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Cite as: Journal of Physical and Chemical Reference Data **8**, 1 (1979); https://doi.org/10.1063/1.555591

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The energy levels of the titanium 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. Term designations, 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; titanium.

Contents

Introduction

At the time of the first compilation of atomic energy levels by Bacher and Goudsmit in 1932, only the first 4 of the 22 spectra of titanium had been studied. By 1949, Moore was able to compile the first 13 spectra of titanium. 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 titanium. 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 in 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 vandium by Sugar and Corliss (1977, 1978), and manganese by Corliss and Sugar (1977). The present work on titanium will be followed by a compilation of the energy levels of calcium.

The present compilation comprises the energy levels of the titanium 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 derived from observed Rydberg series.[1] In a few cases where

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[1] Values for ionization energies are usually derived in their equivalence in cm^{-1}. The conversion factor 8065.479 ± 0.021 $\mathrm{cm}^{-1}/\mathrm{eV}$, as given by E. R. Cohen and B. N. Taylor, J. Phys. Chem. Ref Data 2, 663 (1973), was used to obtain values in eV.

0047-2689/79/010001-62/$05.00

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 spectra.

For a convenient source of wavelengths of titanium 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 Ti xxi and xxii, which are isoelectronic with He i and H i, respectively, we give only theoretical level values since 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 (^{5}H, ^{7}H, etc. in *LS* coupling, for example) are theoretically expected, and spectroscopists have given such names on the basis of *g*-values, intensities, arrangement of the levels, and, more recently, theoretical calculations. We have included the results of calculations, under the heading "Leading components (%)", 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 revised the term and configuration labeling of a level to conform with its calculated leading percentages. In some cases these are quite 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 ψ_A of an actual energy level *A* can be expressed as

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

where $\alpha_1^2 + \alpha_2^2 + \dots + \alpha_n^2 = 1$. The squared quantities α_1^2, α_2^2, etc., multiplied by 100, represent the percentage composition of a given level. Generally, levels are given names corresponding to the basis state having the largest percentage.

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

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

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

The labeling of terms by lower case letters, *a*, *b*, *c*, etc. (for example *a* ^{5}D, *z* ^{5}G°, etc.) has been dropped, except for Ti i and ii, where their use in connection with various wavelength tables makes their retention desirable.

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

i. papers cited by Moore (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 March 1, 1978, at which time the compilations were considered completed.

Acknowledgments

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

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

This work was carried out with the support of the U.S. Department of Energy, Division of Magnetic Fusion Energy, and the Office of Standard Reference Data of the National Bureau of Standards.

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Energy Level Tables

Ti I

$Z=22$

Ground state: $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^2\,4s^2\;{}^3\mathrm{F}_2$

Ionization energy = 55 010 cm^{-1} (6.820 eV)

The structure of the arc spectrum of titanium was first studied by Kiess and Kiess (1923, 1924) who classified 400 lines as members of the triplet and quintet systems. Their results are presented in the form of arrays of triplets and quintets and tables of observed and calculated Zeeman effects.

In 1927 Russell published his classical analyses of Ti I and Ti II. He extended Kiess's analysis of the triplets and quintets in Ti I and established the singlet system. His list of 142 terms is presented in nearly modern notation, with the energy level values measured from the ground state taken as zero. He also gave a table of wavelengths of 1394 classified lines between 9800 and 2100 Å and a table of observed and theoretical Zeeman patterns. Every term was assigned to a definite electron configuration. A key for translating Russell's notation into that used at present is given by Moore (1932). Russell determined an ionization limit at 55 100 cm^{-1}, very close to the value of Catalan and Velasco (1952) adopted here.

In 1928 Kiess calculated 3 decimal place term values for 62 levels of Ti I from interferometer measurements of Ti I wavelengths. This work was revised by Kiess and Thekaekara (1959), who calculated 3 decimal place term values for 152 Ti I levels. These values will be found in the present compilation.

The analysis of Ti I was continued by Meggers and Kiess (1932), who observed the spectrum between 8377 and 10 775 Å. With these data they found the lowest term of $3d^4$, $a\ {}^5\mathrm{D}$, within 500 cm^{-1} of its position as predicted by Russell. The infrared observations were later extended to 11 974 Å by Kiess (1938), who found the next term of $3d^4$, $d\ {}^3\mathrm{P}$.

The *g*-values were calculated by Moore (1949) from the Zeeman patterns quoted by Russell (1927). Moore has omitted the $a\ {}^1\mathrm{S}_0$ level at 15 166 cm^{-1} given by Russell, following his advice. Russell questioned the reality of his level at 40 883 cm^{-1}, and his doubts were supported by the calculations of Roth (1969). We have omitted this level. The ${}^3\mathrm{H}$ term was privately communicated to Moore (1949).

New measurements in the region 2117 to 3072 Å by Wilson and Thekaekara (1961) resulted in a revision of level values for 16 high odd levels and the discovery of two new triplet terms, $s\ {}^3\mathrm{G}^\circ$ and $\mathrm{p}\ {}^3\mathrm{F}^\circ$, which have been assigned to $3d^3\,({}^2\mathrm{F})4p$ by Smith and Siddall (1969). Smith and Siddall also assigned 7 terms to $3d^2\,4s5p$ or $3d^3\,5p$.

The configurations $(3d+4s)^3\,4p$ were calculated by Roth (1969). His percentage compositions and designation changes for experimental levels are adopted here. Roth distinguished repeating terms of the $3d^3$ core by the letters *a*, *b*, etc. rather than by seniority. The percentages include the sum of seniority states contributing to the term. Roth included no experimental levels above 44 000 cm^{-1} in his calculation. We have quoted his results for four terms above 44 000 for which agreement with experiment was clear.

Percentages for the configuration $3d^34s$ are quoted from an ab initio calculation by Vizbaraite, Rudzikas, and Grabauskas (1968).

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Ti I

Configuration	Term	J	Level (cm^{-1})	g	Leading components (%)	
					First	Second
$3d^24s^2$	$a\ {}^3\mathrm{F}$	2	0.000	0.66		
		3	170.132	1.08		
		4	386.874	1.25		
$3d^3(^4\mathrm{F})4s$	$a\ {}^5\mathrm{F}$	1	6556.828	0.00	100	
		2	6598.749	0.99	100	
		3	6661.003	1.25	100	
		4	6742.757	1.35	100	
		5	6842.964	1.41	100	
$3d^24s^2$	$a\ {}^1\mathrm{D}$	2	7255.369	1.02		
$3d^24s^2$	$a\ {}^3\mathrm{P}$	0	8436.618			
		1	8492.421	1.50		
		2	8602.340	1.49		
$3d^3(^4\mathrm{F})4s$	$b\ {}^3\mathrm{F}$	2	11 531.760	0.67	100	
		3	11 639.804	1.08	100	
		4	11 776.806	1.26	100	
$3d^24s^2$	$a\ {}^1\mathrm{G}$	4	12 118.394	0.98		
$3d^3(^4\mathrm{P})4s$	$a\ {}^5\mathrm{P}$	1	13 981.75	2.50	100	
		2	14 028.47	1.82	100	
		3	14 105.68	1.66	100	
$3d^3(^2\mathrm{G})4s$	$a\ {}^3\mathrm{G}$	3	15 108.121	0.74	100	
		4	15 156.787	1.06	100	
		5	15 220.390	1.21	100	
$3d^2(^3\mathrm{F})4s4p(^3\mathrm{P}^\circ)$	$z\ {}^5\mathrm{G}^\circ$	2	*15 877.18*	0.39	100	
		3	*15 975.59*	0.93	100	
		4	*16 106.08*	1.15	100	
		5	*16 267.51*	1.25	100	
		6	*16 458.71*	1.33	100	
$3d^2(^3\mathrm{F})4s4p(^3\mathrm{P}^\circ)$	$z\ {}^5\mathrm{F}^\circ$	1	*16 817.19*	0.00	94	
		2	*16 875.19*		98	
		3	*16 961.42*	1.26?	98	
		4	*17 075.31*	1.34	98	
		5	*17 215.44*	1.42	98	
$3d^3(^2\mathrm{D}2)4s$	$a\ {}^3\mathrm{D}$	1	17 369.59	0.49	94	5 $(^2\mathrm{D}1)\ {}^3\mathrm{D}$
		2	17 423.853	1.17	95	5
		3	17 540.205	1.34	96	4
$3d^3(^2\mathrm{P})4s$	$b\ {}^3\mathrm{P}$	0	17 995.75		100	
		1	18 061.54		100	
		2	18 145.40		100	
$3d^3(^2\mathrm{H})4s$	$a\ {}^3\mathrm{H}$	4	18 037.225	0.80	88	11 $(^2\mathrm{G})\ {}^1\mathrm{G}$
		5	18 141.229	1.02	100	
		6	18 192.577	1.17	100	

Ti I—Continued

Configuration	Term	J	Level (cm^{-1})	g	Leading components (%)	
					First	Second
$3d^3(^2G)4s$	$b\ ^1G$	4	18 287.560	1.02	88	11 $(^2H)\ ^3H$
$3d^2(^3F)4s4p(^3P^\circ)$	$z\ ^5D^\circ$	0	*18 462.83*		94	
		1	*18 482.86*	1.65?	94	
		2	*18 525.07*	1.50	94	
		3	*18 593.99*	1.49	93	
		4	*18 695.23*	1.51	94	
$3d^3(^2P)4s$	$c\ ^3P$	0	18 818.23		100	
		1	18 825.89	1.54?	100	
		2	18 911.399	1.54	100	
$3d^2(^3F)4s4p(^3P^\circ)$	$z\ ^3F^\circ$	2	*19 322.988*	0.67	88	8 $(^1D)(^3P^\circ)\ ^3F^\circ$
		3	*19 421.576*	1.07	88	7
		4	*19 573.968*	1.26	88	7
$3d^2(^3F)4s4p(^3P^\circ)$	$z\ ^3D^\circ$	1	*19 937.859*		84	8 $(^3P)(^3P^\circ)\ ^3D^\circ$
		2	*20 006.032*	1.16	83	8
		3	*20 126.055*	1.34	83	8
$3d^3(^2P)4s$	$a\ ^1P$	1	20 062.98	1.03	98	
$3d^3(^2D2)4s$	$b\ ^1D$	2	20 209.444	1.01?	95	5 $(^2D1)\ ^1D$
$3d^3(^2H)4s$	$a\ ^1H$	5	20 795.599	1.01	100	
$3d^2(^3F)4s4p(^3P^\circ)$	$z\ ^3G^\circ$	3	*21 469.494*	0.75	95	
		4	*21 588.496*	1.05	95	
		5	*21 739.713*	1.21	95	
$3d^2(^3F)4s4p(^3P^\circ)$	$z\ ^1D^\circ$	2	*22 081.198*	1.00	86	10 $(^3P)(^3P^\circ)\ ^1D^\circ$
$3d^2(^3F)4s4p(^3P^\circ)$	$z\ ^1F^\circ$	3	*22 404.69*	1.00	97	
$3d^2(^3F)4s4p(^3P^\circ)$	$z\ ^1G^\circ$	4	*24 694.895*	0.97	94	
$3d^2(^3P)4s4p(^3P^\circ)$	$z\ ^3S^\circ$	1	*24 921.110*	1.99	90	7 $3d^3(^2P)4p\ ^3S^\circ$
$3d^2(^3P)4s4p(^3P^\circ)$	$z\ ^5S^\circ$	2	*25 102.88*	1.93	93	
$3d^2(^3F)4s4p(^1P^\circ)$	$y\ ^3F^\circ$	2	*25 107.417*		44	25 $3d^3(^4F)4p\ ^3F^\circ$
		3	*25 227.217*	1.06	43	25
		4	*25 388.334*	1.21	41	23
$3d^3(^4F)4p$	$y\ ^3D^\circ$	1	*25 317.813*	0.50	49	34 $3d^2(^3F)4s4p(^1P^\circ)\ ^3D^\circ$
		2	*25 438.898*	1.17	28	37 $3d^2(^1D)4s4p(^3P^\circ)\ ^3P^\circ$
		3	*25 643.695*	1.33	32	32 $3d^2(^3P)4s4p(^3P^\circ)\ ^5D^\circ$
$3d^2(^1D)4s4p(^3P^\circ)$	$z\ ^3P^\circ$	2	*25 493.722*	1.47	49	20 $3d^3(^4F)4p\ ^3D^\circ$
		1	*25 537.276*	1.50	64	22 $3d^2(^3P)4s4p(^3P^\circ)\ ^5D^\circ$

Ti I—Continued

Configuration	Term	J	Level (cm^{-1})	g	Leading components (%)	
					First	Second
$3d^2(^3P)4s4p(^3P^\circ)$	$y\ ^5D^\circ$	0	*25 605.03*		51	32 $3d^2(^1D)4s4p(^3P^\circ)\ ^3P^\circ$
		1	*25 635.74*		65	19 $3d^2(^1D)4s4p(^3P^\circ)\ ^3P^\circ$
		2	*25 699.95*		82	6 $3d^3(^4F)4p\ ^5D^\circ$
		3	*25 797.60*		56	19 $3d^3(^4F)4p\ ^3D^\circ$
		4	*25 926.771*	1.52	87	7 $3d^3(^4F)4p\ ^5D^\circ$
$3d^3(^4F)4p$	$y\ ^5G^\circ$	2	*26 494.322*	0.34	94	
		3	*26 564.385*	0.91	96	
		4	*26 657.409*	1.15	98	
		5	*26 772.965*	1.25	100	
		6	*26 910.705*	1.34	100	
$3d^2(^1D)4s4p(^3P^\circ)$	$x\ ^3F^\circ$	2	*26 803.417*	0.66	58	19 $(^3F)(^1P^\circ)\ ^3F^\circ$
		3	*26 892.926*	1.06	57	20
		4	*27 025.652*	1.23	57	20
$3d^2(^1D)4s4p(^3P^\circ)$	$x\ ^3D^\circ$	1	*27 355.042*		78	12 $(^3P)(^3P^\circ)\ ^3D^\circ$
		2	*27 418.015*	1.17	73	9
		3	*27 480.047*	1.36	64	9
$3d^2(^3F)4s4p(^1P^\circ)$	$y\ ^3G^\circ$	3	*27 498.975*	0.75	56	23 $3d^3(^4F)4p\ ^3G^\circ$
		4	*27 614.667*	1.05	55	23
		5	*27 750.124*	1.21	53	24
$3d^2(^3P)4s4p(^3P^\circ)$	$z\ ^5P^\circ$	1	*27 665.57*		97	
		2	*27 740.19*		91	
		3	*27 887.74*		79	16 $(^1D)(^3P^\circ)\ ^3D^\circ$
$3d^2(^1D)4s4p(^1P^\circ)$	$y\ ^1D^\circ$	2	*27 907.026*	0.98	32	26 $3d\,4s^24p\ ^1D^\circ$
$3d^3(^4F)4p$	$y\ ^5F^\circ$	1	*28 596.293*	0.00	98	
		2	*28 638.832*	1.01	98	
		3	*28 702.768*	1.24	98	
		4	*28 788.372*	1.34	98	
		5	*28 896.062*	1.40	97	
$3d^4$	$a\ ^5D$	0	28 772.86			
		1	28 791.62			
		2	28 828.51			
		3	28 882.44			
		4	28 952.10			
$3d^2(^3F)4s4p(^1P^\circ)$	$w\ ^3D^\circ$	1	*29 661.232*	0.51	33	24 $3d^3(^4F)4p\ ^3D^\circ$
		2	*29 768.655*	1.16	29	21 $3d^3(^4F)4p\ ^3D^\circ$
		3	*29 912.262*	1.34	20	35 $3d^3(^4F)4p\ ^3D^\circ$
$3d^3(^2F)4s$	$a\ ^1F$	3	29 818.31		100	
$3d^3(^4F)4p$	$x\ ^5D^\circ$	0	*29 829.097*		91	
		1	*29 855.248*	1.46	87	7 $3d^2(^3P)4s4p(^3P^\circ)\ ^5D^\circ$
		2	*29 907.273*	1.50	77	6 $3d^2(^3P)4s4p(^3P^\circ)\ ^5D^\circ$
		3	*29 986.185*	1.49	55	14 $3d^2(^3F)4s4p(^1P^\circ)\ ^3D^\circ$
		4	*30 060.328*	1.49	91	

Ti I—Continued

Configuration	Term	J	Level (cm^{-1})	g	Leading components (%)	
					First	Second
$3d^2(^1G)4s4p(^3P^\circ)$	$x\,^3G^\circ$	3	*29 914.720*		70	19 $(^3F)(^1P^\circ)\,^3G^\circ$
		4	*29 971.078*		72	19
		5	*30 039.211*	1.19	71	19
$3d^2(^3P)4s4p(^3P^\circ)$	$v\,^3D^\circ$	1	*31 184.021*	0.51	77	16 $(^1D)(^3P^\circ)\,^3D^\circ$
		2	*31 190.631*	1.17	68	15
		3	*31 205.985*	1.34	69	14
$3d^3(^4F)4p$	$w\,^3G^\circ$	3	*31 373.801*	0.75	70	21 $3d^2(^3F)4s4p(^1P^\circ)\,^3G^\circ$
		4	*31 489.451*	1.05	69	22
		5	*31 628.668*	1.19	69	22
$3d^2(^3P)4s4p(^3P^\circ)$	$y\,^3P^\circ$	0	*31 685.90*		85	7 $3d^3(^2P)4p\,^3P^\circ$
		1	*31 725.75*	1.47	85	6
		2	*31 805.94*		85	6
$3d^2(^1G)4s4p(^3P^\circ)$	$z\,^3H^\circ$	4	*31 829.972*	0.80	85	11 $3d^3(^2G)4p\,^3H^\circ$
		5	*31 914.277*	1.04	86	10
		6	*32 013.534*	1.17	86	10
$3d^2(^1D)4s4p(^1P^\circ)$	$y\,^1F^\circ$	3	*32 857.721*	0.99	36	44 $3d^3(^2G)4p\,^1F^\circ$
$3d^3(^4P)4p$	$x\,^3P^\circ$	0	*33 085.153*		33	34 $3d^2(^3P)4s4p(^1P^\circ)\,^3P^\circ$
		1	*33 090.492*	1.46	33	34
		2	*33 114.412*	1.46	34	34
$3d^3(^4F)4p$	$w\,^3F^\circ$	2	*33 655.853*	0.66	54	30 $3d^2(^3F)4s4p(^1P^\circ)\,^3F^\circ$
		3	*33 680.130*	1.09	53	30
		4	*33 700.874*	1.26	53	30
$3d^2(^1D)4s4p(^1P^\circ)$	$z\,^1P^\circ$	1	*33 660.671*	0.94	37	29 $(^3P)(^3P^\circ)\,^1P^\circ$
$3d^2(^1G)4s4p(^3P^\circ)$	$v\,^3F^\circ$	2	*33 980.639*	0.63	81	9 $3d\,4s^24p\,^3F^\circ$
		3	*34 078.580*	1.10	83	9
		4	*34 204.971*	1.23	84	8
$3d^4$	$d\,^3P$	0	34 170.95			
		1	34 327.96			
		2	34 535.04			
$3d^3(^2G)4p$	$z\,^1H^\circ$	5	*34 700.212*	1.02	58	26 $(^2H)\,^1H^\circ$
$3d^2(^3P)4s4p(^3P^\circ)$	$y\,^1P^\circ$	1	*34 947.120*		54	26 $(^1D)(^1P^\circ)\,^1P^\circ$
$3d^2(^3P)4s4p(^3P^\circ)$	$x\,^1D^\circ$	2	*35 035.147*		56	12 $(^3F)(^3P^\circ)\,^1D^\circ$
	$y\,^3S^\circ$	1	*35 439.228*	2.18		
$3d^3(^2G)4p$	$y\,^3H^\circ$	4	*35 454.051*	0.79	84	13 $3d^2(^1G)4s4p(^3P^\circ)\,^3H^\circ$
		5	*35 559.627*	1.04	85	12
		6	*35 685.160*	1.17	85	12

Ti I—Continued

Configuration	Term	J	Level (cm^{-1})	g	Leading components (%)	
					First	Second
$3d^3(^4P)4p$	$w\ ^5D^\circ$	0	*35 503.40*		99	
		1	*35 527.76*	1.51	99	
		2	*35 577.14*	1.53	99	
		3	*35 652.95*	1.46	99	
		4	*35 757.51*	1.46	99	
$3d^24s(^4F)5s$	$e\ ^5F$	1	35 959.07	0.00		
		2	36 013.57	1.03?		
		3	36 096.47	1.24		
		4	36 208.92	1.34		
		5	36 351.43	1.42		
$3d^2(^1G)4s4p(^1P^\circ)$	$y\ ^1G^\circ$	4	*36 000.144*	1.00	45	32 $3d^3(^2G)4p\ ^1G^\circ$
$3d^4$	$b\ ^3G$	3	36 065.75			
		4	36 132.21			
		5	36 200.94			
$3d^3(^4P)4p$	$y\ ^5P^\circ$	1	*36 298.43*	2.47	97	
		2	*36 340.67*	1.81	97	
		3	*36 414.58*	1.66	98	
$3d^3(a\ ^2D)4p$	$w\ ^3P^\circ$	0	*37 090.65*		35	35 $(^4P)\ ^3P^\circ$
		1	*37 172.947*	1.53	36	35
		2	*37 325.407*	1.48	33	33
$3d^3(^4P)4p$	$y\ ^5S^\circ$	2	*37 359.13*	1.99	90	
$3d^24s(^4F)5s$	$e\ ^3F$	2	37 538.804	0.67		
		3	37 659.927	1.11		
		4	37 824.748	1.27		
$3d^3(^2G)4p$	$v\ ^3G^\circ$	3	*37 555.021*	0.77	77	7 $3d^2(^1G)4s4p(^3P^\circ)\ ^3G^\circ$
		4	*37 617.868*	1.05	81	7
		5	*37 690.320*	1.20	85	7
$3d\,4s^24p$	$x\ ^1F^\circ$	3	*37 622.573*	0.94	25	16 $3d^2(^1G)4s4p(^1P^\circ)\ ^1F^\circ$
$3d^3(a\ ^2D)4p$	$u\ ^3F^\circ$	2	*37 654.77*	0.65	49	20 $(^2G)\ ^3F^\circ$
		3	*37 743.933*	1.08	26	14
		4	*37 852.434*	1.24	41	26
$3d^2(^3P)4s4p(^1P^\circ)$	$u\ ^3D^\circ$	1	*37 852.021*	0.53	42	17 $3d^3(^2P)4p\ ^3D^\circ$
		2	*37 976.78*	1.14?	41	17
		3	*38 159.71*	1.35	39	17
$3d^3(^2P)4p$	$z\ ^1S^\circ$	0	*38 200.94*		80	18 $3d^2(^3P)4s4p(^3P^\circ)\ ^1S^\circ$
$3d^3(^2G)4p$	$t\ ^3F^\circ$	2	*38 451.298*	0.66	58	27 $(a\ ^2D)\ ^3F^\circ$
		3	*38 544.38*	1.08	55	30
		4	*38 670.710*	1.25	52	34

Ti I—Continued

Configuration	Term	J	Level (cm^{-1})	g	Leading components (%)	
					First	Second
$3d^3(^2\mathrm{H})4p$	$z\ ^3\mathrm{I}^\circ$	5	*38 572.692*	0.81	100	
		6	*38 668.832*	1.02	100	
		7	*38 779.856*	1.15	100	
$3d^3(^2\mathrm{P})4p$	$t\ ^3\mathrm{D}^\circ$	1	*38 654.23*	0.54?	37	22 $3d\,4s^24p\ ^3\mathrm{D}^\circ$
		2	*38 699.767*		32	20
		3	*38 764.832*	1.32	32	20
$3d^3(^2\mathrm{G})4p$	$x\ ^1\mathrm{G}^\circ$	4	*38 959.499*	1.02	50	29 $(^2\mathrm{H})\ ^1\mathrm{G}^\circ$
$3d^3(a\ ^2\mathrm{D})4p$	$x\ ^1\mathrm{P}^\circ$	1	*39 077.713*		73	16 $(^2\mathrm{P})\ ^1\mathrm{P}^\circ$
$3d^3(^4\mathrm{F})5s$	$f\ ^5\mathrm{F}$	1	39 107.25			
		2	39 149.26			
		3	39 214.38			
		4	39 302.36			
		5	39 412.78			
$3d^3(^2\mathrm{H})4p$	$x\ ^3\mathrm{H}^\circ$	4	*39 115.958*	0.88	93	
		5	*39 152.057*	1.02	85	12 $3d^2(^1\mathrm{G})4s4p(^3\mathrm{P}^\circ)\ ^3\mathrm{H}^\circ$
		6	*39 198.320*	1.18	85	12 $3d^2(^1\mathrm{G})4s4p(^3\mathrm{P}^\circ)\ ^3\mathrm{H}^\circ$
$3d\,4s^24p$	$w\ ^1\mathrm{D}^\circ$	2	*39 265.80*	1.06?	28	30 $3d^3(^2\mathrm{P})4p\ ^1\mathrm{D}^\circ$
$3d^3(^4\mathrm{F})5s$	$f\ ^3\mathrm{F}$	2	39 526.89			
		3	39 640.98			
		4	39 785.94			
$3d^3(a\ ^2\mathrm{D})4p$	$s\ ^3\mathrm{D}^\circ$	1	*39 662.15*	0.52	54	14 $(^2\mathrm{P})\ ^3\mathrm{D}^\circ$
		2	*39 686.10*		60	17
		3	*39 715.437*	1.31	55	20
$3d^3(a\ ^2\mathrm{D})4p$	$w\ ^1\mathrm{F}^\circ$	3	*40 302.950*	1.05	82	7 $3d^2(^1\mathrm{D})4s4p(^1\mathrm{P}^\circ)\ ^1\mathrm{F}^\circ$
$3d^3(^2\mathrm{H})4p$	$z\ ^1\mathrm{I}^\circ$	6	*40 319.80*	1.03	99	
$3d\,4s^24p$	$v\ ^3\mathrm{P}^\circ$	0	*40 369.76*		37	23 $3d^2(^3\mathrm{P})4s4p(^1\mathrm{P}^\circ)\ ^3\mathrm{P}^\circ$
		1	*40 384.58*		24	30 $3d^3(^2\mathrm{P})4p\ ^3\mathrm{S}^\circ$
		2	*40 466.979*		36	21 $3d^2(^3\mathrm{P})4s4p(^1\mathrm{P}^\circ)\ ^3\mathrm{P}^\circ$
$3d^3(^4\mathrm{P})4p$	$r\ ^3\mathrm{D}^\circ$	1	*40 556.07*	0.49	44	22 $(a\ ^2\mathrm{D})\ ^3\mathrm{D}^\circ$
		2	*40 670.60*		43	24
		3	*40 844.19*		40	25
$3d^3(^2\mathrm{P})4p$	$x\ ^3\mathrm{S}^\circ$	1	*40 844.19*		57	13 $3d\,4s^24p\ ^3\mathrm{P}^\circ$
$3d^3(^2\mathrm{H})4p$	$y\ ^1\mathrm{H}^\circ$	5	*41 039.874*	1.03	47	41 $(^2\mathrm{G})\ ^1\mathrm{H}^\circ$
$3d^24s(^2\mathrm{F})5s$	$e\ ^1\mathrm{F}$	3	41 087.31	1.01		

Ti I—Continued

Configuration	Term	J	Level (cm^{-1})	g	Leading components (%)	
					First	Second
$3d^24s(^4F)5p$?	$u\ ^3G^\circ$	3	*41 170.003*	0.73		
		4	*41 255.400*	1.03		
		5	*41 341.553*	1.19		
$3d^24s(^4F)4d$	$e\ ^3G$	3	41 194.42			
		4	41 368.86			
		5	41 481.13			
$3d\,4s^24p$	$s\ ^3F^\circ$	2	*41 337.43*	0.66	66	18 $3d^3(a\ ^2D)4p\ ^3F^\circ$
		3	*41 457.653*	1.09	67	19
		4	*41 624.209*	1.24	68	18
$3d^24s(^4F)4d$	$e\ ^3H$	4	41 515.09			
		5	41 556.33			
		6	41 615.02			
$3d^3(^2G)4p$	$v\ ^1F^\circ$	3	*41 585.24*		43	31 $3d^2(^1D)4s4p(^1P^\circ)\ ^1F^\circ$
$3d^24s(^4F)4d$	$e\ ^5G$	2	41 714.35			
		3	41 757.47			
		4	41 818.70	1.12		
		5	41 903.48	1.24		
		6	42 019.22	1.34		
$3d^24s(^4F)5p$	$w\ ^3H^\circ$	4	*41 780.95*			
		5	*41 895.15*			
		6	*41 995.39*			
$3d^24s(^4F)5p$	$v\ ^5D^\circ$	0	*41 822.99*			
		1	*41 854.01*			
		2	*41 906.51*			
		3	*41 985.83*			
		4	*42 092.42*			
$3d^24s(^4F)4d$	$e\ ^5H$	3	41 823.19			
		4	41 917.05			
		5	42 018.01	1.15		
		6	42 123.77	1.22		
		7	42 205.59	1.28		
$3d^24s(^4F)4d$	$e\ ^5D$	0	41 871.56			
		1	41 901.36			
		2	41 958.51			
		3	42 052.72			
		4	42 184.66			
$3d^24s(^4F)4d$	$g\ ^3F$	2	41 871.87			
		3	41 988.39			
		4	42 107.06			

Ti I—Continued

Configuration	Term	J	Level (cm^{-1})	g	Leading components (%)	
					First	Second
$3d^3(^2P)4p$	$u\ ^3P^\circ$	2	*41 928.528*		38	37 $(a\ ^2D)\ ^3P^\circ$
		1	*41 943.95*		36	37
		0	*41 959.46*		36	36
$3d\,4s^24p$	$q\ ^3D^\circ$	1	*42 146.39*		39	20 $3d^2(^3P)4s4p(^1P^\circ)\ ^3D^\circ$
		2	*42 206.88*		27	14
		3	*42 311.269*	1.32	39	20
$3d^24s(^4F)5p$?	$p\ ^3D^\circ$	1	*42 194.04*			
		2	*42 269.78*			
		3	*42 376.45*			
$3d^24s(^4F)4d$	$e\ ^5P$	1	42 611.58			
		2	42 724.11			
		3	42 858.90	1.64		
	$w\ ^1P^\circ$	1	*42 927.55*	1.00?		
$3d^24s(^4F)4d$	$g\ ^5F$	1	43 034.08			
		2	43 080.92			
		3	43 148.15			
		4	43 231.99			
		5	43 330.07			
$3d^24s(^4F)5p$	$r\ ^3F^\circ$	2	*43 467.55*			
		3	*43 583.14*			
		4	*43 744.55*			
$3d^3(^2H)4p$	$v\ ^1G^\circ$	4	*43 674.130*	0.95	30	36 $(^2F)\ ^1G^\circ$
	$v\ ^1D^\circ$	2	*43 710.28*			
$3d^3(a\ ^2D)4p$	$u\ ^1D^\circ$	2	*43 799.455*	0.98	38	29 $3d^2(^1D)4s4p(^1P^\circ)\ ^1D^\circ$
$3d^3(^4F)4d$	$f\ ^5H$	3	43 843.82			
		4	43 901.630	0.91		
		5	43 971.513	1.11		
		6	44 051.333	1.21		
		7	44 134.639	1.29		
$3d^24s(^4F)5p$	$o\ ^3D^\circ$	1	*43 975.71*			
		2	*44 079.84*	1.18?		
		3	*44 233.65*			
$3d^24s(^4F)5p$	$t\ ^3G^\circ$	4	*44 162.44*			
		5	*44 375.57*			
$3d^2(^1G)4s4p(^1P^\circ)$	$x\ ^1H^\circ$	5	*44 163.24*	1.03	72	27 $3d^3(^2H)4p\ ^1H^\circ$
$3d^3(^4F)4d$	$f\ ^5D$	3	44 254.39			
		4	44 381.17			
$3d^24s(^2D)5s$	$e\ ^1D$	2	44 581.16			

Ti I—Continued

Configuration	Term	J	Level (cm^{-1})	g	Leading components (%)	
					First	Second
$3d^3(^4F)5p$	$q\ ^3F^\circ$	2	*44 824.13*			
		3	*44 922.73*			
		4	*45 040.81*			
$3d^3(^4P)4p$	$w\ ^3S^\circ$	1	*44 858.03*		59	35 $3d^2(^3P)4s4p(^1P^\circ)\ ^3S^\circ$
$3d^3(^4F)5p$	$n\ ^3D^\circ$	1	*44 966.39*			
		2	*45 063.80*			
		3	*45 206.27*			
	$t\ ^3P^\circ$	0	*45 040.70*			
		1	*45 090.73*			
		2	*45 178.06*			
$3d^24s(^2F)4d$	$e\ ^1H$	5	45 485.35			
$3d^3(^4F)4d$?	$f\ ^5G$	3	45 689.89			
		4	45 711.28			
		5	45 756.45?			
		6	45 904.73			
$3d^24s(^2F)4d$	$f\ ^3H$	4	45 721.878	0.80		
		5	45 832.50	1.03		
		6	45 960.439	1.17		
$3d^24s(^4F)6s$	$h\ ^5F$	1	45 764.71			
		2	45 813.01			
		3	45 893.26			
		4	46 007.62			
		5	46 157.76			
$3d^24s(^2F)4d$	$e\ ^1G$	4	46 068.04			
$3d^24s(^4P)5s$	$e\ ^3P$	2	46 244.60			
$3d^24s(^2F)5p$	$u\ ^1G^\circ$	4	*46 257.67*	0.95		
$3d^24s(^4F)6s$	$h\ ^3F$	4	46 530.45			
$3d^24s(^2F)4d$	$f\ ^1F$	3	46 650.26			
$3d^3(^2F)4p$	$s\ ^3G^\circ$	3	*46 725.42*		87	11 $(^2F)\ ^3F^\circ$
		4	*46 838.09*		87	10
		5	*46 974.65*		97	
$3d^24p^2$	$g\ ^5G$	2	46 943.91			
		3	47 030.28			
		4	47 139.86			
		5	47 280.69			
		6	47 446.84			

Ti I—Continued

Configuration	Term	J	Level (cm^{-1})	g	Leading components (%)	
					First	Second
$3d^24s(^2F)4d$	$i\ ^3F$	3	47 038.16			
		4	47 194.68			
$3d^3(^2F)4p$	$p\ ^3F^\circ$	2	*47 187.54*		97	
		3	*47 281.90*		86	11 $(^2F)\ ^3G^\circ$
		4	*47 463.06*		87	10
$3d^3(4f)6s$	$i\ ^5F$	5	47 777.32			
$3d^24s(^4F)5d$	$g\ ^5H$	3	47 840.62			
		4	47 913.61			
		5	47 994.32			
		6	48 106.83			
		7	48 262.83			
$3d^24s(^4F)5d$	$h\ ^5G$	2	47 870.61			
		3	47 936.79			
		4	48 018.08			
		5	48 119.47			
		6	48 233.47			
$3d^24p^2$	$j\ ^5F$	1	48 058.85			
		2	48 107.42			
		3	48 208.87			
		4	48 328.81			
		5	48 462.11			
$3d^24s(^4F)5d$	$g\ ^5D$	3	48 059.82			
		4	48 186.11			
$3d^3(^2F)4p$	$u\ ^1F^\circ$	3	*48 365.09*		48	24 $3d\,4s^24p\ ^1F^\circ$
$3d^24s(^4F)5d$	$k\ ^5F$	2	48 519.21			
		3	48 588.28			
		4	48 672.66			
		5	48 771.73			
$3d^24p^2$	$e\ ^3D$	2	48 724.34			
		1	48 724.83			
		3	48 839.74			

Ti I—Continued

Configuration	Term	J	Level (cm^{-1})	g	Leading components (%)	
					First	Second
$3d^24p^2$	$h\ ^5$D	0	48 802.32			
		1	48 859.51			
		2	48 915.07			
		3	49 024.43			
		4	49 036.46			
	$f\ ^3$D	2	49 571.69			
		3	49 619.72			
	$f\ ^1$D	2	50 128.08			
	$f\ ^1$G	4	52 125.98			
	$e\ ^1$P	1	53 663.32			
Ti II ($^4F_{3/2}$)	*Limit*	....	55 010			

Ti II

$Z=22$

Sc I isoelectronic sequence

Ground state: $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^2\,4s\;{}^4\mathrm{F}_{3/2}$

Ionization energy = 109 500 ± 1000 cm^{-1} (13.58 ± 0.1 eV)

The analysis of Ti II was done by Henry Norris Russell (1927) fifty years ago and no experimentally determined energy levels have been published since.

The *g*-values have been determined by Catalan from the Zeeman patterns observed by King and Babcock and quoted by Russell. They were published by Moore (1949).

The percentage composition of the levels of $3d^3$ are from the Hartree-Fock calculation of Dosinas, Vizbaraite, Rudzikas, and Jucys (1968). The composition of $3d^24s$ levels is taken from the Hartree-Fock calculation of Vizbaraite, Rudzikas, and Grabauskas (1968). We have corrected a misprint for the ${}^4\mathrm{P}_{5/2}$ percentages. They calculate the ${}^2\mathrm{S}$ term 44 000 cm^{-1} above the ground state. Shadmi, Oreg, and Stein (1968) calculate it at 32 000 cm^{-1}. In view of the fact that Russell found six combinations for his ${}^2\mathrm{S}$ level at 21 338 cm^{-1}, we have retained it, pending further observations.

The composition of the levels of the $3d^24p$ and $3d4s4p$ configurations are taken from Roth (1969).

The ionization energy is from Russell (1950), who estimated the uncertainty to be less than 1%.

References

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Ti II

Configuration	Term	*J*	Level (cm^{-1})	*g*	Leading components (%)	
					First	Second
$3d^2({}^3\mathrm{F})4s$	$a\;{}^4\mathrm{F}$	3/2	0.00		100	
		5/2	93.94		100	
		7/2	225.47		100	
		9/2	393.22		100	
$3d^3$	$b\;{}^4\mathrm{F}$	3/2	907.96		100	
		5/2	983.80		100	
		7/2	1087.21		100	
		9/2	1215.58		100	
$3d^2({}^3\mathrm{F})4s$	$a\;{}^2\mathrm{F}$	5/2	4628.61		100	
		7/2	4897.60		100	
$3d^2({}^1\mathrm{D})4s$	$a\;{}^2\mathrm{D}$	3/2	8710.47	0.80	74	25 $({}^3\mathrm{P})\;{}^4\mathrm{P}^\circ$
		5/2	8744.27		50	49
$3d^3$	$a\;{}^2\mathrm{G}$	7/2	8997.69		100	
		9/2	9118.15		100	
$3d^3$	$a\;{}^4\mathrm{P}$	1/2	9363.71	2.63	100	
		3/2	9395.76	1.74	100	
		5/2	9518.05		100	
$3d^3$	$a\;{}^2\mathrm{P}$	1/2	9850.90	0.66	100	
		3/2	9975.92	1.33	96	

Ti II—Continued

Configuration	Term	J	Level (cm^{-1})	g	Leading components (%)	
					First	Second
$3d^2(^3P)4s$	$b\ ^4P$	1/2	9872.87	2.60	100	
		3/2	9930.74		74	26 $(^1D)\ ^2D^\circ$
		5/2	10 024.74		51	49
$3d^3$	$b\ ^2D2$	3/2	12 628.77		74	21 $^2D1$
		5/2	12 758.15		77	22
$3d^3$	$a\ ^2H$	9/2	12 676.99		100	
		11/2	12 774.81		100	
$3d^2(^1G)4s$	$b\ ^2G$	9/2	15 257.53		100	
		7/2	15 265.60		100	
$3d^2(^3P)4s$	$b\ ^2P$	1/2	16 515.79	0.66	100	
		3/2	16 625.25	1.33	100	
$3d^3$	$b\ ^2F$	7/2	20 891.88		100	
		5/2	20 951.77		100	
	$a\ ^2S$	1/2	21 338.00?			
$3d\,4s^2$	$c\ ^2D$	3/2	24 961.34			
		5/2	25 193.04			
$3d^2(^3F)4p$	$z\ ^4G^\circ$	5/2	*29 544.37*		98	
		7/2	*29 734.45*		99	
		9/2	*29 968.08*		100	
		11/2	*30 240.68*		100	
$3d^2(^3F)4p$	$z\ ^4F^\circ$	3/2	*30 836.52*		96	
		5/2	*30 958.70*		98	
		7/2	*31 113.61*		98	
		9/2	*31 300.92*		99	
$3d^2(^3F)4p$	$z\ ^2F^\circ$	5/2	*31 207.44*		85	7 $(^1D)\ ^2F^\circ$
		7/2	*31 490.82*		89	7
$3d^2(^3F)4p$	$z\ ^2D^\circ$	3/2	*31 756.50*	0.92	83	9 $(^3P)\ ^2D^\circ$
		5/2	*32 025.50*	1.20	78	8
$3d^2(^3F)4p$	$z\ ^4D^\circ$	1/2	*32 532.38*	0.00	96	
		3/2	*32 602.51*	1.20	94	
		5/2	*32 697.94*	1.37	91	
		7/2	*32 767.02*		95	
$3d^2(^3F)4p$	$z\ ^2G^\circ$	7/2	*34 543.36*		95	
		9/2	*34 748.50*		95	
$3d^2(^3P)4p$	$z\ ^2S^\circ$	1/2	*37 430.55*	2.09	99	
$3d^2(^1D)4p$	$y\ ^2D^\circ$	3/2	*39 233.44*		61	21 $(^1D)\ ^2P^\circ$
		5/2	*39 476.87*		42	40 $(^1D)\ ^2F^\circ$

Ti II—Continued

Configuration	Term	J	Level (cm^{-1})	g	Leading components (%) First	Second
$3d^2(^1D)4p$	$z\ ^2P^\circ$	3/2	*39 602.90*	1.21	73	19 $(^1D)\ ^2D^\circ$
		1/2	*39 674.64*		97	
$3d^2(^1D)4p$	$y\ ^2F^\circ$	5/2	*39 926.83*		49	37 $(^1D)\ ^2D^\circ$
		7/2	*40 074.71*		87	8 $(^3F)\ ^2F^\circ$
$3d^2(^3P)4p$	$z\ ^4S^\circ$	3/2	*40 027.28*		96	
$3d^2(^3P)4p$	$y\ ^4D^\circ$	1/2	*40 330.25*		97	
		3/2	*40 425.80*		96	
		5/2	*40 581.80*		95	
		7/2	*40 798.37*		93	
$3d^2(^3P)4p$	$z\ ^4P^\circ$	1/2	*41 996.74*		96	
		3/2	*42 068.85*		96	
		5/2	*42 208.84*		96	
$3d^2(^1G)4p$	$y\ ^2G^\circ$	7/2	*43 740.77*		95	
		9/2	*43 780.99*		95	
$3d^2(^3P)4p$	$x\ ^2D^\circ$	5/2	*44 902.42*		79	12 $(^1D)\ ^2D^\circ$
		3/2	*44 914.80*		74	12
$3d^2(^3P)4p$	$y\ ^2P^\circ$	1/2	*45 472.89*		94	
		3/2	*45 548.90*		89	
$3d^2(^1G)4p$	$z\ ^2H^\circ$	9/2	*45 673.75*		99	
		11/2	*45 908.56*		100	
$3d^2(^1G)4p$	$x\ ^2F^\circ$	7/2	*47 466.80*		90	7 $3d(^2D)4s4p(^3P^\circ)\ ^2F^\circ$
		5/2	*47 625.17*		90	7
	$x\ ^4D^\circ$	1/2	*52 329.78*			
$3d(^2D)4s4p(^3P^\circ)$	$^4F^\circ$	3/2	*52 458.98*		98	
		5/2	*52 471.48*		99	
		7/2	*52 631.07*		99	
$3d(^2D)4s4p(^3P^\circ)$	$^4D^\circ$	1/2	*53 121.48*		97	
		3/2	*53 128.17*		95	
$3d(^2D)4s4p(^3P^\circ)$	$w\ ^2D^\circ$	5/2	*53 554.90*		89	
		3/2	*53 596.70*		92	
$3d(^2D)4s4p(^3P^\circ)$	$y\ ^4P^\circ$	1/2	*56 223.13*		97	
		3/2	*56 249.11*		96	
		5/2	*56 325.94*		96	
$3d(^2D)4s4p(^3P^\circ)$	$w\ ^2F^\circ$	5/2	*59 321.79*		96	
		7/2	*59 467.81*		96	

Ti II—Continued

Configuration	Term	*J*	Level (cm^{-1})	*g*	Leading components (%)	
					First	Second
$3d^2(^3F)5s$	*e* ^{4}F	3/2	62 180.02			
		5/2	62 271.25			
		7/2	62 409.58			
		9/2	62 594.27			
$3d^2(^3F)5s$	*e* ^{2}F	5/2	63 168.23			
		7/2	63 444.76			
$3d^2(^3F)4d$	*e* ^{4}G	5/2	64 884.65			
		7/2	64 977.57			
		9/2	65 094.29			
		11/2	65 241.60			
$3d^2(^3F)4d$	*e* ^{4}H	7/2	65 184.72			
		9/2	65 307.45			
		11/2	65 445.85			
		13/2	65 589.10			
$3d^2(^3F)4d$	*f* ^{2}F	5/2	65 312.71			
		7/2	65 458.65			
$3d^2(^3F)4d$	*e* ^{4}D	1/2	66 767.43?			
		3/2	66 816.49			
		5/2	66 937.70			
		7/2	66 996.67			
$3d^2(^3F)4d$	*e* ^{2}G	7/2	67 604.20			
		9/2	67 820.87			
$3d^2(^3F)4d$	*e* ^{2}H	9/2	68 328.95			
		11/2	68 582.34			
$3d^2(^3F)4d$	*f* ^{4}F	3/2	68 767.66			
		5/2	68 845.14			
		7/2	68 950.39			
		9/2	69 081.35			
$3d(^2D)4s4p(^1P°)$	*v* ^{2}D°	3/2	*69 327.32*		95	
		5/2	*69 622.15*		94	
$3d(^2D)4s4p(^1P°)$	*v* ^{2}F°	5/2	*70 606.35*		94	
		7/2	*70 893.00*		95	
Ti III ($^3F_2$)	*Limit*	....	**109 500**			

Ti III

$Z=22$

Ca I isoelectronic sequence

Ground state: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^2\ {}^3\mathrm{F}_2$

Ionization energy = 221 735.6 ± 2 cm^{-1} (27.4919 ± 0.0002 eV)

The first study of Ti III was by Russell and Lang (1927). They identified the $3d^2$, $3d4s$, $3d4p$, $3d4d$, and $4s4p$ configurations. The spectrum has been remeasured and greatly extended by Edlén and Svensson (1975), who have identified the $4s^2$, $3d5p$, $3d5s$, $3d6s$, $3d5d$, $3d4f$, $3d5f$, $3d5g$, $3d6g$, $3d6h$, and $3d7h$ configurations. Their observations of $3d7h$ were fragmentary and for that configuration they gave calculated term values, which we have included here.

The composition of the $3d^2$ ground configuration was calculated by Pasternak and Goldschmidt (1972). The two mixed configurations $3d(4d+5s)$ and $3d(5d+6s)$ were calculated by Wyart (1975). He also calculated as a group five odd configurations. The levels of $3d4s$ were calculated by Shadmi, Caspi, and Oreg (1969) but no percentages were given.

Edlén and Svensson determined the ionization energy from $3d5g$, $3d6g$, and $3d6h$ by means of a polarization formula.

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Ti III

Configuration	Term	J	Level (cm^{-1})	Leading components (%)	
				First	Second
$3d^2$	^{3}F	2	0.0	100	
		3	184.9	100	
		4	420.4	100	
$3d^2$	^{1}D	2	8473.5	99	
$3d^2$	^{3}P	0	10 538.4	100	
		1	10 603.6	100	
		2	10 721.2	99	
$3d^2$	^{1}G	4	14 397.6	100	
$3d^2$	^{1}S	0	32 475.5	100	
$3d\,4s$	^{3}D	1	38 064.35		
		2	38 198.95		
		3	38 425.99		
$3d\,4s$	^{1}D	2	41 704.27		
$3d\,4p$	^{1}D°	2	*75 198.21*	98	
$3d\,4p$	^{3}D°	1	*77 000.23*	100	
		2	*77 167.43*	89	11 ^{3}F°
		3	*77 424.45*	86	13 ^{3}F°
$3d\,4p$	^{3}F°	2	*77 421.86*	88	11 ^{3}D°
		3	*77 746.44*	87	13 ^{3}D°
		4	*78 158.61*	100	

Ti III—Continued

Configuration	Term	*J*	Level (cm^{-1})	Leading components (%) First	Second
3*d* 4*p*	$^{3}\mathrm{P}^{\circ}$	1	*80 939.19*	99	
		0	*80 944.87*	100	
		2	*81 024.47*	100	
3*d* 4*p*	$^{1}\mathrm{F}^{\circ}$	3	*83 116.93*	100	
3*d* 4*p*	$^{1}\mathrm{P}^{\circ}$	1	*83 796.86*	98	
4*s*^{2}	$^{1}\mathrm{S}$	0	102 665.15		
3*d* 4*d*	$^{1}\mathrm{F}$	3	127 790.57	98	
3*d* 4*d*	$^{3}\mathrm{D}$	1	128 433.40	96	4 $^{1}\mathrm{P}$
		2	128 546.38	100	
		3	128 689.67	98	
3*d* 4*d*	$^{3}\mathrm{G}$	3	129 093.28	99	
		4	129 252.74	100	
		5	129 469.37	100	
3*d* 4*d*	$^{1}\mathrm{P}$	1	129 253.41	96	4 $^{3}\mathrm{D}$
3*d* 4*d*	$^{3}\mathrm{S}$	1	130 739.82	99	
3*d* 4*d*	$^{3}\mathrm{F}$	2	133 065.24	100	
		3	133 207.10	100	
		4	133 371.07	100	
3*d* 5*s*	$^{3}\mathrm{D}$	1	133 898.50	100	
		2	133 999.79	91	8 $^{1}\mathrm{D}$
		3	134 275.12	100	
3*d* 5*s*	$^{1}\mathrm{D}$	2	134 557.84	60	32 3*d* 4*d* $^{1}\mathrm{D}$
3*d* 4*d*	$^{1}\mathrm{D}$	2	135 405.27	57	31 3*d* 5*s* $^{1}\mathrm{D}$
3*d* 4*d*	$^{3}\mathrm{P}$	0	135 541.46	100	
		1	135 601.47	100	
		2	135 721.51	88	9 $^{1}\mathrm{D}$
3*d* 4*d*	$^{1}\mathrm{G}$	4	136 339.74	100	
4*s*4*p*	$^{3}\mathrm{P}^{\circ}$	0	*137 258.9*	100	
		1	*137 487.8*	100	
		2	*137 961.2*	100	
3*d* 4*d*	$^{1}\mathrm{S}$	0	140 019.24	100	
3*d* 5*p*	$^{1}\mathrm{D}^{\circ}$	2	*147 212.77*	90	5 $^{3}\mathrm{D}^{\circ}$

Ti III—Continued

Configuration	Term	J	Level (cm^{-1})	Leading components (%)	
				First	Second
$3d5p$	$^3\mathrm{D}^\circ$	1	*147 562.14*	99	
		2	*147 749.89*	92	5 $^3\mathrm{F}^\circ$
		3	*147 939.47*	99	
$3d5p$	$^3\mathrm{F}^\circ$	2	*147 931.47*	92	5 $^1\mathrm{D}^\circ$
		3	*148 111.10*	99	
		4	*148 410.24*	100	
$3d5p$	$^3\mathrm{P}^\circ$	1	*148 978.72*	71	26 $^1\mathrm{P}^\circ$
		0	*149 019.75*	100	
		2	*149 267.99*	99	
$3d5p$	$^1\mathrm{P}^\circ$	1	*149 403.52*	64	28 $^3\mathrm{P}^\circ$
$3d5p$	$^1\mathrm{F}^\circ$	3	*149 655.77*	99	
$4s4p$	$^1\mathrm{P}^\circ$	1	*157 204.16*	60	32 $3d4f$ $^1\mathrm{P}^\circ$
$3d4f$	$^1\mathrm{G}^\circ$	4	*158 285.34*	81	10 $^3\mathrm{F}^\circ$
$3d4f$	$^3\mathrm{F}^\circ$	2	*158 536.63*	93	6 $^1\mathrm{D}^\circ$
		3	*158 557.76*	67	31 $^3\mathrm{G}^\circ$
		4	*158 690.85*	46	28 $^3\mathrm{G}^\circ$
$3d4f$	$^3\mathrm{G}^\circ$	3	*158 740.92*	60	25 $^3\mathrm{F}^\circ$
		4	*158 865.03*	29	40 $^3\mathrm{F}^\circ$
		5	*158 903.55*	70	28 $^3\mathrm{H}^\circ$
$3d4f$	$^3\mathrm{H}^\circ$	4	*159 022.93*	58	35 $^3\mathrm{G}^\circ$
		5	*159 128.94*	69	30 $^3\mathrm{G}^\circ$
		6	*159 269.53*	100	
$3d4f$	$^1\mathrm{D}^\circ$	2	*159 123.78*	89	4 $^3\mathrm{F}^\circ$
$3d4f$	$^1\mathrm{F}^\circ$	3	*159 180.24*	75	6 $^3\mathrm{D}^\circ$
$3d4f$	$^3\mathrm{D}^\circ$	1	*159 394.89*	97	
		2	*159 403.91*	89	4 $^3\mathrm{P}^\circ$
		3	*159 481.95*	86	12 $^1\mathrm{F}^\circ$
$3d4f$	$^3\mathrm{P}^\circ$	2	*159 991.54*	92	6 $^3\mathrm{D}^\circ$
		1	*160 104.61*	97	
		0	*160 167.06*	100	
$3d4f$	$^1\mathrm{H}^\circ$	5	*160 054.90*	97	
$3d4f$	$^1\mathrm{P}^\circ$	1	*161 854.24*	67	28 $4s4p$ $^1\mathrm{P}^\circ$
$3d5d$	$^1\mathrm{F}$	3	167 724.09	92	5 $^3\mathrm{D}$
$3d5d$	$^3\mathrm{D}$	1	167 905.19	86	14 $^1\mathrm{P}$
		2	168 030.15	99	
		3	168 206.79	56	37 $^3\mathrm{G}$

Ti III—Continued

Configuration	Term	*J*	Level (cm^{-1})	Leading components (%)	
				First	Second
3*d* 5*d*	^{3}G	3	168 152.20	60	39 ^{3}D
		4	168 307.06	99	
		5	168 520.52	100	
3*d* 5*d*	^{1}P	1	168 343.62	82	14 ^{3}D
3*d* 5*d*	^{3}S	1	168 932.83	96	4 ^{1}P
3*d* 5*d*	^{3}F	2	169 615.12	97	
		3	169 769.13	99	
		4	169 912.11	99	
3*d* 6*s*	^{3}D	1	169 875.52	100	
		2	169 930.80	72	25 ^{1}D
		3	170 254.75	100	
3*d* 6*s*	^{1}D	2	170 270.02	47	26 ^{3}D
3*d* 5*d*	^{3}P	0	170 579.96	99	
		1	170 659.72	99	
		2	170 666.94	56	25 ^{1}D
3*d* 5*d*	^{1}D	2	170 840.80	46	43 ^{3}P
3*d* 5*d*	^{1}G	4	171 141.93	99	
3*d* 5*d*	^{1}S	0	172 373.52	99	
3*d* 5*f*	^{1}G°	4	*181 219.06*	68	17 ^{3}F°
3*d* 5*f*	^{3}F°	2	*181 339.27*	84	12 ^{1}D°
		3	*181 368.45*	65	30 ^{3}G°
		4	*181 611.79*	58	25 ^{1}G°
3*d* 5*f*	^{3}H°	4	*181 439.64*	69	20 ^{3}G°
		5	*181 558.44*	73	21 ^{3}G°
		6	*181 837.98*	100	
3*d* 5*f*	^{3}G°	3	*181 507.92*	53	22 ^{1}F°
		4	*181 758.34*	68	16 ^{3}F°
		5	*181 821.83*	78	22 ^{3}H°
3*d* 5*f*	^{1}D°	2	*181 700.72*	61	19 ^{3}D°
3*d* 5*f*	^{1}F°	3	*181 860.55*	46	22 ^{3}D°
3*d* 5*f*	^{3}D°	2	*181 908.15*	58	23 ^{1}D°
		3	*182 025.86*	66	32 ^{1}F°
3*d*(^{2}D$_{3/2}$)5*g*	^{2}[9/2]	5	182 013.32		
		4	182 014.92		

Ti III—Continued

Configuration	Term	J	Level (cm^{-1})	Leading components (%)	
				First	Second
$3d(^2D_{3/2})5g$	$^2[7/2]$	3	182 067.49		
		4	182 068.87		
$3d(^2D_{3/2})5g$	$^2[11/2]$	5	182 166.91		
		6	182 170.72		
$3d\,5f$	$^3P^\circ$	2	*182 207.39*	76	19 $^3D^\circ$
		1	*182 276.75*	84	12 $^3D^\circ$
		0	*182 333.95*	100	
$3d(^2D_{3/2})5g$	$^2[5/2]$	3	182 224.72		
		2	182 225.09		
$3d\,5f$	$^1H^\circ$	5	*182 353.45*	94	5 $^3H^\circ$
$3d(^2D_{5/2})5g$	$^2[9/2]$	5	182 403.64		
		4	182 405.25		
$3d(^2D_{5/2})5g$	$^2[11/2]$	5	182 436.46		
		6	182 439.62		
$3d(^2D_{5/2})5g$	$^2[7/2]$	3	182 473.21		
		4	182 474.38		
$3d\,5f$	$^1P^\circ$	1	*182 561.61*	89	8 $^3P^\circ$
$3d(^2D_{5/2})5g$	$^2[5/2]$	3	182 587.12		
		2	182 587.62		
$3d(^2D_{5/2})5g$	$^2[13/2]$	7	182 596.87		
		6	182 601.96		
$3d(^2D_{5/2})5g$	$^2[3/2]$	1	182 680.27		
		2	182 680.53		
$3d(^2D_{3/2})6g$	$^2[9/2]$	5	194 168.25		
		4	194 169.81		
$3d(^2D_{3/2})6g$	$^2[7/2]$	3	194 200.46		
		4	194 201.57		
$3d(^2D_{3/2})6g$	$^2[11/2]$	5	194 261.00		
		6	194 264.82		
$3d(^2D_{5/2})6g$	$^2[9/2]$	4	194 556.67		
$3d(^2D_{5/2})6g$	$^2[11/2]$	5	194 567.08		
		6	194 569.80		
$3d(^2D_{5/2})6g$	$^2[7/2]$	3	194 592.07		
		4	194 592.98		

Ti III—Continued

Configuration	Term	J	Level (cm^{-1})	Leading components (%)	
				First	Second
$3d(^2D_{5/2})6g$	$^2[5/2]$	3	194 656.18		
$3d(^2D_{5/2})6g$	$^2[13/2]$	7	194 664.08		
		6	194 669.10		
$3d(^2D_{3/2})6h$	$^2[11/2]^\circ$	5,6	*194 246.5*		
$3d(^2D_{3/2})6h$	$^2[9/2]^\circ$	4,5	*194 261.8*		
$3d(^2D_{3/2})6h$	$^2[13/2]^\circ$	6,7	*194 301.6*		
$3d(^2D_{3/2})6h$	$^2[7/2]^\circ$	3,4	*194 317.2*		
$3d(^2D_{5/2})6h$	$^2[11/2]^\circ$	5,6	*194 628.2*		
$3d(^2D_{5/2})6h$	$^2[13/2]^\circ$	6,7	*194 639.2*		
$3d(^2D_{5/2})6h$	$^2[9/2]^\circ$	4,5	*194 646.3*		
$3d(^2D_{5/2})6h$	$^2[7/2]^\circ$	3,4	*194 680.2*		
$3d(^2D_{5/2})6h$	$^2[15/2]^\circ$	7,8	*194 694.6*		
$3d(^2D_{5/2})6h$	$^2[5/2]^\circ$	2,3	*194 717.4*		
$3d(^2D_{3/2})7h$	$^2[11/2]^\circ$	5,6	*201 543.5*		
$3d(^2D_{3/2})7h$	$^2[9/2]^\circ$	4,5	*201 553.5*		
$3d(^2D_{3/2})7h$	$^2[13/2]^\circ$	6,7	*201 578.7*		
$3d(^2D_{3/2})7h$	$^2[7/2]^\circ$	3,4	*201 588.7*		
$3d(^2D_{5/2})7h$	$^2[11/2]^\circ$	5,6	*201 926.0*		
$3d(^2D_{5/2})7h$	$^2[13/2]^\circ$	6,7	*201 932.7*		
$3d(^2D_{5/2})7h$	$^2[9/2]^\circ$	4,5	*201 937.4*		
$3d(^2D_{5/2})7h$	$^2[7/2]^\circ$	3,4	*201 958.3*		
$3d(^2D_{5/2})7h$	$^2[15/2]^\circ$	7,8	*201 967.5*		
$3d(^2D_{5/2})7h$	$^2[5/2]^\circ$	2,3	*201 981.7*		
Ti IV ($^2D_{3/2}$)	*Limit*	....	221 735.6		

Ti IV

$Z=22$

K I isoelectronic sequence

Ground state: $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d\ ^2\mathrm{D}_{3/2}$

Ionization energy=348 973.3±1.5 cm^{-1} (43.2675±0.0002 eV)

The initial study of the structure of Ti IV was by Gibbs and White (1926) who identified the low one-electron configurations $3d$, $4s$, and $4p$. The work was extended by Russell and Lang (1927) who recognized the higher configurations $4d$, $5d$, $5s$, $6s$, $5p$, $4f$, and $5g$. New observations by Svensson and Edlén (1974) improved the accuracy of the earlier work and added the configurations $7s$, $6p$, $6d$, $7d$, $5f$, $6g$, $7g$, $6h$, $7h$, $7i$, and $8i$. They also discovered a level of $3p^53d^2$. By application of the polarization formula to the hydrogen-like terms ng, nh, and ni they determined the ionization energy with an uncertainty of ± 1.5 cm^{-1}.

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Ti IV

Configuration	Term	J	Level (cm^{-1})
$3p^63d$	^{2}D	3/2	0.0
		5/2	382.1
$3p^64s$	^{2}S	1/2	80 388.93
$3p^64p$	^{2}P°	1/2	*127 921.36*
		3/2	*128 739.59*
$3p^64d$	^{2}D	3/2	196 804.27
		5/2	196 889.96
$3p^65s$	^{2}S	1/2	212 407.34
$3p^65p$	^{2}P°	1/2	*230 608.89*
		3/2	*230 924.38*
$3p^64f$	^{2}F°	5/2	*236 135.29*
		7/2	*236 142.30*
$3p^65d$	^{2}D	3/2	258 838.48
		5/2	258 877.08
$3p^66s$	^{2}S	1/2	265 847.42
$3p^66p$	^{2}P°	1/2	*274 726.29*
		3/2	*274 881.21*
$3p^53d^2$	^{2}F°	5/2	*274 839.82*
$3p^65f$	^{2}F°	5/2	*275 847.01*
		7/2	*275 861.94*

Ti IV—Continued

Configuration	Term	J	Level (cm^{-1})
$3p^65g$	^{2}G	7/2	278 510.63
		9/2	278 511.23
$3p^66d$	^{2}D	3/2	289 185.99
		5/2	289 206.93
$3p^67s$	^{2}S	1/2	292 999.54
$3p^66g$	^{2}G	7/2	300 045.9
		9/2	300 046.2
$3p^66h$	^{2}H$^\circ$	9/2,11/2	*300 158.76*
$3p^67d$	^{2}D	3/2	306 395.69
		5/2	306 408.30
$3p^67g$	^{2}G	7/2	313 033.9
		9/2	313 034.1
$3p^67h$	^{2}H$^\circ$	9/2,11/2	*313 110.72*
$3p^67i$	^{2}I	11/2,13/2	313 130.66
$3p^68i$	^{2}I	11/2,13/2	321 531.3
Ti v (^{1}S$_0$)	*Limit*	....	**348 973.3**

Ti V

$Z=22$

Ar I isoelectronic sequence

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

Ionization energy = 800 900 ± 100 cm^{-1} (99.300 ± 0.01 eV)

Kruger and Weissberg (1935) and Kruger, Weissberg, and Phillips (1937) identified four resonance lines arising from the $3p^5 4s$ and $5s$ configurations. The $3p^5 3d$ configuration was identified by Gabriel, Fawcett, and Jordan (1966) and extended by Svensson and Ekberg (1968), who also identified the $3p^5 6s$ and $3s3p^6 4p$ configurations. In all, 10 resonance lines were classified.

New observations of the spectrum by Svensson (1976) in the range of 300–2500 Å enabled him to identify 231 more lines. His analysis completed the known configurations and provided the energy levels of the $3p^5 4p$, $3p^5 4d$, $3p^5 6s$, and $3s3p^6 3d$ configurations. He calculated the percentage compositions of the levels.

Recently the $3s3p^6 np$ series was observed in a high voltage spark as absorption lines from the ground state by Kastner, Crooker, Behring, and Cohen (1977). They reported the series through $n = 11$ and calculated the series limit at 997 500 cm^{-1}. This gives an ionization energy of 800 900 cm^{-1}.

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Ti V

Configuration	Term	J	Level (cm^{-1})	Leading components (%)	
				First	Second
$3s^2 3p^6$	^{1}S	0	0		
$3s^2 3p^5 3d$	^{3}P°	0	*274 439.7*	100	
		1	*275 371.9*	100	
		2	*277 310.6*	99	
$3s^2 3p^5 3d$	^{3}F°	4	*287 276.5*	100	
		3	*289 050.2*	98	
		2	*290 778.7*	98	
$3s^2 3p^5 3d$	^{1}D°	2	*306 874.5*	84	14 ^{3}D°
$3s^2 3p^5 3d$	^{3}D°	3	*307 429.2*	80	20 ^{1}F°
		1	*309 252.1*	100	
		2	*309 433.1*	85	14 ^{1}D°
$3s^2 3p^5 3d$	^{1}F°	3	*311 433.8*	79	20 ^{3}D°
$3s^2 3p^5 3d$	^{1}P°	1	*395 320.9*	100	
$3s^2 3p^5 4s$	^{3}P°	2	*434 339.4*	100	
		1	*436 849.8*	81	19 ^{1}P°
		0	*440 065.2*	100	
$3s^2 3p^5 4s$	^{1}P°	1	*443 752.7*	81	19 ^{3}P°
$3s^2 3p^5 4p$	^{3}S	1	481 987.7	97	

Ti V—Continued

Configuration	Term	*J*	Level (cm^{-1})	Leading components (%)	
				First	Second
$3s^23p^54p$	^{3}D	3	487 974.6	65	35 $3s3p^63d$ ^{3}D
		2	488 225.7	47	41
		1	493 300.5	47	22
$3s3p^63d$	^{3}D	1	488 928.7	75	23 $3s^23p^54p$ ^{3}D
		2	491 558.7	51	31 $3s^23p^54p$ ^{1}D
		3	492 567.1	65	35 $3s^23p^54p$ ^{3}D
$3s^23p^54p$	^{1}D	2	494 035.7	33	42 ^{3}P
$3s^23p^54p$	^{1}P	1	496 890.7	50	29 ^{1}D
$3s^23p^54p$	^{3}P	2	498 057.2	55	22 ^{3}D
		0	498 176.4	98	
		1	499 336.2	66	31 ^{1}P
$3s3p^63d$	^{1}D	2	506 224.7	89	10 $3s^23p^54p$ ^{1}D
$3s^23p^54p$	^{1}S	0	514 608.7	98	
$3s^23p^5(^2P^\circ_{3/2})4d$	$^2[1/2]^\circ$	0	*568 698.5*	100	
		1	*569 304.5*	72	22 $(^2P^\circ_{3/2})$ $^2[3/2]^\circ$
$3s^23p^5(^2P^\circ_{3/2})4d$	$^2[3/2]^\circ$	2	*570 597.8*	82	18 $(^2P^\circ_{1/2})$ $^2[3/2]^\circ$
		1	*577 249.8*	74	14 $(^2P^\circ_{3/2})$ $^2[1/2]^\circ$
$3s^23p^5(^2P^\circ_{3/2})4d$	$^2[7/2]^\circ$	4	*571 401.1*	100	
		3	*572 093.9*	90	
$3s^23p^5(^2P^\circ_{3/2})4d$	$^2[5/2]^\circ$	2	*573 838.3*	84	16 $(^2P^\circ_{1/2})$ $^2[5/2]^\circ$
		3	*574 683.8*	84	
$3s^23p^5(^2P^\circ_{1/2})4d$	$^2[5/2]^\circ$	2	*578 698.5*	84	16 $(^2P^\circ_{3/2})$ $^2[5/2]^\circ$
		3	*579 334.6*	90	
$3s^23p^5(^2P^\circ_{1/2})4d$	$^2[3/2]^\circ$	2	*579 584.2*	82	18 $(^2P^\circ_{3/2})$ $^2[3/2]^\circ$
		1	*582 836.5*	82	14 $(^2P^\circ_{3/2})$ $^2[1/2]^\circ$
$3s^23p^5(^2P^\circ_{3/2})5s$	$^2[3/2]^\circ$	2	*607 033.0*	100	
		1	*608 100.7*	97	
$3s^23p^5(^2P^\circ_{1/2})5s$	$^2[1/2]^\circ$	0	*612 793.2*	100	
		1	*613 558.2*	97	
$3s^23p^5(^2P^\circ_{3/2})6s$	$^2[3/2]^\circ$	1	*680 748*		
$3s^23p^5(^2P^\circ_{1/2})6s$	$^2[1/2]^\circ$	1	*685 940*		
$3s3p^64p$	^{3}P$^\circ$	1	*687 980*		
$3s3p^64p$	^{1}P$^\circ$	1	*691 797*		

Ti V—Continued

Configuration	Term	J	Level (cm^{-1})	Leading components (%)	
				First	Second
Ti VI ($^2P^\circ_{3/2}$)	*Limit*	....	**800 900**		
$3s3p^65p$	$^3P^\circ$	1	*825 500*		
$3s3p^65p$	$^1P^\circ$	1	*827 650*		
$3s3p^66p$	$^3P^\circ$	1	*885 770*		
$3s3p^66p$	$^1P^\circ$	1	*888 930*		
$3s3p^67p$	$^3P^\circ$	1	*920 720*		
$3s3p^67p$	$^1P^\circ$	1	*922 140*		
$3s3p^68p$	$^3P^\circ$	1	*940 660*		
$3s3p^68p$	$^1P^\circ$	1	*942 030*		
$3s3p^69p$	$^3P^\circ$	1	*954 820*		
$3s3p^69p$	$^1P^\circ$	1	*955 010*		
$3s3p^610p$	$^3P^\circ$	1	*963 820*		
$3s3p^610p$	$^1P^\circ$	1	*964 010*		
$3s3p^611p$	$^1P^\circ$	1	*970 320*		
Ti VI ($^2S^\circ_{1/2}$)	*Limit*	....	**997 500**		

Ti vi

$Z=22$

Cl i isoelectronic sequence

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

Ionization energy $= 964\ 100\ \mathrm{cm}^{-1}$ (119.53 eV)

The first observation of Ti vi was made by Weissberg and Kruger (1936), who identified the resonance lines $3s^23p^5\ {}^2\mathrm{P}^\circ$–$3s3p^6\ {}^2\mathrm{S}$ at 508 and 524 Å. These have been remeasured by Svensson (1971). In 1937 Edlén reported the $3p^44s$ configuration. Gabriel, Fawcett, and Jordan (1966) and Fawcett and Gabriel (1966) reported terms in $3p^43d$. Fawcett, Peacock, and Cowan (1968) identified $3p^44d$, $5d$, and $5s$. Fawcett, Cowan, and Hayes (1972) observed $3p^43d$–$3p^44f$ transitions at 235 Å but they do not involve any of the terms of the known system.

New measurements in the range of 125–354 Å were made by Svensson and Ekberg (1968), who improved the accuracy of the known levels and added to the known configurations. They determined the ionization energy from an extrapolation formula.

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Ti vi

Configuration	Term	*J*	Level (cm^{-1})
$3s^23p^5$	$^2\mathrm{P}^\circ$	3/2	*0*
		1/2	*5829*
$3s3p^6$	$^2\mathrm{S}$	1/2	196 628
$3s^23p^4(^3\mathrm{P})3d$	$^2\mathrm{P}$	1/2	288 412
		3/2	291 890
$3s^23p^4(^3\mathrm{P})3d$	$^2\mathrm{D}$	3/2	298 991
		5/2	302 386
$3s^23p^4(^3\mathrm{P})3d$	$^4\mathrm{P}$	1/2	301 417
$3s^23p^4(^1\mathrm{D})3d$	$^2\mathrm{F}$	5/2	331 221
$3s^23p^4(^1\mathrm{S})3d$	$^2\mathrm{D}$	3/2	352 625
		5/2	354 340
$3s^23p^4(^1\mathrm{D})3d$	$^2\mathrm{S}$	1/2	379 874
$3s^23p^4(^1\mathrm{D})3d$	$^2\mathrm{P}$	3/2	391 583
		1/2	393 644
$3s^23p^4(^1\mathrm{D})3d$	$^2\mathrm{D}$	5/2	399 231
		3/2	404 123
$3s^23p^4(^3\mathrm{P})4s$	$^4\mathrm{P}$	5/2	492 126
		3/2	495 380
		1/2	497 389

Ti VI—Continued

Configuration	Term	J	Level (cm^{-1})
$3s^23p^4(^3P)4s$	^2P	3/2	502 571
		1/2	506 432
$3s^23p^4(^1D)4s$	^2D	5/2	518 797
		3/2	518 914
$3s^23p^4(^1S)4s$	^2S	1/2	548 995
$3s^23p^4(^3P)4d$	^2D	5/2	651 255
		3/2	651 960
$3s^23p^4(^3P)4d$	^4F	5/2	653 766
		3/2	654 503
$3s^23p^4(^3P)4d$	^2F	5/2	656 437
$3s^23p^4(^3P)4d$	^2P	3/2	658 339
$3s^23p^4(^1D)4d$	^2S	1/2	668 630
$3s^23p^4(^1D)4d$	^2P	3/2	671 096
		1/2	671 549
$3s^23p^4(^1D)4d$	^2D	5/2	674 297
		3/2	675 207
$3s^23p^4(^1S)4d$	^2D	3/2	704 270
		5/2	704 283
$3s^23p^4(^3P)5s$	^4P	3/2	708 652
$3s^23p^4(^3P)5s$	^2P	3/2	712 034
		1/2	714 742
$3s^23p^4(^1D)5s$	^2D	3/2	731 453
		5/2	731 455
$3s^23p^4(^3P)5d$	^2D	5/2	773 702
		3/2	774 306
$3s^23p^4(^3P)5d$	^4F	5/2	778 513
$3s^23p^4(^1D)5d$	^2P	3/2	795 615
$3s^23p^4(^1D)5d$	^2D	5/2	797 092
		3/2	797 406
Ti VII ($^3P_2$)	*Limit*	....	964 100

Ti VII

$Z=22$

S I isoelectronic sequence

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

Ionization energy = 1 136 000 cm^{-1} (140.8 eV)

Edlén (1937) initiated the analysis of this spectrum with identification of the three terms of the ground configuration and all the singlets and triplets of the $3p^34s$ configuration. He also determined the limit quoted here from an isoelectronic extrapolation. Kruger and Pattin (1937) observed the $3s^23p^4\,{}^3P$–$3s3p^5\,{}^3P^\circ$ multiplet. This has been remeasured by Svensson (1971), who has also observed the singlet transitions of the $3s^23p^4$–$3s3p^5$ array.

The $3p^33d$ configuration was first identified by Fawcett and Gabriel (1966) and Gabriel, Fawcett, and Jordon (1966). The higher configuration, $3p^34d$, was reported by Svensson and Ekberg (1968), who remeasured the spectrum between 128 and 332 Å. Fawcett, Cowan, and Hayes (1972) identified some lines in the $3p^33d$–$3p^34f$ array but these are not connected to the known system.

Level-values for the triplet system of $3s^23p^4$ and $3s3p^5$ are from Svensson (1971). The position of the ${}^1D_2$ of $3s^23p^4$ is established by the intersystem transitions of the $3s^23p^4$–$3s^23p^33d$ array measured by Svensson and Ekberg (1968). The singlet transitions given by Svensson (1971) are then used to establish the ${}^1S_0$ of $3s^23p^4$ and the ${}^1P^\circ_1$ of $3s3p^5$. A spin-forbidden resonance line arising from the $3s3p^5\ {}^1P^\circ$ level observed by Smitt, Svensson, and Outred (1976) at 398.075 Å was averaged with the data of Svensson (1971) to determine the position of this level.

The rest of the levels are derived from the wavelengths and identifications of Svensson and Ekberg (1968).

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Ti VII

Configuration	Term	J	Level (cm^{-1})
$3s^23p^4$	${}^3P$	2	0
		1	4534
		0	5888
$3s^23p^4$	${}^1D$	2	24 130
$3s^23p^4$	${}^1S$	0	54 801
$3s3p^5$	${}^3P^\circ$	2	*196 266*
		1	*200 059*
		0	*202 202*
$3s3p^5$	${}^1P^\circ$	1	*251 214*
$3s^23p^3({}^2D^\circ)3d$	${}^1D^\circ$	2	*325 261*
$3s^23p^3({}^2D^\circ)3d$	${}^1F^\circ$	3	*361 904*
$3s^23p^3({}^2D^\circ)3d$	${}^3S^\circ$	1	*375 235*
$3s^23p^3({}^2P^\circ)3d$	${}^3P^\circ$	2	*377 614*
		1	*378 872*
		0	*381 808*
$3s^23p^3({}^2D^\circ)3d$	${}^1P^\circ$	1	*381 894*

Ti VII—Continued

Configuration	Term	J	Level (cm^{-1})
$3s^23p^3(^2P^\circ)3d$	$^3D^\circ$	3	393 667
		2	396 572
		1	398 527
$3s^23p^3(^2P^\circ)3d$	$^1D^\circ$	2	407 703
$3s^23p^3(^2P^\circ)3d$	$^1F^\circ$	3	420 522
$3s^23p^3(^2P^\circ)3d$	$^1P^\circ$	1	450 729
$3s^23p^3(^4S^\circ)4s$	$^3S^\circ$	1	564 217
$3s^23p^3(^2D^\circ)4s$	$^3D^\circ$	1	586 092
		2	586 308
		3	586 998
$3s^23p^3(^2D^\circ)4s$	$^1D^\circ$	2	592 918
$3s^23p^3(^2P^\circ)4s$	$^3P^\circ$	0	607 538
		1	607 982
		2	609 116
$3s^23p^3(^2P^\circ)4s$	$^1P^\circ$	1	614 794
$3s^23p^3(^4S^\circ)4d$	$^3D^\circ$	1	726 277
		2	726 303
		3	726 424
$3s^23p^3(^2D^\circ)4d$	$^3P^\circ$	2	752 850
		1	755 732
$3s^23p^3(^2D^\circ)4d$	$^3D^\circ$	3	753 393
		2	754 591
$3s^23p^3(^2D^\circ)4d$	$^3S^\circ$	1	756 518
$3s^23p^3(^2D^\circ)4d$	$^1D^\circ$	2	757 984
$3s^23p^3(^2D^\circ)4d$	$^1F^\circ$	3	760 504
$3s^23p^3(^2P^\circ)4d$	$^3D^\circ$	2	775 416
		1	776 122
		3	779 699
$3s^23p^3(^2P^\circ)4d$	$^1D^\circ$	2	780 853
$3s^23p^3(^2P^\circ)4d$	$^1F^\circ$	3	781 170
$3s^23p^3(^2P^\circ)4d$	$^1P^\circ$	1	785 716
Ti VIII ($^4S^\circ_{3/2}$)	*Limit*	....	**1 136 000**

Ti VIII

$Z=22$

P I isoelectronic sequence

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

Ionization energy = 1 374 000 cm^{-1} (170.4 eV)

This spectrum was initially studied by Kruger and Pattin (1937), who observed five multiplets of the $3s^23p^3$–$3s^23p^24s$ array in the region 150–162 Å. Fawcett, Gabriel, and Saunders (1967) observed the resonance lines from $3p^2(^3P)3d\ ^4P$ at 268 Å. Later Fawcett (1970) identified the $3s^23p^3$–$3s3p^4$ array in the range 423–514 Å. Fawcett, Cowan, and Hayes (1972) reported four lines of the $3p^23d$–$3p^24f$ array, but they are not connected to the known levels.

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

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

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Ti VIII

Configuration	Term	J	Level (cm^{-1})
$3s^23p^3$	$^4S^\circ$	3/2	*0.0*
$3s^23p^3$	$^2D^\circ$	3/2	*32 190.5*+x
		5/2	*33 256.4*+x
$3s^23p^3$	$^2P^\circ$	1/2	*54 189.2*+x
		3/2	*55 633.6*+x
$3s3p^4$	^4P	5/2	194 474.6
		3/2	198 097.9
		1/2	199 953.6
$3s3p^4$	^2D	3/2	240 971.6+x
		5/2	241 426.0+x
$3s3p^4$	^2P	3/2	278 037.7+x
		1/2	281 108.1+x
$3s3p^4$	^2S	1/2	290 233.6+x
$3s^23p^2(^3P)3d$	^2P	3/2	364 082+x
		1/2	368 663+x
$3s^23p^2(^3P)3d$	^4P	5/2	371 012
		3/2	372 887
		1/2	373 971

Ti VIII—Continued

Configuration	Term	*J*	Level (cm^{-1})
$3s^23p^2(^1D)3d$	^{2}D	5/2	399 323+x
		3/2	399 772+x
$3s^23p^2(^1D)3d$	^{2}P	1/2	412 858+x
		3/2	415 589+x
$3s^23p^2(^1D)3d$	^{2}F	5/2	418 873+x
		7/2	419 939+x
$3s^23p^2(^1D)3d$	^{2}S	1/2	423 834+x
$3s^23p^2(^1S)3d$	^{2}D	5/2	435 049+x
		3/2	436 270+x
$3s^23p^2(^3P)4s$	^{4}P	1/2	660 135
		3/2	662 835
		5/2	666 493
$3s^23p^2(^3P)4s$	^{2}P	1/2	671 405+x
		3/2	675 631+x
$3s^23p^2(^1D)4s$	^{2}D	5/2	690 446+x
		3/2	690 672+x
$3s^23p^2(^1S)4s$	^{2}S	1/2	722 394+x
Ti IX ($^3P_0$)	*Limit*	....	**1 374 000**

Ti IX

$Z=22$

Si I isoelectronic sequence

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

Ionization energy = 1 549 000 cm^{-1} (192.1 eV)

The study of this spectrum was initiated by Phillips (1939) who classified seven lines as transitions between the ground term and two odd terms $3s3p^3\,{}^3S°$ and $3s^23p3d\,{}^3P°$. Fawcett, Gabriel, and Saunders (1967) extended the $3p^2$–$3p3d$ array; Fawcett and Peacock (1967) and Fawcett (1970) added to the $3s^23p^2$–$3s3p^3$ array. Fawcett, Cowan, and Hayes (1972) established terms in $3p4d$ and identified a line in $3p3d$–$3p4f$ which is not connected with the known levels.

Ekberg and Svensson (1970) reobserved the spectrum between 136 and 400 Å. Smitt, Svensson, and Outred (1976) extended the new observations to 580 Å. The level values for the $3s^23p^2$ and $3s3p^3$ configurations are taken from the more accurate data of Smitt et al. and the values for $3s^23p3d$ and $3s^23p4s$ are derived by combining those values with the measurements of Ekberg and Svensson. The uncertainty of the level values is estimated by the authors to be about ±10 cm^{-1}. Six intersystem transitions have been observed.

The ionization energy was extrapolated by Ekberg and Svensson.

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Ti IX

Configuration	Term	J	Level (cm^{-1})
$3s^23p^2$	${}^3P$	0	0
		1	3119
		2	7282
$3s^23p^2$	${}^1D$	2	28 555
$3s^23p^2$	${}^1S$	0	61 100
$3s3p^3$	${}^3D°$	1	*200 209*
		2	*200 293*
		3	*201 000*
$3s3p^3$	${}^3P°$	0	*230 524*
		1	*230 645*
		2	*230 754*
$3s3p^3$	${}^1D°$	2	*254 028*
$3s3p^3$	${}^3S°$	1	*299 944*
$3s3p^3$	${}^1P°$	1	*311 087*
$3s^23p3d$	${}^3P°$	2	*352 632*
		1	*356 962*
		0	*358 427*
$3s^23p3d$	${}^3D°$	1	*364 414*
		2	*365 611*
		3	*366 074*

Ti IX—Continued

Configuration	Term	J	Level (cm^{-1})
$3s^23p3d$	$^1F^\circ$	3	*401 771*
$3s^23p3d$	$^1P^\circ$	1	*411 820*
$3s^23p4s$	$^3P^\circ$	0 1 2	*727 806* *729 111* *735 208*
$3s^23p4s$	$^1P^\circ$	1	*740 648*
$3s^23p4d$	$^1F^\circ$	3	*926 660*
$3s^23p4d$	$^3D^\circ$	3	*914 040*
Ti X ($^2P^\circ_0$)	*Limit*	....	**1 549 000**

Ti x

$Z=22$

Al I isoelectronic sequence

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

Ionization energy=1 741 500±1000 cm^{-1} (215.92±0.1 eV)

The $3p$–$4d$ doublet of Ti x was identified by Edlén (1936) and the $3p$–$3d$ doublet by Gabriel, Fawcett, and Jordan (1966). Fawcett and Peacock (1967) identified the doublets of the $3s3p^2$ configuration. Fawcett (1970) later reported the $3s3p^2\ ^4P$–$3p^3\ ^4S^\circ$ multiplet.

Ekberg and Svensson (1970) remeasured the spectrum between 70 and 366 Å and identified all the remaining terms given here. They extrapolated the position of $3s3p^2\ ^4P$ along the isoelectronic sequence. Since no intersystem transitions have been observed, we use their extrapolation to establish the energy of the quartet terms relative to the ground level. The error is indicated by x.

Smitt, Svensson, and Outred (1976) remeasured the $3s^23p$–$3s3p^2$ array between 350 and 490 Å and determined the doublet terms of those configurations with an uncertainty of ±4 cm^{-1}. We used their term values in combination with the earlier measurements of Ekberg and Svensson to establish the higher doublet term values.

The ionization energy was obtained by Ekberg and Svensson.

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Ti x

Configuration	Term	*J*	Level (cm^{-1})
$3s^23p$	$^2P^\circ$	1/2	0
		3/2	*7543*
$3s3p^2$	^4P	1/2	157 850+x
		3/2	160 655+x
		5/2	164 764+x
$3s3p^2$	^2D	3/2	212 055
		5/2	212 606
$3s3p^2$	^2S	1/2	264 456
$3s3p^2$	^2P	1/2	281 045
		3/2	285 218
$3s^23d$	^2D	3/2	345 329
		5/2	345 857
$3p^3$	$^4S^\circ$	3/2	*421 188*+x
$3s3p3d$	$^4D^\circ$	3/2	*504 516*+x
		5/2	*505 134*+x
		7/2	*505 266*+x
$3s^24s$	^2S	1/2	797 113

Ti X—Continued

Configuration	Term	J	Level (cm^{-1})
$3s3p4s$	$^4P^\circ$	1/2	*966 176*+x
		3/2	*968 680*+x
		5/2	*973 441*+x
$3s^24d$	^2D	3/2	986 655
		5/2	986 919
$3s^24f$	$^2F^\circ$	5/2	*1 046 622*
		7/2	*1 046 694*
$3s^25s$	^2S	1/2	1 180 390
$3s^25d$	^2D	3/2	1 271 460
		5/2	1 271 680
$3s^25f$	$^2F^\circ$	5/2	*1 302 120*
		7/2	*1 302 170*
$3s^26d$	^2D	3/2	1 423 180
		5/2	1 423 470
$3s^26f$	$^2F^\circ$	5/2,7/2	*1 434 560*
Ti XI ($^1S_0$)	*Limit*	....	**1 741 500**

Ti XI

$Z=22$

Mg I isoelectronic sequence

Ground state: $1s^2 2s^2 2p^6 3s^2\ {}^1\mathrm{S}_0$

Ionization energy $=$ 2 137 400 ± 1700 cm^{-1} (265.0 ± 0.2 eV)

Edlén (1936) reported three unconnected systems of levels for this ion: the resonance line $3s^2\ {}^1\mathrm{S}_0$–$3s4p\ {}^1\mathrm{P}^\circ_1$; the triplet system of $3s3p$–$3s4s$, $3s4d$, $3s5d$ and the triplets of $3s3d$–$3s4f$, $3s5f$. Fawcett and Peacock (1967) identified the terms $3p^2\ {}^3\mathrm{P}$, ${}^1\mathrm{D}$ and $3s3p\ {}^1\mathrm{P}^\circ$. Fawcett (1970) identified $3p^2\ {}^1\mathrm{S}$ and several terms in $3p3d$ and unified the two triplet systems established by Edlén.

Svensson and Ekberg (1969) made extensive observations of titanium spark spectra in the region 50 to 425 Å. With these data Ekberg (1971) determined all the levels given in this compilation except the $3p^2\ {}^1\mathrm{S}$ and the $3p3d$ levels taken from Fawcett (1970) and the $3p4f$ levels from Fawcett (1976). The singlets and triplets have not been connected by observations. Ekberg has estimated the value for $3s3p\,{}^3\mathrm{P}^\circ_1$ used here by interpolation along the isoelectronic sequence. The uncertainty "x" is less than 1000 cm^{-1}.

Ekberg extrapolated the value for the ionization energy given here.

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Ti XI

Configuration	Term	J	Level (cm^{-1})
$3s^2$	${}^1\mathrm{S}$	0	0
$3s3p$	${}^3\mathrm{P}^\circ$	0	*171 274*+x
		1	*173 827*+x
		2	*179 473*+x
$3s3p$	${}^1\mathrm{P}^\circ$	1	*258 973*
$3p^2$	${}^3\mathrm{P}$	0	408 710+x
		1	412 230+x
		2	418 780+x
$3p^2$	${}^1\mathrm{D}$	2	408 820
$3p^2$	${}^1\mathrm{S}$	0	482 840
$3s3d$	${}^3\mathrm{D}$	1	497 918+x
		2	498 239+x
		3	498 728+x
$3s3d$	${}^1\mathrm{D}$	2	564 604
$3p3d$	${}^3\mathrm{F}^\circ$	2	*682 000*+x
		3	*685 660*+x
		4	*690 060*+x
$3p3d$	${}^1\mathrm{D}^\circ$	2	*694 610*
$3p3d$	${}^3\mathrm{D}^\circ$	3	*728 640*+x

Ti XI—Continued

Configuration	Term	*J*	Level (cm^{-1})
3*p*3*d*	^{1}P°	1	*750 220*
3*s*4*s*	^{3}S	1	1 048 930+x
3*s*4*s*	^{1}S	0	1 065 780
3*s*4*p*	^{1}P°	1	*1 139 920*
3*s*4*d*	^{3}D	1	1 242 000+x
		2	1 242 340+x
		3	1 242 710+x
3*s*4*d*	^{1}D	2	1 253 100
3*p*4*s*	^{3}P°	0	*1 265 680*+x
		1	*1 267 920*+x
		2	*1 274 120*+x
3*s*4*f*	^{3}F°	2	*1 291 950*+x
		3	*1 292 020*+x
		4	*1 292 120*+x
3*s*4*f*	^{1}F°	3	*1 304 360*
3*p*4*p*	^{3}D	3	1 351 940+x
3*p*4*p*	^{3}P	0	1 352 020+x
		1	1 354 360+x
		2	1 358 220+x
3*p*4*p*	^{3}S	1	1 359 860+x
3*s*5*s*	^{3}S	1	1 482 700+x
3*s*5*s*	^{1}S	0	1 491 740
3*p*4*f*	^{3}G	4	1 498 210+x
		5	1 503 700+x
3*p*4*f*	^{3}F	3	1 500 170+x
		4	1 503 500+x
3*s*5*p*	^{1}P°	1	*1 528 980*
3*s*5*d*	^{3}D	1	1 575 750+x
		2	1 575 900+x
		3	1 576 060+x
3*s*5*d*	^{1}D	2	1 584 970

Ti XI—Continued

Configuration	Term	J	Level (cm^{-1})
$3s5f$	$^3F°$	2	*1 597 930*+x
		3	*1 598 020*+x
		4	*1 598 040*+x
$3s5f$	$^1F°$	3	*1 603 140*
$3s6p$	$^1P°$	1	*1 727 380*
$3s6f$	$^3F°$	4	*1 763 340*+x
$3s7p$	$^1P°$	1	*1 840 880*
Ti XII ($^2S_{1/2}$)	*Limit*	....	**2 137 400**

Ti XII

$Z=22$

Na I isoelectronic sequence

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

Ionization energy=2 351 100±60 cm^{-1} (291.502±0.007 eV)

The first observations were made in the range of 60 to 117 Å by Edlén (1936). His analysis of the spectrum provided three independent systems of doublet terms based on the $3s$, $3p$, and $3d$ terms. These were united by the identifications of the $3s$–$3p$ and $3p$–$3d$ multiplets by Fawcett and Peacock (1967) between 300 and 500 Å.

The new measurements by Ekberg and Svensson (1975) in the region of 52 to 960 Å enabled them to extend the known series through $6s$, $6p$, $8d$, and $8f$. Further extensions were made by Cohen and Behring (1976) through $7s$, $11p$, and $10d$.

The excitation of inner shell resonance lines from the $2p^53s^2$ configuration was accomplished by Feldman and Cohen (1967).

The value for the ionization energy was obtained by Ekberg and Svensson (1975) from the nf series.

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Ti XII

Configuration	Term	J	Level (cm^{-1})
$2p^6(^1S)3s$	^2S	1/2	0
$2p^6(^1S)3p$	$^2P^\circ$	1/2	*208 385*
		3/2	*217 042*
$2p^6(^1S)3d$	^2D	3/2	501 922
		5/2	502 814
$2p^6(^1S)4s$	^2S	1/2	1 133 573
$2p^6(^1S)4p$	$^2P^\circ$	1/2	*1 214 390*
		3/2	*1 217 700*
$2p^6(^1S)4d$	^2D	3/2	1 321 430
		5/2	1 321 870
$2p^6(^1S)4f$	$^2F^\circ$	5/2	*1 360 310*
		7/2	*1 360 470*
$2p^6(^1S)5s$	^2S	1/2	1 606 160
$2p^6(^1S)5p$	$^2P^\circ$	1/2	*1 645 760*
		3/2	*1 647 440*
$2p^6(^1S)5d$	^2D	3/2	1 697 110
		5/2	1 697 320
$2p^6(^1S)5f$	$^2F^\circ$	5/2	*1 716 840*
		7/2	*1 716 920*

Ti XII—Continued

Configuration	Term	J	Level (cm^{-1})
$2p^6(^1S)6s$	^2S	1/2	1 848 640
$2p^6(^1S)6p$	$^2P^\circ$	1/2	*1 870 660*
		3/2	*1 871 490*
$2p^6(^1S)6d$	^2D	3/2	1 899 500
		5/2	1 899 540
$2p^6(^1S)6f$	$^2F^\circ$	5/2	*1 910 630*
		7/2	*1 910 680*
$2p^6(^1S)7s$	^2S	1/2	1 989 000
$2p^6(^1S)7p$	$^2P^\circ$	1/2,3/2	*2 003 500*
$2p^6(^1S)7d$	^2D	3/2	2 020 620
		5/2	2 020 690
$2p^6(^1S)7f$	$^2F^\circ$	5/2	*2 027 700*
		7/2	*2 027 730*
$2p^6(^1S)8p$	$^2P^\circ$	1/2,3/2	*2 087 400*
$2p^6(^1S)8d$	^2D	3/2,5/2	2 098 880
$2p^6(^1S)8f$	$^2F^\circ$	5/2	*2 103 590*
		7/2	*2 103 610*
$2p^6(^1S)9p$	$^2P^\circ$	1/2,3/2	*2 144 000*
$2p^6(^1S)9d$	^2D	3/2,5/2	2 152 300
$2p^6(^1S)10p$	$^2P^\circ$	1/2,3/2	*2 184 200*
$2p^6(^1S)10d$	^2D	3/2,5/2	2 190 500
$2p^6(^1S)11p$	$^2P^\circ$	1/2,3/2	*2 214 000*
Ti XIII ($^1S_0$)	*Limit*	....	**2 351 100**
$2p^53s^2$	$^2P^\circ$	3/2	*3 594 800*
		1/2	*3 637 800*

Ti XIII

$Z=22$

Ne I isoelectronic sequence

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

Ionization energy $= 6\ 354\ 300 \pm 500$ cm^{-1} (787.84 ± 0.06 eV)

Only resonance lines between 17 and 27 Å are classified by this system of energy levels. Edlén and Tyrén (1936) identified transitions from $2p^53s$ and $3d$ and extrapolated an ionization potential which agrees well with the present value. Fawcett (1965) observed three transitions arising from $2p^54d$ and from $2s2p^63p\ ^1P^\circ_1$. Feldman and Cohen (1967) observed nine transitions, including those reported by Fawcett. We have adopted the more accurate values of Feldman and Cohen.

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

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

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

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Ti XIII

Configuration	Term	J	Level (cm^{-1})
$2s^22p^6$	^1S	0	0
$2s^22p^5(^2P^\circ_{3/2})3s$	$(3/2,1/2)^\circ$	1	*3 709 200*
$2s^22p^5(^2P^\circ_{1/2})3s$	$(1/2,1/2)^\circ$	1	*3 753 600*
$2s^22p^5(^2P^\circ_{3/2})3d$	$^2[1/2]^\circ$	1	*4 168 200*
$2s^22p^5(^2P^\circ_{3/2})3d$	$^2[3/2]^\circ$	1	*4 219 800*
$2s^22p^5(^2P^\circ_{1/2})3d$	$^2[3/2]^\circ$	1	*4 281 600*
$2s2p^63p$	$^3P^\circ$	1	*4 733 300*
$2s2p^63p$	$^1P^\circ$	1	*4 754 000*
$2s^22p^5(^2P^\circ_{3/2})4s$	$(3/2,1/2)^\circ$	1	*4 966 500*
$2s^22p^5(^2P^\circ_{1/2})4s$	$(1/2,1/2)^\circ$	1	*5 014 300*
$2s^22p^5(^2P^\circ_{3/2})4d$	$^2[3/2]^\circ$	1	*5 163 700*
$2s^22p^5(^2P^\circ_{1/2})4d$	$^2[3/2]^\circ$	1	*5 207 200*
$2s^22p^5(^2P^\circ_{3/2})5d$	$^2[3/2]^\circ$	1	*5 596 300*
$2s^22p^5(^2P^\circ_{1/2})5d$	$^2[3/2]^\circ$	1	*5 641 100*
Ti XIV $(^2P^\circ_{3/2})$	*Limit*	....	**6 354 300**

Ti XIV

Z=22

F I isoelectronic sequence

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

Ionization energy = 6 961 000 cm^{-1} (863.1 eV)

The first work on this spectrum was done by Fawcett (1965), who classified many lines of the $2s^22p^5$–$2s^22p^43s$ and $3d$ transition arrays between 21 and 25 Å. This work was revised and extended by Feldman, Doschek, Cowan, and Cohen (1973), from whose improved wavelengths all of the $3s$ and $3d$ levels are determined. The ground term $2s^22p^5\,{}^2P^\circ$ interval obtained by Fawcett (1971) from his identification of the $2s^22p^5$–$2s2p^6$ doublet at ~ 125 Å is in agreement with the value provided by Feldman et al. (1973) from much shorter wavelength data.

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

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

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Ti XIV

Configuration	Term	*J*	Level (cm^{-1})
$2s^22p^5$	$^2P^\circ$	3/2	*0*
		1/2	*47 600*
$2s2p^6$	^2S	1/2	820 000
$2s^22p^4(^3P)3s$	^4P	5/2	3 996 000
		3/2	4 014 900
		1/2	4 036 300
$2s^22p^4(^3P)3s$	^2P	3/2	4 043 800
		1/2	4 065 100
$2s^22p^4(^1D)3s$	^2D	5/2	4 112 700
		3/2	4 114 000
$2s^22p^4(^1S)3s$	^2S	1/2	4 221 200
$2s^22p^4(^3P)3d$	^4P	1/2	4 478 700
		3/2	4 488 500
		5/2	4 501 500
$2s^22p^4(^3P)3d$	^4F	5/2	4 488 500
$2s^22p^4(^3P)3d$	^2P	1/2	4 494 800
		3/2	4 525 100
$2s^22p^4(^3P)3d$	^2D	3/2	4 506 600
		5/2	4 531 900
$2s^22p^4(^3P)3d$	^2F	5/2	4 512 200
$2s^22p^4(^1D)3d$	^2S	1/2	4 583 000

Ti XIV—Continued

Configuration	Term	J	Level (cm^{-1})
$2s^22p^4(^1D)3d$	^2D	5/2	4 601 500
		3/2	4 617 400
$2s^22p^4(^1D)3d$	^2P	3/2	4 601 700
$2s^22p^4(^1S)3d$	^2D	5/2	4 685 800
		3/2	4 694 000
$2s2p^5(^3P^\circ)3s$	$^2P^\circ$	3/2	*4 778 800*
		1/2	*4 806 300*
Ti XV ($^3P_2$)	*Limit*	....	**6 961 000**

Ti XV

$Z=22$

O I isoelectronic sequence

Ground state: $1s^2\,2s^2\,2p^4\,{}^3\mathrm{P}_2$

Ionization energy = 7 597 000 cm^{-1} (941.9 eV)

The observed spectrum of Ti XV consists of the strong transition array $2s^22p^4$–$2s2p^5$, which lies between 115 and 149 Å, and the arrays $2p^4$–$2p^33s$ at 23 Å and $2p^4$–$2p^33d$ at 20 Å. The ${}^1\mathrm{S}_0$ due to $2p^6$ radiates to $2s2p^5\,{}^1\mathrm{P}_1^\circ$ at 147 Å. The arrays at 23 Å and 20 Å were first observed by Goldsmith, Feldman, and Cohen (1971). The $J=0$ and 1 levels of the ground term could not be resolved at these wavelengths. Fawcett (1971) then observed the $2s^2\,2p^4$–$2s2p^5$ array above 100 Å and resolved the ground term. Doschek, Feldman, Cowan, and Cohen (1974) reobserved this array with higher resolution. We have determined the levels of the $2s^2p^4$ and $2s2p^5$ configurations from their measurements.

The $2p^6\,{}^1\mathrm{S}_0$ level was reported by Kasyanov et al. (1974) and confirmed by Doschek, Feldman, Davis, and Cowan (1975).

The $2p^33s$ levels are from Doschek, Feldman, and Cohen (1973) and Goldsmith, Feldman, and Cohen (1971).

The $2p^33d$ levels were first reported by Goldsmith, Feldman, and Cohen (1971). A later revised analysis by Fawcett and Hayes (1975) is adopted here. The subsequent revisions proposed by Bromage and Fawcett (1977), following a new calculation, are regarded as tentative and are not included.

Since no intersystem transitions have been observed, we based the singlet system on Edlén's (1972) extrapolated value for $2p^4\,{}^1\mathrm{D}$. Its uncertainty is probably ±100 cm^{-1}.

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

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Ti XV

Configuration	Term	J	Level (cm^{-1})
$2s^22p^4$	${}^3\mathrm{P}$	2	0
		1	39 380
		0	42 420
$2s^22p^4$	${}^1\mathrm{D}$	2	109 100+x
$2s^22p^4$	${}^1\mathrm{S}$	0	216 010+x
$2s2p^5$	${}^3\mathrm{P}^\circ$	2	*712 290*
		1	*742 900*
		0	*762 130*
$2s2p^5$	${}^1\mathrm{P}^\circ$	1	*978 440*+x
$2p^6$	${}^1\mathrm{S}$	0	1 656 770+x
$2s^22p^3({}^4\mathrm{S}^\circ)3s$	${}^3\mathrm{S}^\circ$	1	*4 354 100*

Ti XV—Continued

Configuration	Term	J	Level (cm^{-1})
$2s^22p^3(^2D^\circ)3s$	$^3D^\circ$	1	*4 440 200*
		2	*4 440 400*
		3	*4 451 600*
$2s^22p^3(^2D^\circ)3s$	$^1D^\circ$	2	*4 469 100+x*
$2s^22p^3(^2P^\circ)3s$	$^3P^\circ$	2	*4 523 000*
$2s^22p^3(^2P^\circ)3s$	$^1P^\circ$	1	*4 557 300+x*
$2s^22p^3(^4S^\circ)3d$	$^3D^\circ$	2	*4 780 000*
		3	*4 785 000*
$2s^22p^3(^2D^\circ)3d$	$^3D^\circ$	1	*4 873 000*
		2	*4 891 000*
		3	*4 898 000*
$2s^22p^3(^2D^\circ)3d$	$^1D^\circ$	2	*4 912 000+x*
$2s^22p^3(^2D^\circ)3d$	$^1F^\circ$	3	*4 940 000+x*
$2s^22p^3(^2P^\circ)3d$	$^3P^\circ$	2	*4 950 000*
$2s^22p^3(^2P^\circ)3d$	$^3D^\circ$	1	*4 986 000*
		3	*4 987 000*
		2	*5 006 000*
$2s^22p^3(^2P^\circ)3d$	$^1F^\circ$	3	*5 014 000+x*
Ti XVI ($^4S^\circ_{3/2}$)	*Limit*	....	**7 597 000**

Ti XVI

Z=22

N I isoelectronic sequence

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

Ionization energy = 8 420 000 cm^{-1} (1044 eV)

The strong transition arrays $2s^22p^3$–$2s2p^4$ and $2s2p^4$–$2p^5$ were identified by Fawcett (1971) and confirmed by Kasyanov et al. (1974). The levels are derived from the more accurate data of Kasyanov et al. (1974). The position of the doublets relative to the ground state is based on the estimated position of $2s^22p^3\ ^2D^\circ_{3/2}$ by Fawcett (1975).

The $2p^23d$ terms are from Fawcett and Hayes (1975).

The ionization energy is from Lotz's extrapolation.

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Ti XVI

Configuration	Term	*J*	Level (cm^{-1})
$2s^22p^3$	$^4S^\circ$	3/2	*0*
$2s^22p^3$	$^2D^\circ$	3/2	*113 600*+x
		5/2	*128 460*+x
$2s^22p^3$	$^2P^\circ$	1/2	*195 360*+x
		3/2	*217 100*+x
$2s2p^4$	^4P	5/2	589 140
		3/2	620 420
		1/2	633 800
$2s2p^4$	^2D	3/2	810 740+x
		5/2	815 020+x
$2s2p^4$	^2S	1/2	937 630+x
$2s2p^4$	^2P	3/2	974 400+x
		1/2	1 018 210+x
$2p^5$	$^2P^\circ$	3/2	*1 535 500*+x
		1/2	*1 585 520*+x
$2s^22p^2(^3P)3d$	^2P	3/2	5 192 000+x
$2s^22p^2(^3P)3d$	^4P	5/2	5 232 000
		3/2	5 239 000

Ti XVI—Continued

Configuration	Term	J	Level (cm^{-1})
$2s^22p^2(^3P)3d$	^2F	7/2	5 243 000+x
$2s^22p^2(^3P)3d$	^2D	5/2	5 291 000+x
$2s^22p^2(^1D)3d$	^2F	7/2	5 334 000+x
		5/2	5 346 000+x
Ti XVII ($^3P_0$)	*Limit*	....	**8 420 000**

Ti XVII

$Z=22$

C I isoelectronic sequence

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

Ionization energy = 9 120 000 cm^{-1} (1131 eV)

The $2s^22p^2$–$2s2p^3$ array was classified by Fawcett, Galanti, and Peacock (1974) and by Kasyanov et al. (1974). New measurements and some revised classifications were given by Fawcett and Hayes (1975), who also identified $2s2p^3$–$2p^4$ lines. We derived the levels of $2s^22p^2$, $2s2p^3$, and $2p^4$ from the data of Fawcett and Hayes. All levels of the higher configurations are from the measurements of Goldsmith, Feldman, Crooker, and Cohen (1972) and Fawcett and Hayes (1975).

No intersystem combinations have been observed. Goldsmith et al. extrapolated the position of $2p^2\,^1D_2$ to 141 800 cm^{-1}. Fawcett (1975) obtained an extrapolated value of 140 700 cm^{-1}. We have used the mean of these values as the reference value for the singlet system. Goldsmith et al. identified two quintet transitions but they are not connected to the triplet system.

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

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Ti XVII

Configuration	Term	J	Level (cm^{-1})
$2s^22p^2$	^3P	0	0
		1	29 600
		2	55 700
$2s^22p^2$	^1D	2	141 200+x
$2s^22p^2$	^1S	0	242 600+x
$2s2p^3$	$^3D°$	1	*567 300*
		2	*578 800*
		3	*586 700*
$2s2p^3$	$^3P°$	2	*686 800*
$2s2p^3$	$^3S°$	1	*838 300*
$2s2p^3$	$^1D°$	2	*845 600*+x
$2s2p^3$	$^1P°$	1	*944 000*+x
$2p^4$	^3P	2	1 271 400
		0	1 300 400
		1	1 313 200
$2s^22p3s$	$^3P°$	1	*5 144 000*
		2	*5 193 000*
$2s^22p3s$	$^1P°$	1	*5 213 000*+x

Ti XVII—Continued

Configuration	Term	J	Level (cm^{-1})
$2s^22p3d$	$^3D^\circ$	2	*5 546 000*
		3	*5 557 000*
$2s^22p3d$	$^3P^\circ$	2	*5 568 000*
$2s^22p3d$	$^1P^\circ$	1	*5 600 000*+x
$2s^22p3d$	$^1F^\circ$	3	*5 615 000*+x
$2s2p^2(^2D)3s$	^3D	2	5 707 000
$2s2p^2(^4P)3d$	^5F	3	5 859 000
		4	5 906 000
$2s2p^2(^2D)3d$	^3F	4	6 025 000
Ti XVIII ($^2P^\circ_{1/2}$)	*Limit*	....	9 120 000

Ti XVIII

$Z=22$

B I isoelectronic sequence

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

Ionization energy = 9 850 000 cm^{-1} (1221 eV)

Kasyanov et al. (1974) analyzed the transition arrays $2s^22p$–$2s2p^2$ and $2s2p^2$–$2p^3$ found between 130 and 200 Å. These were more completely observed by Fawcett and Hayes (1975). The levels are derived from the latter paper. The quartet system is based on the prediction of the position of the $^4P_{3/2}$ level of $2s2p^2$ by Kasyanov et al.

Fawcett and Hayes reported the observations of transitions from the $2s^23d$, $2s2p3p$, and $2s2p3d$ configurations at 16–18 Å.

The ionization energy is from Lotz (1967).

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Ti XVIII

Configuration	Term	J	Level (cm^{-1})
$2s^22p$	$^2P^\circ$	1/2	*0*
		3/2	*56 240*
$2s2p^2$	^4P	1/2	310 520+x
		3/2	334 200+x
		5/2	361 520+x
$2s2p^2$	^2D	3/2	555 960
		5/2	561 720
$2s2p^2$	^2S	1/2	673 760
$2s2p^2$	^2P	1/2	733 840
		3/2	747 040
$2p^3$	$^4S^\circ$	3/2	*963 130*+x
$2s^23d$	^2D	3/2	5 807 000
		5/2	5 815 000
$2s2p(^3P^\circ)3p$	^2P	1/2	5 917 000
		3/2	5 960 000
$2s2p(^3P^\circ)3p$	^2D	3/2	6 038 000
		5/2	6 072 000
$2s2p(^3P^\circ)3d$	$^2D^\circ$	5/2	*6 142 000*
$2s2p(^3P^\circ)3d$	$^4D^\circ$	7/2	*6 142 000*+x
$2s2p(^3P^\circ)3d$	$^4P^\circ$	5/2	*6 149 000*+x

Ti xviii—Continued

Configuration	Term	J	Level (cm^{-1})
$2s2p(^3P^\circ)3d$	$^2F^\circ$	5/2	*6 201 000*
		7/2	*6 234 000*
$2s2p(^1P^\circ)3d$	$^2F^\circ$	7/2	*6 393 000*
$2s2p(^1P^\circ)3d$	$^2D^\circ$	5/2	*6 433 000*
Ti xix ($^1S_0$)	*Limit*	....	**9 850 000**

Ti XIX

$Z=22$

Be I isoelectronic sequence

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

Ionization energy = 10 860 000 cm^{-1} (1346 eV)

The intersystem resonance line, $2s^2\ {}^1S_0–2s2p\ {}^3P^\circ_1$, has not been observed. An extrapolated value for $2s2p\ {}^3P^\circ_2$ on which to base the triplet system has been taken from Goldsmith, Oren, Crooker, and Cohen (1973). The multiplet $2s2p\ {}^3P^\circ–2p^2\ {}^3P$, observed by them near 200 Å, was used to establish those terms. They also identified the resonance transition $2s^2\ {}^1S_0–2s2p\ {}^1P^\circ_1$.

The high terms (with $n=3$) are determined from the observations of Fawcett and Hayes (1975) and of Boiko, Pikuz, Safronova, and Faenov (1977).

The ionization energy is from Lotz (1967).

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Ti XIX

Configuration	Term	J	Level (cm^{-1})
$2s^2$	^1S	0	0
$2s2p$	$^3P^\circ$	0	*290 900*+x
		1	*307 600*+x
		2	*350 100*+x
$2s2p$	$^1P^\circ$	1	*590 580*
$2p^2$	^3P	1	813 200+x
		2	841 600+x
$2p^2$	^1D	2	926 300
$2s3s$	^3S	1	6 164 000+x
$2s3p$	$^1P^\circ$	1	*6 303 000*
$2s3d$	^3D	2	6 394 000+x
		3	6 406 000+x
$2s3d$	^1D	2	6 447 000
$2p3p$	^3D	3	6 702 000+x
$2p3p$	^3S	1	6 704 000+x
$2p3p$	^1D	2	6 772 000
$2p3d$	$^3D^\circ$	2	*6 801 000*+x
		3	*6 817 000*+x

Ti XIX—Continued

Configuration	Term	J	Level (cm^{-1})
2*p*3*d*	^{3}P°	2	*6 823 000+x*
2*p*3*d*	^{1}P°	1	*6 875 000?*
2*p*3*d*	^{1}F°	3	*6 878 000?*
Ti XX ($^2S_{1/2}$)	*Limit*	....	**10 860 000**

Ti xx

$Z=22$

Li I isoelectronic sequence

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

Ionization energy = 11 501 000 cm^{-1} (1425.9 eV)

The $2s$–$3p$, $2p$–$3s$, and $2p$–$3d$ transitions near 16 Å were first reported by Goldsmith, Feldman, Oren and Cohen (1972). Aglitskii, Boiko, Pikuz, and Faenov (1974) confirmed the lines identified by Goldsmith et al. and added the $4p$ to $9p$ and $4d$ to $8d$ terms. They also derived the ionization energy from the $nd\ ^2D_{3/2}$ Rydberg series, where $n=3$ to 8. A predicted value for $1s^2\ 2p\ ^2P^{\circ}_{1/2}$ is taken from their paper.

The doubly excited levels were obtained by Aglitskii, Boiko, Zakharov, Pikuz, and Faenov (1974) from lines observed at 2.6 Å in a laser-produced plasma.

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Ti xx

Configuration	Term	J	Level (cm^{-1})
$1s^22s$	^2S	1/2	0
$1s^22p$	$^2P^{\circ}$	1/2	*326 000+x*
		3/2	*388 000+x*
$1s^23s$	^2S	1/2	6 465 000+x
$1s^23p$	$^2P^{\circ}$	1/2	*6 556 000*
		3/2	*6 574 000*
$1s^23d$	^2D	3/2	6 612 000+x
		5/2	6 619 000+x
$1s^24p$	$^2P^{\circ}$	1/2,3/2	*8 732 000*
$1s^24d$	^2D	3/2	8 749 000+x
		5/2	8 751 000+x
$1s^25p$	$^2P^{\circ}$	1/2,3/2	*9 730 000*
$1s^25d$	^2D	3/2	9 742 000+x
		5/2	9 743 000+x
$1s^26p$	$^2P^{\circ}$	1/2,3/2	*10 274 000*
$1s^26d$	^2D	3/2,5/2	10 280 000+x
$1s^27p$	$^2P^{\circ}$	1/2,3/2	*10 600 000*
$1s^27d$	^2D	3/2	10 600 000+x
		5/2	10 605 000+x

Ti xx—Continued

Configuration	Term	J	Level (cm^{-1})
$1s^28p$	$^2P^\circ$	1/2,3/2	*10 815 000*
$1s^28d$	^2D	3/2,5/2	10 815 000+x
$1s^29p$	$^2P^\circ$	1/2,3/2	*10 955 000*
Ti xxi ($^1S_0$)	*Limit*	....	**11 501 000**
$1s(^2S)2s2p(^3P^\circ)$	$^4P^\circ$		*37 764 000*
$1s(^2S)2s2p(^3P^\circ)$	$^2P^\circ$	1/2,3/2	*38 030 000*
$1s2p^2$	^4P		38 100 000+x
$1s(^2S)2s2p(^1P^\circ)$	$^2P^\circ$	1/2,3/2	*38 162 000*
$1s2p^2$	^2D	3/2	38 321 000+x
		5/2	38 331 000+x
$1s2p^2$	^2P	3/2	38 418 000+x
$1s2p^2$	^2S	1/2	38 550 000

Ti XXI

$Z=22$

He I isoelectronic sequence

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

Ionization energy$=50\ 404\ 600\pm 100$ cm^{-1} (6249.42 ± 0.01 eV)

The theoretical values calculated by Ermolaev and Jones (1974) for the singlet and triplet S and P terms of this two-electron ion are more accurate than the observed values. We have quoted them up to $n=4$. The uncertainty of the ionization energy and level values is estimated to be of the order of ± 100 cm^{-1}. For comparison, the $1s^2$–$1s2p$ transition of this ion has been observed by Aglitskii et al. (1974) in a laser-produced plasma. They place $1s2p\ ^3P_1^\circ$ at 38 130 000 cm^{-1} and $1s2p\ ^1P_1^\circ$ 38 310 000 cm^{-1}, in good agreement with the calculations.

References

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Ti XXI

Configuration	Term	J	Level (cm^{-1})
$1s^2$	^1S	0	0
$1s2s$	^3S	1	37 927 500
$1s2p$	$^3P^\circ$	0	*38 118 700*
		1	*38 129 200*
		2	*38 183 600*
$1s2s$	^1S	0	38 135 000
$1s2p$	$^1P^\circ$	1	*38 311 600*
$1s3s$	^3S	1	44 915 100
$1s3p$	$^3P^\circ$	0	*44 967 900*
		1	*44 970 800*
		2	*44 987 200*
$1s3s$	^1S	0	44 969 900
$1s3p$	$^1P^\circ$	1	*45 021 900*
$1s4s$	^3S	1	47 332 000
$1s4p$	$^3P^\circ$	0	*47 353 900*
		1	*47 355 200*
		2	*47 362 100*
$1s4s$	^1S	0	47 354 200
$1s4p$	$^1P^\circ$	1	*47 376 200*
Ti XXII ($^2S_{1/2}$)	*Limit*	....	**50 404 600**

Ti XXII

$Z=22$

H I isoelectronic sequence

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

Ionization energy = 53 440 400 ± 100 cm^{-1} (6625.82 ± 0.01 eV)

Because the theoretical values calculated by Erikson for terms of this hydrogen-like ion are much more accurate than any observed values, they are given below through $n=4$. The binding energy of the $1s$ electron is reported with an uncertainty of ± 100 cm^{-1}; the levels measured from the ground state taken as zero will also have this uncertainty.

Lie and Elton (1971) have reported measured wavelengths for the $1s$–$2p$ transitions of 2.510 Å and 2.496 Å for $^2S_{1/2}$–$^2P^\circ_{1/2,\,3/2}$.

References

Erikson, G. W. (1977), J. Phys. Chem. Ref. Data **6**, 831.
Lie, T. M., and Elton, R. C. (1971), Phys. Rev. **A3**, 865.

Ti XXII

Configuration	Term	J	Level (cm^{-1})
1*s*	^{2}S	1/2	0
2*p*	^{2}P°	1/2	*40 053 800*
		3/2	*40 141 000*
2*s*	^{2}S	1/2	40 056 500
3*p*	^{2}P°	1/2	*47 500 500*
		3/2	*47 526 400*
3*s*	^{2}S	1/2	47 501 300
3*d*	^{2}D	3/2	47 526 300
		5/2	47 534 800
4*p*	^{2}P°	1/2	*50 103 300*
		3/2	*50 114 200*
4*s*	^{2}S	1/2	50 103 600
4*d*	^{2}D	3/2	50 114 200
		5/2	50 117 800
4*f*	^{2}F°	5/2	*50 117 800*
		7/2	*50 119 500*
	Limit	....	**53 440 400**