</i> <sup>6</sup> ( <sup>1</sup> S <sub>0</sub> )11 <i>d</i>	<sup>2</sup> D	3/2, 5/2	91 672.0
3 <i>p</i> <sup>6</sup> ( <sup>1</sup> S <sub>0</sub> )9 <i>d</i>	<sup>2</sup> D	3/2 5/2	89 487.93 89 489.13	3 <i>p</i> <sup>6</sup> ( <sup>1</sup> S <sub>0</sub> )12 <i>d</i>	<sup>2</sup> D	3/2, 5/2	92 359.0
3 <i>p</i> <sup>6</sup> ( <sup>1</sup> S <sub>0</sub> )9 <i>f</i>	<sup>2</sup> F°	5/2, 7/2	90 300.0	3 <i>p</i> <sup>6</sup> ( <sup>1</sup> S <sub>0</sub> )13 <i>d</i>	<sup>2</sup> D	3/2, 5/2	92 883.0
3 <i>p</i> <sup>6</sup> ( <sup>1</sup> S <sub>0</sub> )9 <i>g</i>	<sup>2</sup> G	7/2, 9/2	90 326.45	3 <i>p</i> <sup>6</sup> ( <sup>1</sup> S <sub>0</sub> )14 <i>d</i>	<sup>2</sup> D	3/2, 5/2	93 297.6
3 <i>p</i> <sup>6</sup> ( <sup>1</sup> S <sub>0</sub> )10 <i>d</i>	<sup>2</sup> D	3/2 5/2	90 753.92 90 754.80	3 <i>p</i> <sup>6</sup> ( <sup>1</sup> S <sub>0</sub> )15 <i>d</i>	<sup>2</sup> D	3/2, 5/2	93 626.9
3 <i>p</i> <sup>6</sup> ( <sup>1</sup> S <sub>0</sub> )10 <i>f</i>	<sup>2</sup> F°	5/2, 7/2	91 338.0	3 <i>p</i> <sup>6</sup> ( <sup>1</sup> S <sub>0</sub> )16 <i>d</i>	<sup>2</sup> D	3/2, 5/2	93 894.5
3 <i>p</i> <sup>6</sup> ( <sup>1</sup> S <sub>0</sub> )10 <i>h</i>	<sup>2</sup> H°	9/2, 11/2	91 361.00	Ca III ( <sup>1</sup> S <sub>0</sub> )	<i>Limit</i>		95 751.87
				3 <i>p</i> <sup>5</sup> 4 <i>s</i> <sup>2</sup>	<sup>2</sup> P°	3/2 1/2	227 444 230 224

## Ca III

Z=20

Ar I isoelectronic sequence

Ground state:  $1s^2 2s^2 2p^6 3s^2 3p^6 1S_0$ Ionization energy =  $410\,642 \pm 2 \text{ cm}^{-1}$  ( $50.9135 \pm .0002 \text{ eV}$ )

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  $3s 3p^6 3d$  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  $3s 3p^6 3d$  configurations. The percentages for  $3p^5 4p$  in LS coupling are from Borgström (1971).

The two  $1P^{\circ}$  levels from  $3s 3p^6 4p$  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 <sup>-1</sup> )	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	<i>J</i>	Level (cm <sup>-1</sup> )	Leading percentages	
3s <sup>2</sup> 3p <sup>5</sup> 4p	<sup>3</sup> D	3	277 022.40	100	
		2	277 380.86	77	
		1	278 621.01	83	
3s <sup>2</sup> 3p <sup>5</sup> 3d	<sup>1</sup> P°	1	279 353.64		
3s <sup>2</sup> 3p <sup>5</sup> 4p	<sup>1</sup> D	2	279 741.80	57	
3s <sup>2</sup> 3p <sup>5</sup> 4p	<sup>1</sup> P	1	281 139.55	57	
3s <sup>2</sup> 3p <sup>5</sup> 4p	<sup>3</sup> P	2	281 882.24	63	
		0	282 075.15	98	
		1	282 571.43	64	
3s <sup>2</sup> 3p <sup>5</sup> 4p	<sup>1</sup> S	0	290 934.30	98	
3s <sup>2</sup> 3p <sup>5</sup> 4d	<sup>3</sup> P°	0	322 663.28		
		1	323 003.56		
		2	323 655.06		
3s <sup>2</sup> 3p <sup>5</sup> 4d	<sup>3</sup> F°	4	324 110.24		
		3	324 660.47		
		2	325 467.67		
3s <sup>2</sup> 3p <sup>5</sup> 4d	<sup>1</sup> F°	3	326 186.32		
3s <sup>2</sup> 3p <sup>5</sup> ( <sup>2</sup> P <sub>3/2</sub> °)5s	<sup>2</sup> [ <sup>3</sup> / <sub>2</sub> ] <sup>o</sup>	2	327 922.87		
		1	328 582.45		
3s <sup>2</sup> 3p <sup>5</sup> 4d	<sup>3</sup> D°	1	327 962.11		
		3	328 588.76		
		2	328 606.78		
3s <sup>2</sup> 3p <sup>5</sup> 4d	<sup>1</sup> D°	2	328 090.99		
3s <sup>2</sup> 3p <sup>5</sup> ( <sup>2</sup> P <sub>1/2</sub> °)5s	<sup>2</sup> [ <sup>1</sup> / <sub>2</sub> ] <sup>o</sup>	0	331 048.86		
		1	331 403.20		
3s <sup>2</sup> 3p <sup>5</sup> 4d	<sup>1</sup> P°	1	336 749.11		
3s <sup>2</sup> 3p <sup>5</sup> ( <sup>2</sup> P <sub>3/2</sub> °)5p	<sup>2</sup> [ <sup>1</sup> / <sub>2</sub> ]	1	339 198.09	91	9 ( <sup>2</sup> P <sub>1/2</sub> °) <sup>2</sup> [ <sup>1</sup> / <sub>2</sub> ]
		0	343 110.24	75	25
3s <sup>2</sup> 3p <sup>5</sup> ( <sup>2</sup> P <sub>3/2</sub> °)5p	<sup>2</sup> [ <sup>5</sup> / <sub>2</sub> ]	3	340 580.15	100	
		2	340 748.72	90	8 ( <sup>2</sup> P <sub>3/2</sub> °) <sup>2</sup> [ <sup>3</sup> / <sub>2</sub> ]
3s <sup>2</sup> 3p <sup>5</sup> ( <sup>2</sup> P <sub>3/2</sub> °)5p	<sup>2</sup> [ <sup>3</sup> / <sub>2</sub> ]	1	341 349.19	96	4 ( <sup>2</sup> P <sub>1/2</sub> °) <sup>2</sup> [ <sup>3</sup> / <sub>2</sub> ]
		2	341 601.46	90	9 ( <sup>2</sup> P <sub>3/2</sub> °) <sup>2</sup> [ <sup>5</sup> / <sub>2</sub> ]
3s <sup>2</sup> 3p <sup>5</sup> ( <sup>2</sup> P <sub>1/2</sub> °)5p	<sup>2</sup> [ <sup>3</sup> / <sub>2</sub> ]	1	343 784.96	95	4 ( <sup>2</sup> P <sub>3/2</sub> °) <sup>2</sup> [ <sup>3</sup> / <sub>2</sub> ]
		2	344 149.81	97	
3s <sup>2</sup> 3p <sup>5</sup> ( <sup>2</sup> P <sub>1/2</sub> °)5p	<sup>2</sup> [ <sup>1</sup> / <sub>2</sub> ]	1	344 257.92	90	9 ( <sup>2</sup> P <sub>3/2</sub> °) <sup>2</sup> [ <sup>1</sup> / <sub>2</sub> ]
		0	346 692.34	75	25
3s <sup>2</sup> 3p <sup>5</sup> ( <sup>2</sup> P <sub>3/2</sub> °)4f	<sup>2</sup> [ <sup>3</sup> / <sub>2</sub> ]	1	346 732.19	99	
		2	346 896.26	90	8 ( <sup>2</sup> P <sub>3/2</sub> °) <sup>2</sup> [ <sup>5</sup> / <sub>2</sub> ]

## Ca III—Continued

Configuration	Term	<i>J</i>	Level (cm <sup>-1</sup> )	Leading percentages	
$3s^2 3p^5 ({}^2P_{3/2}^{\circ}) 4f$	$2[{}^9_2]$	5	347 344.37	100	
		4	347 383.51	100	
$3s^2 3p^5 ({}^2P_{3/2}^{\circ}) 4f$	$2[{}^5_2]$	3	347 417.05	93	6 $({}^2P_{1/2}^{\circ}) 2[{}^5_2]$
		2	347 758.22	88	9 $({}^2P_{3/2}^{\circ}) 2[{}^5_2]$
$3s^2 3p^5 ({}^2P_{3/2}^{\circ}) 4f$	$2[{}^7_2]$	3	348 028.13	97	
		4	348 051.86	97	
$3s^2 3p^5 ({}^2P_{1/2}^{\circ}) 4f$	$2[{}^5_2]$	3	350 741.19	93	7 $({}^2P_{3/2}^{\circ}) 2[{}^5_2]$
		2	350 900.04	96	4 $({}^2P_{3/2}^{\circ}) 2[{}^5_2]$
$3s^2 3p^5 ({}^2P_{1/2}^{\circ}) 4f$	$2[{}^7_2]$	3	350 779.47	97	
		4	350 805.32	98	
$3s^2 3p^5 ({}^2P_{3/2}^{\circ}) 5d$	$2[{}^1_2]^{\circ}$	0	358 940.91		
		1	359 156.83		
$3s^2 3p^5 ({}^2P_{3/2}^{\circ}) 5d$	$2[{}^3_2]^{\circ}$	2	359 520.60		
		1	361 794.08		
$3s^2 3p^5 ({}^2P_{3/2}^{\circ}) 5d$	$2[{}^7_2]^{\circ}$	4	359 543.08		
		3	359 800.57		
$3s^2 3p^5 ({}^2P_{3/2}^{\circ}) 5d$	$2[{}^5_2]^{\circ}$	2	360 207.16		
		3	360 388.68		
$3s^2 3p^5 ({}^2P_{3/2}^{\circ}) 6s$	$2[{}^3_2]^{\circ}$	2	361 154.07		
		1	361 353.31		
$3s^2 3p^5 ({}^2P_{1/2}^{\circ}) 5d$	$2[{}^5_2]^{\circ}$	2	362 893.47		
		3	363 118.75		
$3s^2 3p^5 ({}^2P_{1/2}^{\circ}) 5d$	$2[{}^3_2]^{\circ}$	2	363 021.27		
		1	365 363.88		
$3s^2 3p^5 ({}^2P_{1/2}^{\circ}) 6s$	$2[{}^1_2]^{\circ}$	0	364 229.89		
		1	364 343.85		
$3s 3p^6 3d$	${}^3D$	1	366 778.85	65	31 $3p^5 ({}^2P_{3/2}^{\circ}) 5f 2[{}^3_2]$
		2	366 926.33	55	17 $3p^5 ({}^2P_{3/2}^{\circ}) 6p 2[{}^5_2]$
		3	367 472.91	53	24 $3p^5 ({}^2P_{3/2}^{\circ}) 6p 2[{}^5_2]$
$3s^2 3p^5 ({}^2P_{3/2}^{\circ}) 6p$	$2[{}^5_2]$	3	367 026.65	75	18 $3s 3p^6 3d {}^3D$
$3s^2 3p^5 ({}^2P_{3/2}^{\circ}) 5f$	$2[{}^9_2]$	5	370 141.77	100	
		4	370 172.43	100	
$3s^2 3p^5 ({}^2P_{3/2}^{\circ}) 5f$	$2[{}^5_2]$	2	370 304.54?	58	34 $3p^5 ({}^2P_{3/2}^{\circ}) 5f 2[{}^3_2]$
		3	371 059.95?	80	17 $3s 3p^6 3d {}^3D$
$3s^2 3p^5 ({}^2P_{1/2}^{\circ}) 6p$	$2[{}^3_2]$	2	370 454.04	93	6 $3p^5 ({}^2P_{3/2}^{\circ}) 5f 2[{}^5_2]$
$3s^2 3p^5 ({}^2P_{3/2}^{\circ}) 5f$	$2[{}^7_2]$	3	370 515.36	99	
		4	370 533.07	99	
$3s^2 3p^5 ({}^2P_{3/2}^{\circ}) 5g$	$2[{}^5_2]^{\circ}$	2	370 901.88		
		3	370 903.12		

## Ca III—Continued

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

## Ca III—Continued

Configuration	Term	<i>J</i>	Level (cm <sup>-1</sup> )	Leading percentages
3s <sup>2</sup> 3p <sup>5</sup> (2P <sub>1/2</sub> <sup>o</sup> ) 6g	2[ <sup>9</sup> / <sub>2</sub> ] <sup>o</sup>	4	386 248.39	
		5	386 248.68	
3s <sup>2</sup> 3p <sup>5</sup> (2P <sub>1/2</sub> <sup>o</sup> ) 6g	2[ <sup>7</sup> / <sub>2</sub> ] <sup>o</sup>	4	386 249.78	
		3	386 250.31	
3s <sup>2</sup> 3p <sup>5</sup> (2P <sub>3/2</sub> <sup>o</sup> ) 7f	2[ <sup>9</sup> / <sub>2</sub> ]	5	390 054.0	
3s <sup>2</sup> 3p <sup>5</sup> (2P <sub>3/2</sub> <sup>o</sup> ) 7f	2[ <sup>7</sup> / <sub>2</sub> ]	4	390 207.6	
3s <sup>2</sup> 3p <sup>5</sup> (2P <sub>3/2</sub> <sup>o</sup> ) 7g	2[ <sup>5</sup> / <sub>2</sub> ] <sup>o</sup>	3	390 392.62	
3s <sup>2</sup> 3p <sup>5</sup> (2P <sub>3/2</sub> <sup>o</sup> ) 7g	2[ <sup>11</sup> / <sub>2</sub> ] <sup>o</sup>	6	390 411.58	
		5	390 411.99	
3s <sup>2</sup> 3p <sup>5</sup> (2P <sub>3/2</sub> <sup>o</sup> ) 7g	2[ <sup>7</sup> / <sub>2</sub> ] <sup>o</sup>	3	390 451.97	
3s <sup>2</sup> 3p <sup>5</sup> (2P <sub>3/2</sub> <sup>o</sup> ) 7g	2[ <sup>9</sup> / <sub>2</sub> ] <sup>o</sup>	4	390 471.79	
		5	390 472.32	
3s <sup>2</sup> 3p <sup>5</sup> (2P <sub>1/2</sub> <sup>o</sup> ) 7f	2[ <sup>7</sup> / <sub>2</sub> ]	4	393 224.9	
3s <sup>2</sup> 3p <sup>5</sup> (2P <sub>1/2</sub> <sup>o</sup> ) 7g	2[ <sup>9</sup> / <sub>2</sub> ] <sup>o</sup>	5	393 551.86	
		4	393 561.59	
3s <sup>2</sup> 3p <sup>5</sup> (2P <sub>1/2</sub> <sup>o</sup> ) 7g	2[ <sup>7</sup> / <sub>2</sub> ] <sup>o</sup>	4	393 552.31	
		3	393 552.81	
Ca IV (2P <sub>3/2</sub> <sup>o</sup> )	<b>Limit</b>		410 642	
3s3p <sup>6</sup> 4p	1P <sup>o</sup>	1	431 100	
3s3p <sup>6</sup> 5p	1P <sup>o</sup>	1	492 850	

## Ca IV

Z=20

Cl I isoelectronic sequence

Ground state:  $1s^2 2s^2 2p^6 3s^2 3p^5 \ ^2P^{\circ}_{3/2}$ Ionization energy =  $542\,600\text{ cm}^{-1}$  (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  $3p^4s$  terms from their observations below 350 Å.

Levels of  $3p^4 3d \ ^4D$ ,  $^2D$  and  $^2F$  terms and the  $3p^4 4p$  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  $\pm 2\text{ cm}^{-1}$  for the levels relative to the ground term and less than  $\pm 1\text{ cm}^{-1}$  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  $3p^4 5s \ ^2D$  term retained from Tsien.

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

## References

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## Ca IV

Configuration	Term	$J$	Level ( $\text{cm}^{-1}$ )	Configuration	Term	$J$	Level ( $\text{cm}^{-1}$ )
$3s^2 3p^5$	$^2P^{\circ}$	$3/2$	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	$3s^2 3p^4(^3P)4s$	$^4P$	$5/2$	291 456
		$5/2$	201 747			$3/2$	292 864
		$3/2$	202 031			$1/2$	294 292
		$1/2$	202 254				
$3s^2 3p^4(^3P)3d$	$^4F$	$9/2$	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				
$3s^2 3p^4(^1D)3d$	$^2P$	$1/2$	219 991	$3s^2 3p^4(^3P)3d$	$^2D$	$5/2$	301 218
		$3/2$	221 945	$3/2$	303 850		
$3s^2 3p^4(^3P)3d$	$^4P$	$1/2$	227 214	$3s^2 3p^4(^3P)4s$	$^2P$	$3/2$	301 718
		$3/2$	227 825	$1/2$	303 604		
		$5/2$	228 694				
$3s^2 3p^4(^1D)3d$	$^2D$	$3/2$	228 436	$3s^2 3p^4(^1D)4s$	$^2D$	$5/2$	312 517
		$5/2$	230 119	$3/2$	312 650		
$3s^2 3p^4(^3P)3d$	$^2F$	$7/2$	231 288	$3s^2 3p^4(^3P)4p$	$^4P^{\circ}$	$5/2$	330 693
		$5/2$	233 851			$3/2$	331 173
						$1/2$	331 969
$3s^2 3p^4(^1D)3d$	$^2G$	$9/2$	234 498				
		$7/2$	234 642				

## Ca IV—Continued

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

## Ca v

Z=20

S I isoelectronic sequence

Ground state:  $1s^2 2s^2 2p^6 3s^2 3p^4 \ ^3P_2$ Ionization energy =  $681\,600\text{ cm}^{-1}$  (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  $3s^2 3p^4$ ,  $3s 3p^5$ ,  $3s^2 3p^3 3d$ ,  $3s^2 3p^3 4s$ , and  $3s^2 3p^3 5s$ . By means of isoelectronic comparisons Svensson and Ekberg (1968) revised and extended the  $3p^3 3d$  configuration.

New measurements of the transition array  $3s^2 3p^4 - 3s 3p^5$  by Smitt, Svensson, and Outred (1976) led to improved values for the levels of these configurations.

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

## References

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## Ca v

Configuration	Term	<i>J</i>	Level (cm <sup>-1</sup> )	Configuration	Term	<i>J</i>	Level (cm <sup>-1</sup> )								
$3s^2 3p^4$	$^3P$	2	0.0	$3s^2 3p^3(^2P^\circ)3d$	$^1F^\circ$	3	329 229								
		1	2 404.7			$3s^2 3p^3(^4S^\circ)4s$	$^3S^\circ$	1	350 914						
		0	3 275.6					$3s^2 3p^3(^2P^\circ)3d$	$^1P^\circ$	1	353 220				
$3s^2 3p^4$	$^1D$	2	18 830.3	$3s^2 3p^3(^2D^\circ)4s$	$^3D^\circ$					1	369 590				
		$3s^2 3p^4$	$^1S$			0	43 836.5			2	369 696				
								3	369 959						
$3s 3p^5$	$^3P^\circ$	2	154 670.8	$3s^2 3p^3(^2D^\circ)4s$	$^1D^\circ$	2	374 728								
		1	156 760.2			$3s^2 3p^3(^2P^\circ)4s$	$^3P^\circ$	0	387 039						
		0	157 900.5					1	387 226						
2	387 652														
$3s 3p^5$	$^1P^\circ$	1	197 844.5	$3s^2 3p^3(^2P^\circ)4s$	$^1P^\circ$	1	392 283								
$3s^2 3p^3(^2D^\circ)3d$	$^1D^\circ$	2	254 124			$3s^2 3p^3(^4S^\circ)5s$	$^3S^\circ$	1	501 127						
										$3s^2 3p^3(^2D^\circ)3d$	$^1F^\circ$	3	283 955	$3s^2 3p^3(^2D^\circ)5s$	$^3D^\circ$
				2	524 770										
3	525 053														
$3s^2 3p^3(^2D^\circ)3d$	$^3S^\circ$	1	293 785	$3s^2 3p^3(^2D^\circ)5s$	$^1D^\circ$	2	526 523								
								$3s^2 3p^3(^2P^\circ)3d$	$^3P^\circ$	2	298 214	$3s^2 3p^3(^2P^\circ)5s$	$^3P^\circ$	1	542 249
														1	299 534
0	300 594	$3s^2 3p^3(^2P^\circ)5s$	$^1P^\circ$	1	544 143										
$3s^2 3p^3(^2D^\circ)3d$	$^1P^\circ$					1	302 184	Ca VI ( $^4S_{3/2}$ )	<i>Limit</i>	681 600					
											$3s^2 3p^3(^2P^\circ)3d$	$^3D^\circ$	3	308 188	
		2	309 831												
1	310 943														
$3s^2 3p^3(^2P^\circ)3d$	$^1D^\circ$	2	318 741												

## Ca vi

Z=20

P I isoelectronic sequence

Ground state:  $1s^2 2s^2 2p^6 3s^2 3p^3 \ ^4S^{\circ}_{3/2}$ Ionization energy =  $877\,400\text{ cm}^{-1}$  (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  $3s^2 3p^3$  and  $3s 3p^4$  configurations are taken from the latter paper. They have an uncertainty of about  $\pm 2\text{ cm}^{-1}$ . We have combined these values with the measurements and classifications given by Ekberg and Svensson to derive new level values for the  $3p^2 3d$  and  $4s$  configurations. The uncertainty of these upper levels is about  $\pm 10\text{ cm}^{-1}$ . Since no inter-system 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 cal-

culations by Smitt, Svensson and Outred and is expected to be less than  $\pm 20\text{ cm}^{-1}$ .

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).

## References

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## Ca vi

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

## Ca VII

Z = 20

Si I isoelectronic sequence

Ground state:  $1s^2 2s^2 2p^6 3s^2 3p^2 \ ^3P_0$ Ionization energy =  $1\ 026\ 000\ \text{cm}^{-1}$  (127.2 eV)

The level values for  $3s^2 3p^2$  and  $3s 3p^3$  are taken from Smitt, Svensson, and Outred (1976). Ekberg and Svensson (1970) revised and extended the interpretation of the  $3p^2$ - $3p 3d$ ,  $4s$  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	<i>J</i>	Level ( $\text{cm}^{-1}$ )	Configuration	Term	<i>J</i>	Level ( $\text{cm}^{-1}$ )
$3s^2 3p^2$	$^3P$	0	0.0	$3s 3p^3$	$^1P^\circ$	1	252 489.9
		1	1 624.9				
		2	4 071.4	$3s^2 3p 3d$	$^3P^\circ$	2	286 224
$3s^2 3p^2$	$^1D$	2	21 864.0			1	288 160
		0	48 981.4			0	289 004
$3s 3p^3$	$^3D^\circ$	1	160 157.5	$3s^2 3p 3d$	$^3D^\circ$	1	295 138
		2	160 220.3			2	295 772
		3	160 529.2			3	296 132
$3s 3p^3$	$^3P^\circ$	0	185 356.6	$3s^2 3p 3d$	$^1F^\circ$	3	324 885
		1	185 392.9			$3s^2 3p 3d$	$^1P^\circ$
		2	185 412.2	$3s^2 3p 4s$	$^3P^\circ$		
$3s 3p^3$	$^1D^\circ$	2	203 616.1			1	490 919
		2	245 240.5			2	494 262
$3s 3p^3$	$^3S^\circ$	1	245 240.5	$3s^2 3p 4s$	$^1P^\circ$	1	498 683
						Ca VIII ( $^2P_{1/2}^\circ$ )	<b>Limit</b>

## Ca VIII

Z=20

Al I isoelectronic sequence

Ground state:  $1s^2 2s^2 2p^6 3s^2 3p^2 P^{\circ}_{1/2}$ Ionization energy =  $1\ 187\ 600 \pm 1000\ \text{cm}^{-1}$  ( $147.24 \pm 0.1\ \text{eV}$ )

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

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 <sup>-1</sup> )	Configuration	Term	J	Level (cm <sup>-1</sup> )
$3s^2 3p$	$2P^{\circ}$	$1/2$	0.0	$3s^2 4s$	$2S$	$1/2$	547 322
		$3/2$	4 308.3				
$3s 3p^2$	$4P$	$1/2$	129 100+x	$3s 3p 4s$	$4P^{\circ}$	$1/2$	688 747+x
		$3/2$	130 678+x			$3/2$	690 128+x
		$5/2$	133 042+x			$5/2$	692 833+x
$3s 3p^2$	$2D$	$3/2$	171 572.2	$3s^2 4d$	$2D$	$3/2$	698 232
		$5/2$	171 830.7			$5/2$	698 420
$3s 3p^2$	$2S$	$1/2$	216 584.9	$3s^2 4f$	$2F^{\circ}$	$5/2$	743 288
$3s 3p^2$	$2P$	$1/2$	231 016.3	$3s^2 5d$	$2D$	$3/2$	885 693
		$3/2$	233 592.8			$5/2$	885 750
$3s^2 3d$	$2D$	$3/2$	282 356	$3s^2 5f$	$2F^{\circ}$	$5/2$	905 052
		$5/2$	282 577			$7/2$	905 087
$3p^3$	$4S^{\circ}$	$3/2$	345 274+x	$3s^2 6d$	$2D$	$3/2$	979 749
$3s 3p 3d$	$4P^{\circ}$	$5/2$	408 227+x	$3s^2 6f$	$2F^{\circ}$	$5/2$	991 023
		$3/2$	409 291+x			$7/2$	991 028
$3s 3p 3d$	$4D^{\circ}$	$1/2$	411 816+x	$3s^2 7f$	$2F^{\circ}$	$7/2$	1 043 207
		$3/2$	412 388+x			$5/2$	1 043 275
		$5/2$	412 772+x				
		$7/2$	412 881+x				
			Ca IX ( $1S_0$ )	<i>Limit</i>			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 =  $1\ 519\ 000 \pm 1000\ \text{cm}^{-1}$  ( $188.3 \pm 0.1\ \text{eV}$ )

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

## Ca ix—Continued

Configuration	Term	<i>J</i>	Level (cm <sup>-1</sup> )	Configuration	Term	<i>J</i>	Level (cm <sup>-1</sup> )
3s5d	<sup>1</sup> D	2	1 139 810	3s6d	<sup>3</sup> D	1	1 258 080
3s5d	<sup>3</sup> D	1	1 143 670			2	1 258 260
		3	1 144 290			3	1 258 450
3s5f	<sup>3</sup> F°	2-4	1 158 110	3s6d	<sup>1</sup> D	2	1 260 390
3s5f	<sup>1</sup> F°	3	1 162 610	3s6f	<sup>3</sup> F°	2-4	1 269 050
3s6s	<sup>3</sup> S	1	1 218 220	3s7p	<sup>1</sup> P°	1	1 315 300
3s6p	<sup>1</sup> P°	1	1 235 830	3s7d	<sup>3</sup> D	1-3	1 329 760
				3s8d	<sup>3</sup> D	1-3	1 374 830
				Ca x ( <sup>2</sup> S <sub>1/2</sub> )	<b>Limit</b>		1 519 000

## Ca x

Z = 20

Na I isoelectronic sequence

Ground state:  $1s^2 2s^2 2p^6 3s^2 S_{1/2}$ Ionization energy =  $1\,704\,047 \pm 3 \text{ cm}^{-1}$  ( $211.277 \pm .001 \text{ eV}$ )

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**, 399.  
 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 ( $\text{cm}^{-1}$ )	Configuration	Term	$J$	Level ( $\text{cm}^{-1}$ )
$2p^6(1S)3s$	$^2S$	$1/2$	0	$2p^6(1S)6d$	$^2D$	$3/2$ $5/2$	1 389 840 1 389 870
$2p^6(1S)3p$	$^2P^\circ$	$1/2$ $3/2$	174 213 179 287	$2p^6(1S)6f$	$^2F^\circ$	$5/2$ $7/2$	1 398 330 1 398 440
$2p^6(1S)3d$	$^2D$	$3/2$ $5/2$	417 112 417 522	$2p^6(1S)7s$	$^2S$	$1/2$	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
$2p^6(1S)4p$	$^2P^\circ$	$1/2$ $3/2$	899 290 901 200	$2p^6(1S)7d$	$^2D$	$3/2$ $5/2$	1 474 040 1 474 090
$2p^6(1S)4d$	$^2D$	$3/2$ $5/2$	987 300 987 490	$2p^6(1S)7f$	$^2F^\circ$	$5/2$ $7/2$	1 479 470 1 479 540
$2p^6(1S)4f$	$^2F^\circ$	$5/2$ $7/2$	1 016 100 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
$2p^6(1S)5p$	$^2P^\circ$	$1/2$ $3/2$	1 206 850 1 207 760	$2p^6(1S)8d$	$^2D$	$3/2$ $5/2$	1 528 490 1 528 510
$2p^6(1S)5d$	$^2D$	$3/2$ $5/2$	1 248 920 1 249 030	$2p^6(1S)8f$	$^2F^\circ$	$5/2$ $7/2$	1 532 290 1 532 390
$2p^6(1S)5f$	$^2F^\circ$	$5/2$ $7/2$	1 263 690 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
$2p^6(1S)6p$	$^2P^\circ$	$1/2$ $3/2$	1 366 360 1 366 890	$2p^6(1S)9f$	$^2F^\circ$	$5/2$ $7/2$	1 568 390 1 568 420

## Ca x—Continued

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

## Ca XI

Z = 20

Ne I isoelectronic sequence

Ground state:  $1s^2 2s^2 2p^6 \ ^1S_0$ Ionization energy =  $4\,774\,000\text{ cm}^{-1}$  (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  $2p^5 3p$  and  $2p^5 4d$ , but there is no connection with the levels given here.

We derived the ionization energy from the  $2s^2 2p^5 (^2P^{\circ}_{3/2}) nd \ ^2[3/2]^{\circ}$  series for  $n=3$  and 4 with the change in quantum defect  $\Delta n^*$  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	<i>J</i>	Level (cm <sup>-1</sup> )	Configuration	Term	<i>J</i>	Level (cm <sup>-1</sup> )
$2s^2 2p^6$	$^1S$	0	0	$2s2p^6 3p$	$^3P^{\circ}$	1	3 692 900
$2s^2 2p^5 (^2P^{\circ}_{3/2}) 3s$	$(\frac{3}{2}, \frac{1}{2})^{\circ}$	1	2 810 880	$2s2p^6 3p$	$^1P^{\circ}$	1	3 708 900
$2s^2 2p^5 (^2P^{\circ}_{1/2}) 3s$	$(\frac{1}{2}, \frac{1}{2})^{\circ}$	1	2 839 940	$2s^2 2p^5 (^2P^{\circ}_{3/2}) 4s$	$(\frac{3}{2}, \frac{1}{2})^{\circ}$	1	3 753 900
$2s^2 2p^5 (^2P^{\circ}_{3/2}) 3d$	$^2[1/2]^{\circ}$	1	3 199 300	$2s^2 2p^5 (^2P^{\circ}_{1/2}) 4s$	$(\frac{1}{2}, \frac{1}{2})^{\circ}$	1	3 781 900
$2s^2 2p^5 (^2P^{\circ}_{3/2}) 3d$	$^2[3/2]^{\circ}$	1	3 239 700	$2s^2 2p^5 (^2P^{\circ}_{3/2}) 4d$	$^2[3/2]^{\circ}$	1	3 919 000
$2s^2 2p^5 (^2P^{\circ}_{1/2}) 3d$	$^2[3/2]^{\circ}$	1	3 284 300	$2s^2 2p^5 (^2P^{\circ}_{1/2}) 4d$	$^2[3/2]^{\circ}$	1	3 948 400
				Ca XII ( $^2P^{\circ}_{3/2}$ )	<b>Limit</b>		4 774 000

## Ca XII

$$Z=20$$

F I isoelectronic sequence

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

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

The first work on this spectrum was by Edlén and Tyrén (1936), who classified 10 lines of the  $2s^2 2p^5$ - $2s^2 2p^4 3s$  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  $2s^2 2p^5$ - $2s^2 2p^6$  doublet at  $\sim 140$  Å. The  $2s^2 2p^5 \ ^2P^{\circ}$  term interval is obtained from the solar flare line at 3327.5 Å (in air) identified by Edlén (1942, 1976).

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

## Ca XIII

Z=20

O I isoelectronic sequence

Ground state:  $1s^2 2s^2 2p^4 \ ^3P_2$ Ionization energy =  $5\ 861\ 000\ \text{cm}^{-1}$  (726.6 eV)

The observed spectrum of Ca XIII consists of the strong transition array  $2s^2 2p^4 - 2s 2p^5$ , 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  $2s 2p^5 \ ^3P^\circ$  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  $2s 2p^5 \ ^1P^\circ_1$  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 <sup>-1</sup> )	Configuration	Term	J	Level (cm <sup>-1</sup> )		
$2s^2 2p^4$	$^3P$	2	0	$2s^2 2p^3(^2P^\circ)3s$	$^1P^\circ$	1	$3\ 544\ 600+x$		
		1	24 460			$2s^2 2p^3(^4S^\circ)3d$	$^3D^\circ$	2	$3\ 739\ 000$
		0	28 830					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	$3\ 839\ 000$		
$2s 2p^5$	$^3P^\circ$	2	618 260	$2s^2 2p^3(^2D^\circ)3d$	$^3P^\circ$	2	$3\ 846\ 000$		
		1	638 260			$2s^2 2p^3(^2D^\circ)3d$	$^3S^\circ$	1	$3\ 864\ 000$
		0	650 160					$2s^2 2p^3(^2P^\circ)3d$	$^3D^\circ$
$2s^2 2p^3(^4S^\circ)3s$	$^3S^\circ$	1	$3\ 374\ 600$	3	$3\ 917\ 000$				
		$s^2 2p^3(^2D^\circ)3s$	$^3D^\circ$	1	$3\ 452\ 700$	2	$3\ 924\ 000$		
				2	$3\ 453\ 200$	Ca XIV ( $^4S_{3/2}$ )	<b>Limit</b>	5 861 000	
3	$3\ 458\ 300$								
$2s^2 2p^3(^2D^\circ)3s$	$^1D^\circ$	2	$3\ 474\ 800+x$						

## Ca xiv

Z=20

N I isoelectronic sequence

Ground state:  $1s^2 2s^2 2p^3 \ ^4S^{\circ}_{3/2}$ Ionization energy =  $6\,595\,000\text{ cm}^{-1}$  (817.6 eV)

The levels of the configurations  $2s^2 2p^3$ ,  $2s 2p^4$ , 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  $2s^2 2p^3 \ ^2D^{\circ}_{5/2}$  by Eldén (1972).

The  $2p^2 3d$  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.

## References

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## Ca xiv

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

## Ca xiv—Continued

Configuration	Term	$J$	Level ( $\text{cm}^{-1}$ )	Leading percentages
$2s^2 2p^2 ({}^1\text{D}) 3d$	${}^2\text{D}$	$\frac{5}{2}$	$4\ 241\ 000+x$	67      18    ( ${}^1\text{D}$ ) ${}^2\text{F}$
$2s^2 2p^2 ({}^1\text{D}) 3d$	${}^2\text{P}$	$\frac{3}{2}$	$4\ 250\ 400+x$	90
Ca xv ( ${}^3\text{P}_0$ )	<i>Limit</i>		$6\ 595\ 000$	

## Ca xv

Z = 20

CI isoelectronic sequence

Ground state:  $1s^2 2s^2 2p^2 \ ^3P_0$ Ionization energy = 7 215 000  $\text{cm}^{-1}$  (894.5 eV)

The levels of the  $2s^2 2p^2$ ,  $2s 2p^3$ , 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  $2s^2 2p^2 \ ^3P$  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  $\text{cm}^{-1}$ . Sandlin, Brueckner, and Tousey (1977) have identified the  $^3P_2 - ^1D_2$  forbidden transition in  $2s^2 2p^2$  at 1375.95 Å in the solar corona. This put  $^1D_2$  at 108 600  $\text{cm}^{-1}$  above the ground state. We have used that value as the reference value for the singlet system.

The percentage compositions for the  $2p 3d$  configuration were calculated by Bromage and Fawcett.

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

## References

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## Ca xv

Configuration	Term	J	Level ( $\text{cm}^{-1}$ )	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	
$2s 2p^3$	$^3D^\circ$	2	496 680	
		1	497 590	
		3	500 240	
$2s 2p^3$	$^3P^\circ$	0	581 730	
		1	582 840	
		2	585 660	
$2s 2p^3$	$^3S^\circ$	1	728 910	
$2s 2p^3$	$^1D^\circ$	2	729 720	
$2s 2p^3$	$^1P^\circ$	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	<i>J</i>	Level (cm <sup>-1</sup> )	Leading percentages	
$2s^2 2p3d$	$^3F^\circ$	2	4 363 000	74	25 $^1D^\circ$
		3	4 379 000	88	
$2s^2 2p3d$	$^3D^\circ$	1	4 399 000	78	15 $^3P^\circ$
		2	4 412 000	45	24 $^1D^\circ$
		3	4 426 000	88	10 $^3F^\circ$
$2s^2 2p3d$	$^3P^\circ$	1	4 435 000	82	17 $^3D^\circ$
		2	4 435 000	61	36
$2s^2 2p3d$	$^1P^\circ$	1	4 473 000	92	
$2s^2 2p3d$	$^1F^\circ$	3	4 475 000	95	
$2s2p^2(^4P)3d$	$^3F$	4	4 727 000		
Ca XVI ( $^2P_{1/2}^\circ$ )	<i>Limit</i>		7 215 000		

## Ca xvi

Z=20

B I isoelectronic sequence

Ground state:  $1s^2 2s^2 2p^2 P^{\circ}_{1/2}$ Ionization energy = 7 860 000  $\text{cm}^{-1}$  (974 eV)

The low lying configurations  $2s^2 2p$ ,  $2s 2p^2$ , 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).

## References

- Kononov, E. Y., Koshelev, K. N., Podobedova, L. I., and Churilov, S. S. (1975), *Opt. Spectrosc.* **39**, 458.  
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## Ca xvi

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

## Ca xvii

Z=20

Be I isoelectronic sequence

Ground state:  $1s^2 2s^2 \ ^1S_0$ Ionization energy =  $8\ 770\ 000\ \text{cm}^{-1}$  (1087 eV)

The strong singlet resonance line  $2s^2 \ ^1S_0 - 2s2p \ ^1P^{\circ}_1$  at  $192.8\ \text{\AA}$  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.

## References

- Fawcett, B. C., and Hayes, R. W. (1975), *Mon. Not. R. Astr. Soc.* **170**, 185.  
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## Ca xvii

Configuration	Term	<i>J</i>	Level ( $\text{cm}^{-1}$ )	Configuration	Term	<i>J</i>	Level ( $\text{cm}^{-1}$ )
$2s^2$	$^1S$	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				
$2s2p$	$^1P^{\circ}$	1	518 620	$2s3d$	$^1D$	2	5 236 000
$2p^2$	$^3P$	1	706 680	$2p3p$	$^3D$	3	5 448 000
		2	726 450	$2p3d$	$^3D^{\circ}$	2	5 533 000
			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 ( $^2S_{1/2}$ )	<i>Limit</i>		8 770 000

## Ca XVIII

Z=20

Li I isoelectronic sequence

Ground state:  $1s^2 2s^2 S_{1/2}$ Ionization energy =  $9\,332\,000\text{ cm}^{-1}$  (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).

## References

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## Ca XVIII

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

## Ca XIX

 $Z=20$ 

He I isoelectronic sequence

Ground state:  $1s^2\ ^1S_0$ Ionization energy =  $41\ 369\ 120 \pm 40\ \text{cm}^{-1}$  ( $5129.16 \pm 0.01\ \text{eV}$ )

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  $1s2p\ ^3P^{\circ}_1$  at  $31\ 322\ 000\ \text{cm}^{-1}$  and  $1s2p\ ^1P^{\circ}_1$  at  $31\ 480\ 000\ \text{cm}^{-1}$ .

## References

- Ermolaev, A. M. and Jones, M. (1974), *J. Phys.* **B 7**, 199.  
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## Ca XIX

Configuration	Term	$J$	Level ( $\text{cm}^{-1}$ )	Configuration	Term	$J$	Level ( $\text{cm}^{-1}$ )
$1s^2$	$^1S$	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
$1s2s$	$^1S$	0	31 330 780			2	38 878 300
$1s2p$	$^1P^{\circ}$	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 ( $^2S_{1/2}$ )	<b>Limit</b>		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 =  $44\,117\,200 \pm 200 \text{ cm}^{-1}$  ( $5469.88 \pm 0.02 \text{ eV}$ )

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