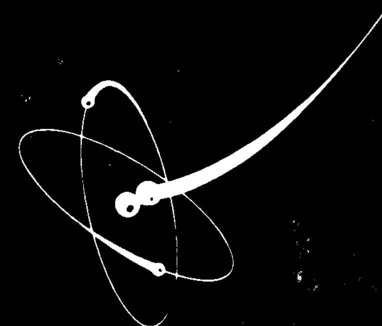
ORNL-6551/V1

Spectroscopic Data for Titanium, Chromium, and Nickel

Volume 1. Titanium

W. L. Wiese and A. Musgrove, Editors

ATOMIC DATA FOR FUSION



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Physics Division

ATOMIC DATA FOR FUSION - VOLUME VI

SPECTROSCOPIC DATA FOR TITANIUM, CHROMIUM, AND NICKEL
Volume 1. Titanium

W. L. Wiese and A. Musgrove
National Institute for Standards and Technology

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Series Preface

The primary objective of the Controlled Fusion Atomic Data Center at Oak Ridge National Laboratory is to publish handbooks containing numerical and graphical cross sections and other physical data relevant to fusion energy research. In 1977, a two-volume compilation was published as ORNL reports ORNL-5206 and ORNL-5207. Since that time, a large volume of pertinent data has become available, necessitating an update of the previous compilation. Plans are to include both cross sections and rate coefficients for collisional processes, and to publish the revised series in handbook form. The specific volumes which are in preparation are listed below, with their expected completion dates.

Vol. 1, "Collisions of H, H_2, He, and Li Atoms and Ions with Atoms and Molecules," C. F. Barnett, ORNL (December 1989).

Vol. 2, "Collisions of Electrons with Atoms and Molecules," J. W. Gallagher, National Institute of Standards and Technology; and D. C. Gregory, ORNL (December 1990).

Vol. 3, "Particle Interactions with Surfaces," E. W. Thomas, Georgia Institute of Technology (January 1985).

Vol. 4, "Spectroscopic Data for Iron," W. L. Wiese, National Bureau of Standards (March 1985).

Vol. 5, "Collisions of Carbon and Oxygen Ions with Electrons, H, H_2, and He," R. A. Phaneuf, ORNL; R. K. Janev, Institute of Physics, Yugoslavia; and M. S. Pindzola, Auburn University (January 1987).

Vol. 6, "Spectroscopic Data for Titanium, Chromium, and Nickel," W. L. Wiese and A. Musgrove, National Institute for Standards and Technology (September 1989).

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Abstract

Comprehensive spectroscopic data tables are presented for all ionization stages of titanium, chromium, and nickel. Tables of ionization potentials, spectral lines, energy levels, and transition probabilities are presented. These tables contain data which have been excerpted from general critical compilations prepared under the sponsorship of the National Standard Reference Data System (NSRDS).

Spectroscopic Data for Titanium, Chromium, and Nickel — Volume 1. Titanium

W. L. Wiese and A. Musgrove, Editors

Table of Contents

General Introduction

This compendium contains a collection of recent spectroscopic data tables for titanium, chromium, and nickel. The tables are issued in three separate volumes, each containing one element. The individual volumes are identified as Oak Ridge National Laboratory ORNL 6551/V1 (titanium); ORNL 6551/V2 (chromium); and ORNL 6551/V3 (nickel). These chemical elements, together with the earlier tabulated[1] element iron, are the principal heavy metals which are widely used as first-wall materials (including limiters, armor plates, etc.) of magnetic fusion research machines, particularly tokamaks. Spectral radiation data for both high and low stages of ionization for Ti, Cr and Ni have thus become important for the assessment and modeling of the effects of impurities on plasma properties and power balance, for the study of plasma-wall interactions as well as for the application of plasma diagnostic techniques.

Numerical data are tabulated for those spectroscopic quantities which are of principal importance for such plasma studies and for plasma diagnostics. The specific spectroscopic quantities are ionization energies, wavelengths of allowed and forbidden lines, atomic energy levels, and atomic transition probabilities. Most of the critical evaluation and compilation work for these data has been done at the National Institute of Standards and Technology, formerly the National Bureau of Standards. The tables are usually parts of larger tabulations[2–7] containing many other chemical elements besides Ti, Cr, and Ni. Excerpting the data from these larger compilations required some modifications in the reprinted material, especially the modification of the introductory remarks with comments and explanations that specifically refer to the Ti, Cr, and Ni spectra. All of the material is quite recent, and is under the sponsorship of the National Standard Reference Data System (NSRDS). Since the various data tables have been completed at different times, there may be occasional slight inconsistencies between overlapping material when the data are based on different sources. Also, sometimes there may be different judgments of independent evaluators on the quality of the source material. For example, wavelengths which are derived from atomic energy levels may be sometimes slightly different from the observed data in the wavelength tables. There also may be slight inconsistencies between the energy level data contained in the wavelength and transition probability tables when compared to the data in the energy level table itself. But any such differences are so small that they do not matter for any plasma applications, and therefore the use of any of the recent tabulations is appropriate. But we generally recommend to use the *primary* tables to obtain data on a specific atomic quantity.

Each of the three volumes of this compendium is divided into six sections which cover:

Ionization energies,
General spectral line lists,
Vacuum ultraviolet lines,
Magnetic dipole lines,
Atomic energy levels, and
Atomic transition probabilities.

The editors gratefully acknowledge the cooperation of the data compilers. We also thank NSRDS, the American Institute of Physics, and American Chemical Society for permission to reprint excerpts of these tables.

References

1. W. L. Wiese, Editor, *Spectroscopic Data for Iron*, ORNL-6089 [1985], Fourth Volume of Oak Ridge Natl. Lab. Series 6086.
2. J. Reader, C. H. Corliss, W. L. Wiese, and G. A. Martin, *Wavelengths and Transition Probabilities for Atoms and Atomic Ions*, Natl. Stand. Ref. Data Ser., Natl. Bur. Stand. (U.S.), 68, 415 pgs. [1980].
3. R. L. Kelly, *Atomic and Ionic Spectral Lines Below 2000 Å (H through Kr)*, J. Phys. Chem. Ref. Data **16**, Suppl. 1 (1987).
4. J. Sugar and C. Corliss, *Atomic Energy Levels of the Iron-Period Elements: Potassium through Nickel*, J. Phys. Chem. Ref. Data **14**, Suppl. 2 [1985].
5. V. Kaufman and J. Sugar, *Forbidden Lines in ns^2np^k Ground Configurations and nsnp Excitation Configurations of Be through Mo Atoms and Ions*, J. Phys. Chem. Ref. Data **15**, 321–416 [1986].
6. G. A. Martin, J. R. Fuhr, and W. L. Wiese, *Atomic Transition Probabilities—Scandium through Manganese*, J. Phys. Chem. Ref. Data **17**, Suppl. 3 [1988].
7. J. R. Fuhr, G. A. Martin, and W. L. Wiese, *Atomic Transition Probabilities—Iron through Nickel*, J. Phys. Chem. Ref. Data **17**, Suppl. 4 [1988].

A. Ionization Energies of Titanium Ions

A. Ionization Energies of Titanium Ions

[Excerpted from: J. Sugar and C. Corliss, J. Phys. Chem. Ref. Data **14**, Suppl. 2 (1985)]

Spectrum	Ground State Configuration	Ground Level	Ionization Energy (eV)
Ti I	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^2 4s^2$	$^3F_2$	6.820
Ti II	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^2 4s$	$^4F_{3/2}$	13.5756
Ti III	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^2$	$^3F_2$	27.4919
Ti IV	$1s^2 2s^2 2p^6 3s^2 3p^6 3d$	$^2D_{3/2}$	43.2675
Ti V	$1s^2 2s^2 2p^6 3s^2 3p^6$	$^1S_0$	99.30
Ti VI	$1s^2 2s^2 2p^6 3s^2 3p^5$	$^2P^\circ_{3/2}$	119.53
Ti VII	$1s^2 2s^2 2p^6 3s^2 3p^4$	$^3P_2$	140.8
Ti VIII	$1s^2 2s^2 2p^6 3s^2 3p^3$	$^4S^\circ_{3/2}$	170.4
Ti IX	$1s^2 2s^2 2p^6 3s^2 3p^2$	$^3P_0$	192.1
Ti X	$1s^2 2s^2 2p^6 3s^2 3p$	$^2P^\circ_{1/2}$	215.92
Ti XI	$1s^2 2s^2 2p^6 3s^2$	$^1S_0$	265.07
Ti XII	$1s^2 2s^2 2p^6 3s$	$^2S_{1/2}$	291.502
Ti XIII	$1s^2 2s^2 2p^6$	$^1S_0$	787.84
Ti XIV	$1s^2 2s^2 2p^5$	$^2P^\circ_{3/2}$	863.1
Ti XV	$1s^2 2s^2 2p^4$	$^3P_2$	941.9
Ti XVI	$1s^2 2s^2 2p^3$	$^4S^\circ_{3/2}$	1044
Ti XVII	$1s^2 2s^2 2p^2$	$^3P_0$	1131
Ti XVIII	$1s^2 2s^2 2p$	$^2P^\circ_{1/2}$	1221
Ti XIX	$1s^2 2s^2$	$^1S_0$	1346
Ti XX	$1s^2 2s$	$^2S_{1/2}$	1425.4
Ti XXI	$1s^2$	$^1S_0$	6249.0
Ti XXII	$1s$	$^2S_{1/2}$	6625.87

B. Prominent Spectral Lines for Ti I to Ti V

B. Prominent Spectral Lines for Ti I to Ti V
(Vacuum Ultraviolet to Near Infrared Regions)

[Excerpted from: J. Reader, C. H. Corliss, W. L. Wiese, and G. A. Martin, Natl. Stand. Ref. Data Ser., Natl. Bur. Stand. (U.S.) 68, 415 pgs. (1980); and J. Reader and C. H. Corliss, in *Handbook of Chemistry and Physics*, 70th Edition (1989)]

These lists were prepared under the auspices of the Committee of Line Spectra of the Elements of the National Academy of Sciences—National Research Council as part of a general wavelength table[1,2]. The tables contain the outstanding spectral lines,—from the far ultraviolet to the far infrared,—of neutral (I), singly ionized (II), doubly ionized (III), triply ionized (IV), and quadruply ionized (V) titanium atoms. The lines are selected from larger lists (see references) in such a way as to include the stronger observed lines in each spectral region.

The data were compiled by Charles H. Corliss, NBS (Ti I – Ti V). For Ti I and II, the following literature reference was used as the principal source of data:

> W. F. Meggers, C. H. Corliss, and B. F. Scribner, Natl. Bur. Stand. (U.S.), Monogr. 145, Washington, D.C. (1975).

For Ti III, IV and V, the following references were used:

> B. Edlén, J. W. Swensson, Phys. Scr. **12**, 21 (1975).
>
> J. W. Swensson, B. Edlén, Phys. Scr. **9**, 335 (1974).
>
> L. A. Svensson, Phys. Scr. **13**, 235 (1976).

All wavelengths are given in Angstrom units (Å). Below 2000 Å, the wavelengths are in vacuum; above 2000 Å, the wavelengths are in air. The line intensities for Ti I and Ti II are estimates of the relative line strengths that take into account the variations of detection sensitivity with wavelength. They are given on a linear scale. For the other Ti spectra, the line intensities represent rather qualitative estimates of the relative strengths of lines which are not greatly separated in wavelength. Because different emission sources are involved, and because the scales for the intensity estimates are sometimes not linear, these intensities are only useful as a rough indication of the appearances of the spectra. Furthermore, in the tables of first and second spectra the intensities of the lines of the singly ionized atoms relative to those of the neutral atom should be used with caution, inasmuch as the concentration of the ions in the light source depends greatly on the excitation conditions.

The descriptive symbols used in the tables have the following meaning:

H – hazy
D – line consists of two unresolved lines

References

1. J. Reader, C. H. Corliss, W. L. Wiese, and G. A. Martin, *Wavelengths and Transition Probabilities for Atoms and Atomic Ions*, Natl. Stand. Ref. Data Ser., Natl. Bur. Stand. (U.S.), 68, 415 pgs. (1980).
2. J. Reader and C. H. Corliss, in *Handbook of Chemistry and Physics*, 70th Edition (R. C. Weast, Ed.), CRC Press, Inc., Boca Raton, FL (1989).

Titanium (Ti)

$Z=22$

Intensity	Wavelength (Å)	Spectrum	Intensity	Wavelength (Å)	Spectrum
	Ti I and II		75	2611.48	I
	Air		300	2619.94	I
			170	2631.54	I
			170	2632.42	I
140	2272.61	I	640	2641.10	I
180	2273.28	I	800	2644.26	I
130	2276.70	I	950	2646.64	I
190	2279.96	I	30	2649.30	I
150	2299.85	I	15	2654.93	I
140	2302.73	I	35	2657.19	I
190	2305.67	I	85	2661.97	I
65	2380.81	I	95	2669.60	I
35	2384.52	I	130	2679.93	I
55	2418.36	I	26	2684.80	I
75	2421.30	I	30	2685.14	I
95	2424.24	I	65	2688.82	I
40	2428.23	I	26	2716.25	II
35	2433.22	I	85	2725.07	I
19	2434.10	I	75	2727.42	I
35	2440.21	II	21	2731.13	I
65	2440.98	I	40	2731.58	I
24	2450.44	II	170	2733.26	I
24	2504.54	I	55	2735.29	I
75	2517.43	II	40	2735.61	I
40	2519.04	I	85	2739.81	I
140	2520.54	I	250	2742.32	I
75	2524.64	II	40	2749.06	I
360	2525.60	II	65	2757.40	I
29	2527.98	I	95	2758.08	I
210	2529.85	I	15	2761.29	II
190	2531.25	II	250	2802.50	I
190	2534.62	II	55	2805.70	I
130	2535.87	II	30	2806.50	II
190	2541.92	I	40	2809.17	I
65	2555.99	II	75	2810.30	II
110	2571.03	II	30	2812.98	I
50	2572.65	II	30	2817.40	I
50	2580.82	I	65	2817.84	I
35	2590.26	I		2817.87	II
190	2593.64	I	65	2828.07	I
65	2596.58	I		2828.15	II
270	2599.92	I	130	2832.16	II
340	2605.15	I	190	2841.94	II
510	2611.28	I	110	2851.10	II

Intensity	Wavelength (Å)	Spectrum	Intensity	Wavelength (Å)	Spectrum
40	2853.93	II	230	3103.80	II
95	2862.32	II	230	3105.08	II
55	2868.74	II	260	3106.23	II
180	2877.44	II	70	3106.81	I
280	2884.11	II	50	3110.67	II
65	2888.93	II	50	3112.48	I
55	2891.07	II	140	3117.67	II
55	2905.66	I	720	3119.72	I
30	2909.92	II		3119.80	II
450	2912.08	I	190	3123.07	I
340	2928.34	I	240	3130.80	II
15	2931.03		140	3141.54	I
180	2933.55	I	95	3141.67	I
26	2935.96		220	3143.76	II
150	2937.32	I	240	3148.04	II
1100	2942.00	I	240	3152.25	II
1300	2948.26	I	240	3154.20	II
30	2954.58		240	3155.67	II
1600	2956.13	I	500	3161.20	II
170	2956.80	I	780	3161.77	II
30	2958.77		1000	3162.57	II
26	2959.71	I	1600	3168.52	II
35	2959.99	I	2400	3186.45	I
170	2965.71	I	1000	3190.87	II
190	2967.22	I	3100	3191.99	I
26	2968.23	I	50	3197.52	II
75	2970.38	I	3800	3199.92	I
30	2974.93	I	780	3202.54	II
170	2983.31	I	50	3203.44	II
35	3000.87	I	240	3203.83	I
120	3017.19	II	50	3204.87	I
140	3029.73	II	110	3213.14	II
110	3046.68	II	260	3214.24	I
130	3056.74	II	190	3214.75	II
130	3057.40	II	1100	3217.06	II
170	3058.09	II	110	3217.94	I
85	3059.74	II	260	3218.27	II
1300 D	3066.22	II	110	3219.21	I
	3066.35	II	110	3221.38	I
70	3071.24	II	1300	3222.84	II
600	3072.11	II	220	3223.52	I
1100	3072.97	II	240	3224.24	II
1600	3075.22	II	140	3226.13	I
2300	3078.64	II	530	3228.60	II
3600	3088.02	II	780	3229.19	II
180	3089.40	II	530	3229.42	II
180	3097.19	II	110	3231.32	II
180	3100.67	I	240	3232.28	II

Intensity	Wavelength (Å)	Spectrum
6600	3234.52	II
220	3236.12	II
5200	3236.57	II
4100	3239.04	II
220	3239.66	II
2600	3241.99	II
1200	3248.60	II
950	3251.91	II
1200	3252.91	II
1200	3254.25	II
1200	3261.60	II
310	3271.65	II
310	3272.08	II
200	3278.29	II
260	3278.92	II
220	3282.33	II
530	3287.66	II
290	3292.08	I
170	3299.41	I
170	3306.88	I
220	3308.39	I
220	3308.81	II
260	3309.50	I
60	3309.73	I
110	3312.69	I
840	3314.42	I
	3314.52	I
290	3315.32	II
330	3318.02	II
550	3321.70	II
2900	3322.94	II
380	3326.76	II
2100	3329.46	II
550	3332.11	II
1800	3335.20	II
1100	3340.34	II
5700	3341.88	I
120	3342.15	I
260	3343.77	II
330	3346.73	II
4300	3349.04	II
12000	3349.41	II
120	3352.94	I
4100	3354.64	I
290	3358.28	I
290	3360.99	I
7200	3361.21	II
	3361.26	I
120	3361.84	I
1100	3370.44	I
4300	3371.45	I
140	3372.21	II
5700	3372.80	II
60	3374.35	II
2900 D	3377.48	I
	3377.58	I
290	3379.22	I
1400	3380.28	II
170	3382.31	I
5700	3383.76	II
170	3385.66	I
1400	3385.95	I
1400	3387.84	II
60	3388.76	II
140	3390.68	I
140	3392.71	I
1100	3394.58	II
60	3398.63	I
60	3402.42	II
60	3407.20	II
95	3409.81	II
60	3439.30	I
890	3444.31	II
60	3452.47	II
180	3456.39	II
600	3461.50	II
95	3467.26	I
600	3477.18	II
60	3478.92	I
240	3480.53	I
60	3485.69	I
60	3489.74	II
480	3491.05	II
60	3495.75	I
95	3499.10	I
890	3504.89	II
120	3506.64	I
600	3510.84	II
60	3520.25	II
310	3535.41	II
190	3547.03	I
120	3573.74	II
60	3574.24	I
60	3587.13	II
240	3596.05	II
190	3598.72	I

Intensity	Wavelength (Å)	Spectrum	Intensity		Wavelength (Å)	Spectrum
600	3610.16	I	600		3771.66	I
190	3624.82	II	30		3776.06	II
95	3635.20	I	840		3786.04	I
4800	3635.46	I	120		3789.30	I
120	3637.97	I	70		3795.90	I
190	3641.33	II	60		3798.31	I
6600	3642.68	I	70		3818.22	I
180	3646.20	I	60		3822.03	I
7200	3653.50	I	240		3828.19	I
290	3654.59	I	95		3833.68	I
660	3658.10	I	95		3836.78	I
120	3659.76	II	60		3846.45	I
380	3660.63	I	130		3853.05	I
190	3662.24	II	130		3853.73	I
380	3668.97	I	170		3858.14	I
600	3671.67	I	240		3866.44	I
3100	3685.20	II	170		3868.40	I
120	3685.96	I	120		3873.21	I
95	3687.35	I	260		3875.26	I
600	3689.91	I	170		3882.15	I
140	3694.45	I	170		3882.33	I
30	3698.18	I	500		3882.89	I
60	3698.43	I	60	H	3888.02	I
60	3700.08	I	70		3889.95	I
120	3702.29	I	200	H	3895.25	I
190	3704.30	I	85		3898.49	I
140	3706.23	II	530		3900.54	II
50	3707.53	I	180		3900.96	I
290	3709.96	I	2600		3904.78	I
30	3715.40	I	110	H	3911.19	I
450	3717.40	I	500		3913.46	II
140	3721.64	II	500		3914.34	I
330	3722.57	I	24		3914.74	I
600	3724.57	I	35		3919.82	I
380	3725.16	I	290		3921.42	I
2900	3729.82	I	1100		3924.53	I
50	3735.67	I	110		3926.32	I
60	3738.90	I	890		3929.88	I
3300	3741.06	I	35		3932.02	II
330	3741.64	II	70		3934.24	I
160	3748.10	I	1100		3947.78	I
5200	3752.86	I	4500		3948.67	I
600	3753.64	I	4500		3956.34	I
140	3757.69	II	5200		3958.21	I
3300	3759.30	II	950		3962.85	I
2900	3761.32	II	950		3964.27	I
50	3761.89	II	4800		3981.76	I
60	3766.45	I				

Intensity		Wavelength (Å)	Spectrum
570		3982.48	I
60		3984.33	I
35		3985.25	I
60		3985.59	I
5700		3989.76	I
35		3994.70	I
7800		3998.64	I
70		3999.36	I
70		4002.49	I
70		4003.81	I
35		4005.97	I
70		4008.06	I
950		4008.93	I
190		4009.66	I
70		4012.39	II
180		4013.58	I
70		4015.38	I
35		4016.28	I
120	H	4017.77	I
140		4021.83	I
1200		4024.57	I
40		4025.14	II
190	H	4026.54	I
40		4027.48	I
40		4028.34	II
190	H	4030.51	I
40		4033.91	I
30		4034.91	I
110		4035.83	I
35	H	4040.32	I
290		4055.02	I
85		4057.62	I
85		4058.14	I
410		4060.26	I
200		4064.22	I
200		4065.10	I
840		4078.47	I
40		4079.72	I
290		4082.46	I
85		4099.17	I
220		4112.71	I
85		4122.17	I
40		4123.31	I
85		4123.57	I
130		4127.54	I
40		4129.17	I
40		4131.25	I
140		4137.29	I
85		4143.05	I
170		4150.96	I
85		4159.64	I
70		4163.65	II
35		4164.14	I
40		4166.32	I
85		4169.35	I
120		4171.03	I
40		4171.90	II
35		4183.30	I
360		4186.12	I
40		4188.69	I
70		4200.75	I
85		4203.46	I
35		4211.73	I
40		4224.79	I
40		4227.65	I
130		4237.89	I
85		4249.12	I
130		4256.04	I
70		4258.54	I
70		4261.60	I
330		4263.13	I
35		4265.71	I
40		4266.22	I
70		4270.14	I
85		4272.43	I
240		4274.58	I
120		4276.43	I
120		4278.23	I
30		4278.81	I
110		4281.38	I
220		4282.71	I
160		4284.99	I
890		4286.01	I
840		4287.40	I
30		4288.16	I
950		4289.07	I
120		4290.23	II
840		4290.94	I
120		4291.14	I
140		4294.12	II
840		4295.76	I
2000		4298.66	I
200		4299.23	I
200		4299.64	I
200		4300.05	II
2900		4300.56	I

Intensity	Wavelength (Å)	Spectrum	Intensity	Wavelength (Å)	Spectrum
4100	4301.09	I	230	4443.80	II
85	4301.93	II	24	4444.27	I
6000	4305.92	I	840	4449.15	I
180	4307.90	II	30	4450.49	II
35	4308.50	I	550	4450.90	I
40	4311.65	I	840	4453.32	I
85	4312.87	II	290	4453.71	I
85	4314.35	I	950	4455.33	I
1200	4314.80	I	1100	4457.43	I
360	4318.64	I	21	4462.09	I
180	4321.66	I	70	4463.38	I
190	4325.13	I	95	4463.54	I
160	4326.36	I	290	4465.81	I
30	4334.84	I	240	4468.50	II
160	4337.92	II	240	4471.24	I
24	4344.29	II	95	4474.85	I
70	4346.11	I	95	4479.70	I
35	4354.06	I	50	4480.59	I
95	4360.49	I	530	4481.26	I
24	4368.94	I	95	4482.69	I
95	4369.68	I	19	4488.32	II
60	4372.38	I	260	4489.09	I
30	4388.08	I	24	4492.55	I
170	4393.92	I	40	4495.01	I
330	4395.04	II	240	4496.15	I
60	4399.77	II	24	4497.73	I
240	4404.28	I	200	4501.27	II
60	4404.90	I	40	4503.78	I
30	4405.68	I	21	4506.36	I
60	4416.54	I	50	4511.17	I
220	4417.28	I	780	4512.74	I
60	4417.72	II	19	4515.62	I
120	4421.76	I	1000	4518.03	I
120	4422.82	I	95	4518.70	I
24	4424.39	I	1000	4522.80	I
30	4425.83	I	780	4527.31	I
120	4426.06	I	6000	4533.24	I
890	4427.10	I	240	4533.97	II
21	4430.02	I	3600	4534.78	I
85	4430.37	I	2400	4535.58	I
50	4431.28	I	1200	4535.92	I
30	4432.60	I	1200	4536.05	I
24	4433.58	I	24	4537.23	I
170	4434.00	I	24	4539.10	I
70	4436.59	I	720	4544.69	I
30	4438.23	I	950	4548.77	I
130	4440.35	I	240	4549.63	II
50	4441.27	I	950	4552.46	I

Intensity	Wavelength (Å)	Spectrum	Intensity	Wavelength (Å)	Spectrum
24	4555.08	I	45	4766.33	I
720	4555.49	I	28	4769.77	I
19	4557.86	I	65	4778.26	I
19	4558.11	I	45	4781.72	I
60	4559.92	I	110	4792.49	I
50	4562.63	I	45	4796.22	I
35	4563.43	I	35	4797.98	I
110	4563.77	II	110	4799.80	I
35	4570.91	I	28	4805.10	II
240	4571.98	II	110	4805.43	I
19	4585.84		45	4808.53	I
24	4589.95	II	22	4811.08	I
60	4599.23	I	40	4812.25	I
21	4609.37	I	200	4820.42	I
950	4617.27	I	22	4825.46	I
24	4619.52	I	40	4836.13	I
480	4623.09	I	470	4840.87	I
190	4629.34	I	65	4848.47	I
50 D	4634.87		290	4856.01	I
60	4637.88	I	35	4864.18	I
240	4639.37	I	200	4868.26	I
220	4639.67	I	250	4870.14	I
190	4639.95	I	28	4880.91	I
140	4645.19	I	45	4882.35	I
120	4650.02	I	400	4885.08	I
24	4656.04	I	380	4899.91	I
720	4656.47	I	320	4913.62	I
840	4667.59	I	55	4915.24	I
70	4675.12	I	130	4919.87	I
950	4681.92	I	180	4921.77	I
21	4686.92	I	55	4925.41	I
24	4690.80	I	30	4926.16	I
190	4691.34	I	150	4928.34	I
40	4693.68	I	30	4937.74	I
24	4696.94	I	95	4938.29	I
190	4698.76	I	30	4941.58	I
120	4710.19	I	21	4948.19	I
24	4715.30	I	21	4958.25	I
65	4722.62	I	55	4964.75	I
65	4723.17	I	21	4966.04	I
55	4731.17	I	65	4968.58	I
45	4733.43	I	75	4973.05	I
18	4734.68	I	120	4975.35	I
22	4742.11	I	65	4977.74	I
170	4742.79	I	120	4978.20	I
22	4747.68	I	5800	4981.73	I
310	4758.12	I	150	4989.15	I
310	4759.28	I	4600	4991.07	I

Intensity		Wavelength (Å)	Spectrum	Intensity		Wavelength (Å)	Spectrum
30		4995.08	I	85	H	5194.04	I
140		4997.10	I	65		5201.10	I
4000		4999.51	I	120		5206.08	I
230		5001.01	I	75		5207.87	I
3600		5007.21	I	65		5208.42	
120		5009.65	I	1400		5210.39	I
230		5013.30	I	65		5212.29	I
3200	D	5014.19	I	150		5219.71	I
		5014.24	I	95		5222.69	I
580		5016.17	I	85		5223.64	I
840		5020.03	I	250		5224.32	I
840		5022.87	I	95		5224.56	I
580		5024.84	I	190		5224.95	I
300		5025.58	I	65		5226.56	II
1200		5035.91	I	120		5238.58	I
840		5036.47	I	21		5246.15	I
740		5038.40	I	55		5246.57	I
1200		5039.95	I	75		5247.31	I
75		5040.62	I	21		5250.95	I
85		5043.59	I	110		5252.11	I
35		5044.27	I	75		5255.83	I
55		5045.41	I	55		5259.99	I
26		5048.21	I	55		5263.50	I
110		5052.87	I	150		5265.98	I
21		5054.08	I	40		5282.39	I
110		5062.11	I	140		5283.45	I
35		5064.07	I	35		5284.39	I
1400		5064.66	I	26		5288.81	
95		5065.99	I	65		5295.79	I
35	H	5068.33	I	120		5297.26	I
65		5069.35	I	65		5298.44	I
130		5071.48	I	26		5336.81	II
40		5085.34	I	17		5341.50	I
130		5087.07	I	75		5351.08	I
21		5103.15	I	26		5366.65	I
55		5109.44	I	55		5369.64	I
190		5113.44	I	40		5389.18	I
270		5120.42	I	55		5389.99	I
30		5129.15	II	17		5396.60	I
270		5145.47	I	85		5397.09	I
230		5147.48	I	35		5404.02	I
210		5152.20	I	110		5409.61	I
1100		5173.75	I	40		5426.26	I
40		5186.34	I	75		5429.15	I
85		5188.70	II	26		5436.73	I
30		5189.58	I	17		5438.32	I
1300		5192.98	I	40		5446.64	I

Intensity		Wavelength (Å)	Spectrum
30		5448.90	I
21		5449.16	I
35		5453.65	I
55		5460.51	I
75		5471.21	I
35		5472.70	I
40	H	5473.55	I
85		5474.23	I
30		5474.46	I
120	H	5477.71	I
110		5481.43	I
75		5481.87	I
85	H	5488.20	I
150		5490.15	I
26		5490.84	I
110		5503.90	I
40		5511.78	I
340		5512.53	I
270		5514.35	I
320		5514.54	I
26		5530.49	
110		5565.49	I
13		5579.16	
21	H	5582.98	
30	H	5585.68	
17		5635.84	
250		5644.14	I
75		5648.58	I
190		5662.16	I
75		5662.91	I
21		5673.42	I
130		5675.44	I
30	H	5679.94	I
95		5689.47	I
75		5702.68	I
35		5708.23	I
65		5711.88	I
40	H	5713.92	I
95		5715.13	I
55		5716.48	I
35		5720.48	I
85		5739.51	I
40		5740.02	I
19		5741.22	I
21		5752.84	I
19		5756.86	I
40	H	5762.27	I
55	H	5766.35	I
75	H	5774.05	I
30		5780.78	I
75	H	5785.98	I
65	H	5804.26	I
40		5823.71	I
21	H	5841.18	
21		5852.34	
400		5866.46	I
65		5880.31	I
21	H	5888.68	
230		5899.32	I
55		5903.33	I
120		5918.55	I
150		5922.12	I
75		5937.82	I
120		5941.76	I
300		5953.17	I
200		5965.84	I
270		5978.56	I
340		5999.04	I
65		5999.68	I
21		6012.73	
110		6064.63	I
120		6085.23	I
120		6091.17	I
40		6092.81	I
40	H	6098.67	I
35	H	6121.01	I
120		6126.22	I
19		6138.38	I
30		6146.22	I
21		6149.74	I
35		6186.15	I
95	H	6215.28	I
75	H	6220.49	I
65	H	6221.41	I
380		6258.10	I
380		6258.70	I
300		6261.10	I
65		6303.75	I
55		6312.24	I
26		6318.03	I
30		6336.10	I

Intensity		Wavelength (Å)	Spectrum
35		6366.35	I
11		6419.10	I
17		6497.69	I
19		6508.14	I
55		6546.28	I
65		6554.23	I
11	H	6554.83	
75		6556.07	I
19	H	6565.62	I
14	H	6575.18	I
35		6599.11	I
18	H	6666.55	I
22	H	6667.74	
9		6668.39	
18		6677.18	I
26		6716.68	I
80		6743.12	I
22		6745.52	I
18		6844.64	
18		6860.39	
35		6861.47	I
9		6873.92	I
12		6913.19	I
14	H	6933.15	I
14	H	6943.70	I
23		6996.63	I
15		7004.66	I
14		7008.35	I
14		7010.94	I
14	H	7035.86	I
40		7038.80	I
14		7050.65	I
23		7069.11	I
23		7072.05	
26		7138.91	I
26		7167.13	
23		7171.53	
55		7189.89	I
260		7209.44	I
60		7216.20	I
130		7244.86	I
130		7251.72	I
19		7263.40	
19		7266.29	I
15		7315.56	I
26		7318.39	I
120		7344.72	I
11		7352.16	I
90		7357.74	I
60		7364.11	I
26		7440.60	I
9		7474.94	I
26		7489.61	I
19		7496.12	I
12		7580.55	I
15		7614.50	I
23		7654.44	I
30		7949.17	I
26	H	7961.58	I
60		7978.88	I
9		7979.07	I
30		7996.53	I
7	H	8003.55	
55		8024.84	I
30		8068.24	I
8		8267.62	
14	H	8306.31	I
9	H	8307.41	I
9	H	8311.76	I
8	H	8312.85	I
12		8334.37	I
14		8353.15	I
75		8364.24	I
100		8377.85	I
100		8382.54	I
55		8382.82	I
75		8396.87	I
120		8412.36	I
19		8416.98	I
15		8424.41	I
170		8426.52	I
490		8434.94	I
240		8435.70	I
40		8438.93	I
40		8450.89	I

Intensity		Wavelength (Å)	Spectrum
9	H	8457.10	I
19	H	8467.15	I
45		8468.50	I
15		8496.04	I
19	H	8518.05	I
40		8518.32	I
14		8539.38	I
40		8548.12	I
9		8569.77	I
9	H	8598.18	I
90		8675.39	I
45		8682.99	I
23		8692.33	I
19		8734.69	I
23		8766.64	I
15	H	8778.71	I
		Ti III	
		Vacuum	
6		1282.48	III
6		1286.23	III
15		1286.36	III
10		1289.30	III
10		1291.62	III
10		1293.23	III
15		1294.70	III
10		1295.88	III
20		1298.66	III
20		1298.97	III
12		1327.59	III
10		1420.04	III
10		1420.44	III
10		1421.63	III
10		1421.77	III
12		1422.40	III
10		1424.14	III
23		1455.19	III
10		1498.70	III
		Air	
10		2199.22	III
12		2237.77	III
10		2327.02	III
15		2331.35	III
15		2331.66	III
15		2334.34	III
17		2339.00	III
18		2346.79	III
18		2374.99	III
22		2413.99	III
25		2516.05	III
24		2527.84	III
23		2540.06	III
24		2563.44	III
23		2565.42	III
22		2567.56	III
15		2576.47	III
15		2580.46	III
10		2692.16	III
12		2701.96	III
22		2984.75	III
12	D	3354.71	III
12		3872.50	III
12		3881.21	III
12		3893.63	III
10		3896.33	III
15		3915.47	III
12		3921.38	III
10		3921.61	III
12		3922.95	III
10		3924.86	III
10		4060.21	III
10		4119.14	III
11		4215.52	III
11		4269.84	III
11		4296.70	III
10		4348.04	III
11		4433.91	III
10		4540.22	III
15		4549.84	III
10	D	4555.46	III
15	D	4572.20	III
10		4649.45	III
12		4652.86	III
10		4874.00	III
10		4950.10	III
10		4971.19	III
10		5083.80	III
14		5147.31	III
12	D	5226.28	III
11		5247.49	III
17		5278.12	III
10		5278.70	III
12		5298.43	III
16		5301.20	III
15		5306.88	III
10		5395.69	III

Intensity	Wavelength (Å)	Spectrum
12	5533.01	III
10	5817.44	III
12	6611.38	III
18	6621.58	III
10	6629.37	III
14	6647.47	III
18	6667.99	III
15	6674.19	III
14	6707.76	III
12	6724.80	III
16	6734.10	III
15	6862.26	III
12	6874.35	III
10	6896.12	III
12	7015.38	III
10	7071.93	III
20	7072.64	III
18	7084.57	III
15	7124.13	III
11	7171.79	III
10	7175.92	III
10	7217.50	III
9	7225.55	III
12	7270.67	III
14	7316.30	III
10	7316.68	III
12	7379.96	III
10	7408.13	III
10	7457.85	III
15	7506.87	III
17	7507.68	III
10	7523.85	III
12	7544.29	III
9	7566.25	III
10 H	8172.21	III
9 H	8173.37	III
9 H	8178.00	III
10	8182.42	III
9 H	8192.68	III
9 H	8194.75	III
9 H	8263.67	III
15 H	8267.32	III
10	8338.54	III
12	8394.20	III
20	8466.87	III
5	8699.85	III
3	9017.10	III

Intensity	Wavelength (Å)	Spectrum
	Ti IV	
	Vacuum	
10	776.76	IV
18	779.07	IV
16	781.73	IV
8	1183.64	IV
10	1195.21	IV
18	1451.74	IV
20	1467.34	IV
12	1469.19	IV
	Air	
20	2067.56	IV
18	2103.16	IV
10	2359.14	IV
10	2359.50	IV
8	2541.79	IV
10	2546.88	IV
5	2862.60	IV
6	2929.96	IV
14	2937.33	IV
12	2957.31	IV
15	3541.36	IV
17	3576.44	IV
10	3581.39	IV
13	4131.22	IV
14	4133.78	IV
10	4397.33	IV
9	4403.45	IV
15	4618.11	IV
20	5398.93	IV
8	5470.98	IV
18	5492.51	IV
10	5517.72	IV
14	5877.79	IV
15	5885.96	IV
7	5891.15	IV
6	6231.62	IV
17	6246.65	IV
11	6247.74	IV
15	6292.41	IV
12	6913.85	IV
15	6978.51	IV
9	7491.37	IV
8	7494.77	IV
5 H	7652.12	IV
8 H	7706.85	IV

Intensity		Wavelength (Å)	Spectrum	Intensity		Wavelength (Å)	Spectrum
		Ti v		9		541.71	v
		Vacuum		7		543.10	v
				7		543.34	v
12		225.35	v	7		1128.55	v
10		228.91	v	8		1192.35	v
17		252.96	v	9		1198.66	v
7		323.36	v	9		1222.36	v
7		461.41	v	10		1230.36	v
8		474.69	v	11		1239.96	v
8		483.99	v	10		1241.67	v
108	D	488.58	v	7		1246.13	v
15		498.26	v	8		1268.49	v
14		502.08	v	8		1306.11	v
7		502.71	v	8		1411.31	v
12		504.66	v	9		1675.15	v
7		506.47	v	8		1687.16	v
8		513.37	v	11		1717.40	v
7		523.05	v	8		1759.76	v
12		524.58	v	7		1771.45	v
13		526.57	v	10		1841.49	v
8		529.32	v	7		1864.45	v
10		535.84	v	7		1881.89	v
10		535.89	v	7		1920.16	v
8	D	540.14	v	7		1988.75	v
8		541.46	v				

C. Vacuum Ultraviolet Lines for Ti I through Ti XXII
(Wavelengths and Classifications)

C. Vacuum Ultraviolet Lines for Ti I through Ti XXII

[Excerpted from: R. L. Kelly, J. Phys. Chem. Ref. Data **16**, Supplement 1 (1987)]

The following tables, including the introductory comments, are excerpted from a new tabulation by R. L. Kelly,[1] which supersedes and revises his previous tables published with Palumbo in 1973.[2]

The listed wavelength data are generally from observations, with lines of the helium-like and hydrogen-like ions (Ti XXI and Ti XXII) as notable exceptions. But also in some cases where lines have been observed, wavelengths given here are those resulting from a comprehensive analysis of the spectrum rather than the measured values. A few lines have been predicted from unpublished extrapolations along isoelectronic sequences, and some unobserved weak lines in multiplets have been included for completeness. Such predicted values of wavelength are marked by the symbol P in the column labeled "Notes".

The lines are arranged in order of increasing wavelength within each spectrum, and the vacuum wavelengths are given as they are reported in the reference listed first for each line. A complete listing of these references is given at the end of these introductory comments. Where more than one publication reports the wavelength of the line, the decision as to which to retain was based primarily on the present author's judgement of the best value. This judgement was based on consideration of the dates of publication, on probable accuracy from the type of instrumentation used and the wavelength standards employed, on the spectroscopic source used, and on the comparison of the observations with the wavelengths predicted from the best known values of energy levels as described above.

With respect to the accuracy of the wavelength data, it is conservatively estimated that all wavelengths reported should have uncertainties of ten to twenty in the last digit given.

The listed intensities have been normalized to a maximum of 1000 for convenience in comparing the different references. The normalization procedure used was generally a linear or logarithmic transformation of the intensities reported by the original authors, depending on the particular case. Intensities given by different observers have seldom been found compatible, however, and the tabulated intensities should be used only as a rough estimate.

The transitions are shown in standard spectroscopic notation with the lower level given first, and the energy levels, i.e., energies above the ground state, are presented in units of 1000 cm^{-1}, each value being rounded off to conserve space. Additive uncertainties are indicated by B, C, K, etc. which may be thousands of cm^{-1}. The energy level data are taken from the files of the Naval Postgraduate School Spectroscopic Data Center (and thus do not necessarily agree with those tabulated in Section E of this book).

The multiplet numbers assigned by C. E. Moore[3] are given in a separate column. The classifications of the transitions are given in the accepted form, the primary references being the NBS spectroscopy tables.[3,4] For convenience, separate columns are used for showing the configurations, terms, and J-values. In the term column, the symbol g is used to denote the ground term. Otherwise, the term designation follows that of Cowan and Andrew.[5]

The parent terms are given where they are known and where they are not immediately obvious. The older practice of using primes, double primes, etc. to indicate that the parent term of a configuration is an excited state of the next higher ion has been abandoned. But the notation of a, b, c, ... (for even terms) and z, y, x, ... (for odd terms) to indicate the order of appearance of terms of the same multiplicity and same type has been continued.

A few descriptive symbols are used in the "Notes" column which have the following meanings:

F – line is forbidden by electric dipole selection rules
A – line observed in absorption
Q – uncertain classification
P – predicted value of wavelength

There are three classes of predicted lines:

(a) lines that have been observed but for which calculations of wavelengths from energy levels are superior to the observations as in hydrogenic spectra and in other specific transitions.
(b) lines which have not been observed but for which Ritz calculations between known levels can be made, as in many of the forbidden lines.
(c) lines for which one or both of the energy levels have been found by Hartree-Fock type calculations, by interpolation, or by extrapolation.

These three classes are not separately distinguished in the "Notes" column.

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TITANIUM , Z = 22
Unclassified Lines

Multiplet	Rel. Int.	λ_{vac} (in Å)	Levels (in 10^3 cm^{-1})	Configurations	Terms	J - J	Notes	References
	1	72.093						714
	1	72.234						714
	1	72.772						714
	1	72.991						714
	1	76.030						714
	1	76.490						714
	1	77.435						714
	1	77.506						714
	1	77.541						714
	1	77.823						714
	1	77.935						714
	1	81.306						714
	6	87.972						714
	1	88.284						714
	1	88.642						714
	1	88.961						714
	1	89.181						714
	3	89.814						714
	1	92.272						714
	1	92.581						714
	3	94.570						714
	3	95.293						714
	3	96.017						714
	6	99.377						714
	6	100.208						714
	3	100.359						714
	3	100.638						714
	3	101.111						714
	6	104.015						714
	6	104.348						714
	1	104.466						714
	3	104.659						714
	3	104.861						714
	3	107.801						714
	3	108.493						714
	1	109.153						714
	3	109.509						714
	3	109.593						714
	1	109.963						714
	1	110.072						714
	3	111.942						714
	1	112.002						714
	1	112.116						714
	1	112.153						714
	3	112.178						714
	3	113.151						714
	3	113.289						714
	1	113.643						714
	3	114.053						714
	6	118.131						714
	6	118.915						714
	6	119.050						714
	10	119.268						714
	1	120.226						714

Ti Unclassified Lines — Continued

Multiplet	Rel. Int.	λ_{vac} (in Å)	Levels (in 10^3 cm^{-1})	Configurations	Terms	J - J	Notes	References
	1	120.406						714
	20	120.559						714
	6	121.464						714
	1	121.783						714
	3	121.922						714
	1	122.136						714
	6	122.376						714
	6	122.847						714
	3	123.196						714
	6	123.253						714
	3	124.104						714
	1	124.632						714
	6	124.940						714
	1	125.195						714
	3	125.744						714
	6	128.111						714
	3	128.591						714
	3	128.731						714
	0	129.288						302
		129.384						714
	1	129.418						302,269
	3	131.102						714
	1	131.474						714
	3	131.623						714
	1	132.924						714
	3	133.053						714
	1	133.170						302
	6	133.482						714
	1	133.568						714
	1	133.721						714
	0	133.866						302
	0	133.990						302
	1	134.287						714
	3	134.894						714
	1	135.326						714
	1	135.458						714
	3	140.240						714
	1	141.208						714
	1	142.543						714
	1	144.092						714
	1	144.461						714
	1	147.268						714
	1	147.316						714
	3	149.842						714
	1	155.456						714
	1	155.494						714
	1	155.545						714
	6	157.378						714
	3	158.391						714
	3	158.952						714
	1	165.653						714
	1	166.566						714
	1	167.625						714
	1	167.701						714

Ti UNCLASSIFIED LINES — Continued

Multiplet	Rel. Int.	λ_{vac} (in Å)	Levels (in 10^3 cm^{-1})	Configurations	Terms	J - J	Notes	References
	1	167.930						714
	1	169.036						714
	1	176.105						714
	1	176.538						714
	1	177.729						714
	1	179.842						714
	250	179.91						384
	1	186.417						714
	1	187.671						714
	1	187.752						714
	1	187.819						714
	1	190.762						714
	1	193.737						714
	1	193.791						714
	1	194.420						714
	3	194.490						714
	1	196.443						714
	1	196.785						714
	3	197.178						714
	6	197.629						714
	6	197.697						714
	3	197.843						714
	1	198.079						714
	3	198.137						714
	3	198.311						714
	3	198.540						714
	3	199.960						714
	1	199.993						714
	1	200.691						714
	1	202.303						714
	1	205.880						714
	1	220.045						714
	1	220.739						714
	1	222.021						714
	1	224.169						714
	1	224.818						714
	1	225.033						714
	1	226.409						714
	1	226.462						714
	1	226.629						714
	1	226.680						714
	1	226.722						714
	1	227.639						714
	1	228.135						714
	1	230.155						714
	1	230.304						714
	1	230.425						714
	1	230.591						714
	1	231.553						714
	1	232.361						714
	1	232.466						714
	1	232.711						714
	1	232.847						714
	1	233.787						714

Tl UNCLASSIFIED LINES — Continued

Multiplet	Rel. Int.	λ_{vac} (in Å)	Levels (in 10^3 cm^{-1})	Configurations	Terms	J - J	Notes	References
	3	234.184						714
	1	234.680						714
	1	234.902						714
	10	235.096						714
	6	235.353						714
	6	235.450						714
	20	235.683						714
	10	235.887						714
	1	236.914						714
	3	237.059						714
	1	237.250						714
	1	237.519						714
	1	237.826						714
	6	238.054						714
	1	238.294						714
	3	238.689						714
	3	239.404						714
	1	239.933						714
	1	240.009						714
	3	240.321						714
	10	240.926						714
	1	241.013						714
	1	241.750						714
	3	241.917						714
	1	242.059						714
	1	242.403						714
	3	242.475						714
	1	242.604						714
	3	242.847						714
	3	243.035						714
	1	243.259						714
	1	243.503						714
	3	243.968						714
	1	244.291						714
	1	244.482						714
	1	244.779						714
	1	245.535						714
	1	245.637						714
	1	245.894						714
	1	245.937						714
	6	246.198						714
	3	246.395						714
	10	246.564						714
	1	246.699						714
	1	246.743						714
	1	247.135						714
	1	247.278						714
	1	247.385						714
	1	247.536						714
	3	247.719						714
	3	247.929						714
	1	248.481						714
	1	248.592						714
	6	248.980						714

Tl Unclassified Lines — Continued

Multiplet	Rel. Int.	λ_{vac} (in Å)	Levels (in 10^3 cm^{-1})	Configurations	Terms	J - J	Notes	References
	1	249.229						714
	1	249.278						714
	1	249.471						714
	1	249.529						714
	1	249.632						714
	1	249.688						714
	1	249.785						714
	20	249.920						714
	1	250.050						714
		250.339						714
	3	250.790						714
	10	250.999						714
	6	251.266						714
	35	251.622						714
	1	251.715						714
	6	251.800						714
	20	252.065						714
	3	252.874						714
	1	253.427						714
	1	253.518						714
	1	253.591						714
	3	253.906						714
	3	254.188						714
	20	254.288						714
	6	254.485						714
	1	254.574						714
	1	254.859						714
	1	255.439						714
	3	255.628						714
	1	255.754						714
	10	255.813						714
	6	255.875						714
	6	256.149						714
	10	256.305						714
	10	256.454						714
	1	256.525						714
	20	256.586						714
	6	256.732						714
	1	256.815						714
	1	256.869						714
	10	257.003						714
	1	257.382						714
	6	257.645						714
	1	258.008						714
	1	258.056						714
	1	258.178						714
	1	258.467						714
	3	258.868						714
	3	258.930						714
	3	258.969						714
	35	259.448						714
	20	259.649						714
	10	259.835						714
	3	259.895						714

TI UNCLASSIFIED LINES — Continued

Multiplet	Rel. Int.	λ_{vac} (in Å)	Levels (in 10^3 cm^{-1})	Configurations	Terms	J - J	Notes	References
	1	260.145						714
	60	260.251						714
	1	260.408						714
	6	260.522						714
	1	260.566						714
	3	260.986						714
	10	261.026						714
	1	261.224						714
	1	261.365						714
	10	261.493						714
	1	261.916						714
	3	262.300						714
	1	262.499						714
	1	262.894						714
	1	262.967						714
	6	263.384						714
	6	263.658						714
	1	263.822						714
	20	264.272						714
	3	264.367						714
	1	264.650						714
	1	264.739						714
	1	264.958						714
	3	265.145						714
	1	265.255						714
	1	265.666						714
	3	266.180						714
	3	266.670						714
	3	267.024						714
	1	267.187						714
	6	268.269						714
	1	268.566						714
	1	268.699						714
	1	268.748						714
	1	269.010						714
	1	269.314						714
	1	269.708						714
	10	269.939						714
	3	270.067						714
	10	270.281						714
	1	270.443						714
	10	270.675						714
	6	270.913						714
	6	271.030						714
	6	271.234						714
	6	271.488						714
	1	271.892						714
	3	272.417						714
	3	272.569						714
	1	272.707						714
	6	273.562						714
	3	273.916						714
	6	274.028						714
	3	275.128						714

Ti UNCLASSIFIED LINES — Continued

Multiplet	Rel. Int.	λ_{vac} (in Å)	Levels (in 10^3 cm^{-1})	Configurations	Terms	J - J	Notes	References
	1	275.979						714
	35	276.565						714
	1	276.909						714
	1	277.034						714
	3	277.111						714
	1	277.168						714
	1	277.760						714
	3	277.866						714
	3	277.984						714
	35	278.065						714
	60	278.331						714
	10	278.627						714
	6	278.926						714
	35	279.140						714
	3	279.195						714
	6	279.654						714
	20	280.284						714
	1	281.193						714
	6	282.086						714
	1	282.520						714
	1	283.204						714
	1	283.316						714
	20	284.349						714
	90	285.417						714
	35	285.543						714
	3	285.726						714
	10	285.860						714
	1	286.233						714
	1	286.333						714
	20	286.532						714
	10	287.041						714
	6	287.355						714
	6	287.400						714
	6	288.125						714
	6	288.232						714
	3	289.019						714
	1	289.178						714
	10	289.318						714
	1	289.456						714
	1	289.731						714
	1	289.992						714
	10	290.215						714
	3	290.344						714
	20	290.385						714
	1	290.506						714
	3	290.726						714
	60	291.186						714
	6	291.403						714
	3	291.585						714
	1	291.958						714
	1	292.401						714
	1	293.033						714
	1	293.240						714
	1	293.549						714

Ti UNCLASSIFIED LINES — Continued

Multiplet	Rel. Int.	λ_{vac} (in Å)	Levels (in 10^3 cm^{-1})	Configurations	Terms	J - J	Notes	References
	1	293.640						714
	20	293.944						714
	1	294.239						714
	6	295.070						714
	6	295.207						714
	3	297.106						714
	1	297.312						714
	1	297.418						714
	6	297.527						714
	1	297.858						714
	3	298.014						714
	1	298.380						714
	3	299.563						714
	1	299.889						714
	1	300.416						714
	1	301.244						714
	1	302.007						714
	1	302.558						714
	1	302.906						714
	1	303.791						714
	35	303.891						714
	1	306.083						714
	1	307.493						714
	3	308.408						714
	1	310.518						714
	1	311.659						714
	3	314.940						714
	1	315.670						714
	3	315.779						714
	3	315.844						714
	1	318.543						714
	1	319.887						714
	1	324.047						714
	1	325.767						714
	1	326.259						714
	1	328.248						714
	1	331.074						714
	1	332.554						714
	1	334.859						714
	1	343.668						714
	1	349.299						714
	1	350.732						714
	6	351.126						714
	1	351.351						714
	1	352.348						714
	1	352.574						714
	1	353.757						714
	1	354.843						714
	3	368.818						714
	1	370.408						714
	1	370.789						714
	1	371.332						714
	6	371.410						714
	1	375.508						714

Ti Unclassified Lines — Continued

Multiplet	Rel. Int.	λ_{vac} (in Å)	Levels (in 10^3 cm^{-1})	Configurations	Terms	J - J	Notes	References
	1	378.630						714
	1	385.211						714
	1	394.153						714
	1	396.288						714

TITANIUM II (Ti^{1+}), Z = 22
Ground State $1s^22s^22p^63s^23p^63d^24s(^4F_{3/2})$ (21 electrons)
Ionization Potential 109 500 cm^{-1}; 13.58 eV

Multiplet	Rel. Int.	λ_{vac} (in Å)	Levels (in 10^3 cm^{-1})	Configurations	Terms	J - J	Notes	References
		1545.009	4.89760 – 69.62215	$3d^2(a^3F)4s - 3d4s(b^1D)4p$	$a^2F - v^2D^\circ$	$\frac{7}{2}-\frac{5}{2}$	P	375
		1545.626	4.62861 – 69.32732	$3d^2(a^3F)4s - 3d4s(b^1D)4p$	$a^2F - v^2D^\circ$	$\frac{5}{2}-\frac{3}{2}$	P	375
		1609.043	8.74427 – 70.89300	$3d^2(a^1D)4s - 3d4s(b^1D)4p$	$a^2D - v^2F^\circ$	$\frac{5}{2}-\frac{7}{2}$	P	375
		1615.616	8.71047 – 70.60635	$3d^2(a^1D)4s - 3d4s(b^1D)4p$	$a^2D - v^2F^\circ$	$\frac{3}{2}-\frac{5}{2}$	P	375
		1618.782	9.11815 – 70.89300	$3d^3 - 3d4s(b^1D)4p$	$a^2G - v^2F^\circ$	$\frac{9}{2}-\frac{7}{2}$	P	375
		1628.148	8.99769 – 70.60635	$3d^3 - 3d4s(b^1D)4p$	$a^2G - v^2F^\circ$	$\frac{7}{2}-\frac{5}{2}$	P	375
		1642.633	8.74427 – 69.62215	$3d^2(a^1D)4s - 3d4s(b^1D)4p$	$a^2D - v^2D^\circ$	$\frac{5}{2}-\frac{5}{2}$	P	375
		1649.706	8.71047 – 69.32732	$3d^2(a^1D)4s - 3d4s(b^1D)4p$	$a^2D - v^2D^\circ$	$\frac{3}{2}-\frac{3}{2}$	P	375
		1676.552	9.97592 – 69.62215	$3d^3 - 3d4s(b^1D)4p$	$a^2P - v^2D^\circ$	$\frac{3}{2}-\frac{5}{2}$	P	375
		1681.339	9.85090 – 69.32732	$3d^3 - 3d4s(b^1D)4p$	$a^2P - v^2D^\circ$	$\frac{1}{2}-\frac{3}{2}$	P	375
		1720.139	12.75815 – 70.89300	$3d^3 - 3d4s(b^1D)4p$	$b^2D - v^2F^\circ$	$\frac{5}{2}-\frac{7}{2}$	P	375
		1724.805	12.62877 – 70.60635	$3d^3 - 3d4s(b^1D)4p$	$b^2D - v^2F^\circ$	$\frac{3}{2}-\frac{5}{2}$	P	375
		1758.582	12.75815 – 69.62215	$3d^3 - 3d4s(b^1D)4p$	$b^2D - v^2D^\circ$	$\frac{5}{2}-\frac{5}{2}$	P	375
		1763.714	12.62877 – 69.32732	$3d^3 - 3d4s(b^1D)4p$	$b^2D - v^2D^\circ$	$\frac{3}{2}-\frac{3}{2}$	P	375
		1797.414	15.25753 – 70.89300	$3d^2(a^1G)4s - 3d4s(b^1D)4p$	$b^2G - v^2F^\circ$	$\frac{9}{2}-\frac{7}{2}$	P	375
		1806.987	15.26560 – 70.60635	$3d^2(a^1G)4s - 3d4s(b^1D)4p$	$b^2G - v^2F^\circ$	$\frac{7}{2}-\frac{5}{2}$	P	375
		1828.382	4.62861 – 59.32179	$3d^2(a^3F)4s - 3d(^2D)4s4p(^3P^\circ)$	$a^2F - w^2F^\circ$	$\frac{5}{2}-\frac{5}{2}$	P	375
		1832.502	4.89760 – 59.46781	$3d^2(a^3F)4s - 3d(^2D)4s4p(^3P^\circ)$	$a^2F - w^2F^\circ$	$\frac{7}{2}-\frac{7}{2}$	P	375
		1903.416	0.09394 – 52.63107	$3d^2(a^3F)4s - 3d(^2D)4s4p(^3P^\circ)$	$ga^4F - {}^4F^\circ$	$\frac{5}{2}-\frac{7}{2}$	P	375
		1905.797	0.0 – 52.47148	$3d^2(a^3F)4s - 3d(^2D)4s4p(^3P^\circ)$	$ga^4F - {}^4F^\circ$	$\frac{3}{2}-\frac{5}{2}$	P	375
	300	1906.251	0.0 – 52.45898	$3d^2(a^3F)4s - 3d(^2D)4s4p(^3P^\circ)$	$ga^4F - {}^4F^\circ$	$\frac{3}{2}-\frac{3}{2}$	P	488,601
	300	1908.193	0.22547 – 52.63107	$3d^2(a^3F)4s - 3d(^2D)4s4p(^3P^\circ)$	$ga^4F - {}^4F^\circ$	$\frac{7}{2}-\frac{7}{2}$	P	488,601
	200	1909.215	0.09394 – 52.47148	$3d^2(a^3F)4s - 3d(^2D)4s4p(^3P^\circ)$	$ga^4F - {}^4F^\circ$	$\frac{5}{2}-\frac{5}{2}$	P	488
	200	1909.671	0.09394 – 52.45898	$3d^2(a^3F)4s - 3d(^2D)4s4p(^3P^\circ)$	$ga^4F - {}^4F^\circ$	$\frac{5}{2}-\frac{3}{2}$	P	488
	50	1911.958	0.0 – 52.32978	$3d^2(a^3F)4s -$	$ga^4F - x^4D^\circ$	$\frac{3}{2}-\frac{5}{2}$	P	488
	25	1914.022	0.22547 – 52.47148	$3d^2(a^3F)4s - 3d(^2D)4s4p(^3P^\circ)$	$ga^4F - {}^4F^\circ$	$\frac{7}{2}-\frac{5}{2}$	P	488
		1914.321	0.39322 – 52.63107	$3d^2(a^3F)4s - 3d(^2D)4s4p(^3P^\circ)$	$ga^4F - {}^4F^\circ$	$\frac{9}{2}-\frac{7}{2}$	P	488

TITANIUM III (Ti^{2+}), Z = 22
Ground State $1s^22s^22p^63s^23p^63d^2(^3F_2)$ (20 electrons)
Ionization Potential 221 735.6 cm^{-1}; 27.4919 eV

Multiplet	Rel. Int.	λ_{vac} (in Å)	Levels (in 10^3 cm^{-1})	Configurations	Terms	J - J	Notes	References
	3	629.572	.1849 – 159.02293	$3d^2$ – 3d4f	g^3F - $^3H°$	3 – 4		227
	3	629.957	0.000 – 158.74092	$3d^2$ – 3d4f	g^3F - $^3G°$	2 – 3		227
	3	630.086	.4204 – 159.12894	$3d^2$ – 3d4f	g^3F - $^3H°$	4 – 5		227
	1	630.199	.1849 – 158.86503	$3d^2$ – 3d4f	g^3F - $^3G°$	3 – 4		227
	3	630.685	0.000 – 158.55776	$3d^2$ – 3d4f	g^3F - $^3F°$	2 – 3		227
	3	630.692	.1849 – 158.74092	$3d^2$ – 3d4f	g^3F - $^3G°$	3 – 3		227
	1	630.769	0.000 – 158.53663	$3d^2$ – 3d4f	g^3F - $^3F°$	2 – 2		227
	3	630.891	.1849 – 158.69085	$3d^2$ – 3d4f	g^3F - $^3F°$	3 – 4		227
	7	630.982	.4204 – 158.90355	$3d^2$ – 3d4f	g^3F - $^3G°$	4 – 5		227
	1	631.135	.4204 – 158.86503	$3d^2$ – 3d4f	g^3F - $^3G°$	4 – 4		227
	0	631.421	.1849 – 158.55776	$3d^2$ – 3d4f	g^3F - $^3F°$	3 – 3		227
	0	631.830	.4204 – 158.69085	$3d^2$ – 3d4f	g^3F - $^3F°$	4 – 4		227
	0	632.509	.1849 – 158.28534	$3d^2$ – 3d4f	g^3F - $^1G°$	3 – 4		227
	3	663.541	8.4735 – 159.18024	$3d^2$ – 3d4f	^1D - $^1F°$	2 – 3		227
	1	663.789	8.4735 – 159.12378	$3d^2$ – 3d4f	^1D - $^1D°$	2 – 2		227
	3	669.926	10.7212 – 159.99154	$3d^2$ – 3d4f	^3P - $^3P°$	2 – 2		227
	1	671.788	10.5384 – 159.39489	$3d^2$ – 3d4f	^3P - $^3D°$	0 – 1		227
	3	672.042	10.6036 – 159.40391	$3d^2$ – 3d4f	^3P - $^3D°$	1 – 2		227
	7	672.220	10.7212 – 159.48195	$3d^2$ – 3d4f	^3P - $^3D°$	2 – 3		227
	0	675.722	.4204 – 148.41024	$3d^2$ – 3d5p	g^3F - $^3F°$	4 – 4		227
	0	675.982	10.6036 – 158.53663	$3d^2$ – 3d4f	^3P - $^3F°$	1 – 2		227
	0	675.989	0.000 – 147.93147	$3d^2$ – 3d5p	g^3F - $^3F°$	2 – 2		227
	0	676.013	.1849 – 148.11110	$3d^2$ – 3d5p	g^3F - $^3F°$	3 – 3		227
	1	677.667	.1849 – 147.74989	$3d^2$ – 3d5p	g^3F - $^3D°$	3 – 2		227
	1	677.681	0.000 – 147.56214	$3d^2$ – 3d5p	g^3F - $^3D°$	2 – 1		227
	1	677.878	.4204 – 147.93947	$3d^2$ – 3d5p	g^3F - $^3D°$	4 – 3		227
	15	686.543	14.3976 – 160.05490	$3d^2$ – 3d4f	^1G - $^1H°$	4 – 5		227
	1	694.986	14.3976 – 158.28534	$3d^2$ – 3d4f	^1G - $^1G°$	4 – 4		227
	1	739.327	14.3976 – 149.65577	$3d^2$ – 3d5p	^1G - $^1F°$	4 – 3		227
	0	865.802	41.70427 – 157.20416	3d4s – 4s4p	^1D - $^1P°$	2 – 1		227
	3	1002.384	38.19895 – 137.9612	3d4s – 4s4p	^3D - $^3P°$	2 – 2		227
	40	1004.670	38.42599 – 137.9612	3d4s – 4s4p	^3D - $^3P°$	3 – 2		227
	3	1005.798	38.06435 – 137.4878	3d4s – 4s4p	^3D - $^3P°$	1 – 1		227
	25	1007.163	38.19895 – 137.4878	3d4s – 4s4p	^3D - $^3P°$	2 – 1		227
	7	1008.119	38.06435 – 137.2589	3d4s – 4s4p	^3D - $^3P°$	1 – 0		227
	0	1077.234	77.42445 – 170.25475	3d4p – 3d6s	$^3D°$ - ^3D	3 – 3		227
	0	1081.225	77.42445 – 169.91211	3d4p – 3d5d	$^3D°$ - ^3F	3 – 4		227
	1	1082.899	77.42445 – 169.76913	3d4p – 3d5d	$^3D°$ - ^3F	3 – 3		227
	0	1104.233	77.74644 – 168.30706	3d4p – 3d5d	$^3F°$ - ^3G	3 – 4		227
	1	1106.661	78.15861 – 168.52052	3d4p – 3d5d	$^3F°$ - ^3G	4 – 5		227
	1	1136.041	83.11693 – 171.14193	3d4p – 3d5d	$^1F°$ - ^1G	3 – 4		227
	7	1235.495	0.000 – 80.93919	$3d^2$ – 3d4p	g^3F - $^3P°$	2 – 1		227
	0	1237.018	.1849 – 81.02447	$3d^2$ – 3d4p	g^3F - $^3P°$	3 – 2		227
2	60	1282.484	.1849 – 78.15861	$3d^2$ – 3d4p	g^3F - $^3F°$	3 – 4		227
2	60	1286.233	0.000 – 77.74644	$3d^2$ – 3d4p	g^3F - $^3F°$	2 – 3		227
2	360	1286.369	.4204 – 78.15861	$3d^2$ – 3d4p	g^3F - $^3F°$	4 – 4		227
2	160	1289.299	.1849 – 77.74644	$3d^2$ – 3d4p	g^3F - $^3F°$	3 – 3		227
1		1291.581	0.000 – 77.42445	$3d^2$ – 3d4p	g^3F - $^3D°$	2 – 3		227
2	160	1291.624	0.000 – 77.42186	$3d^2$ – 3d4p	g^3F - $^3F°$	2 – 2		227
2	160	1293.226	.4204 – 77.74644	$3d^2$ – 3d4p	g^3F - $^3F°$	4 – 3		227
1	200	1294.673	.1849 – 77.42445	$3d^2$ – 3d4p	g^3F - $^3D°$	3 – 3		227
2	160	1294.716	.1849 – 77.42186	$3d^2$ – 3d4p	g^3F - $^3F°$	3 – 2		227
1	160	1295.884	0.000 – 77.16743	$3d^2$ – 3d4p	g^3F - $^3D°$	2 – 2		227
1	700	1298.634	.4204 – 77.42445	$3d^2$ – 3d4p	g^3F - $^3D°$	4 – 3		227

Ti III — Continued

Multiplet	Rel. Int.	λ_{vac} (in Å)	Levels (in 10^3 cm^{-1})	Configurations	Terms	J - J	Notes	References
1	300	1298.698	0.000 – 77.00023	3d^2 – 3d4p	g^{3}F – ^{3}D°	2 – 1		227
1	640	1298.997	.1849 – 77.16743	3d^2 – 3d4p	g^{3}F – ^{3}D°	3 – 2		227
4	230	1327.609	8.4735 – 83.79686	3d^2 – 3d4p	^{1}D – ^{1}P°	2 – 1		227
	25	1329.819	0.000 – 75.19821	3d^2 – 3d4p	g^{3}F – ^{1}D°	2 – 2		227
	40	1339.703	8.4735 – 83.11693	3d^2 – 3d4p	^{1}D – ^{1}F°	2 – 3		227
	0	1365.029	10.5384 – 83.79686	3d^2 – 3d4p	^{3}P – ^{1}P°	0 – 1		227
	7	1368.444	10.7212 – 83.79686	3d^2 – 3d4p	^{3}P – ^{1}P°	2 – 1		227
	7	1379.963	8.4735 – 80.93919	3d^2 – 3d4p	^{1}D – ^{3}P°	2 – 1		227
	160	1420.033	10.6036 – 81.02447	3d^2 – 3d4p	^{3}P – ^{3}P°	1 – 2		227
	160	1420.438	10.5384 – 80.93919	3d^2 – 3d4p	^{3}P – ^{3}P°	0 – 1		227
	160	1421.640	10.6036 – 80.94487	3d^2 – 3d4p	^{3}P – ^{3}P°	1 – 0		227
	160	1421.755	10.6036 – 80.93919	3d^2 – 3d4p	^{3}P – ^{3}P°	1 – 1		227
	230	1422.408	10.7212 – 81.02447	3d^2 – 3d4p	^{3}P – ^{3}P°	2 – 2		227
	160	1424.136	10.7212 – 80.93919	3d^2 – 3d4p	^{3}P – ^{3}P°	2 – 1		227
	40	1433.85						604
		1450.305	8.4735 – 77.42445	3d^2 – 3d4p	^{1}D – ^{3}D°	2 – 3		227
	15	1450.360	8.4735 – 77.42186	3d^2 – 3d4p	^{1}D – ^{3}F°	2 – 2		227
5	850	1455.195	14.3976 – 83.11693	3d^2 – 3d4p	^{1}G – ^{1}F°	4 – 3		227
	3	1455.733	8.4735 – 77.16743	3d^2 – 3d4p	^{1}D – ^{3}D°	2 – 2		227
	15	1491.976	10.7212 – 77.74644	3d^2 – 3d4p	^{3}P – ^{3}F°	2 – 3		227
	20	1495.08						604
	7	1496.596	10.6036 – 77.42186	3d^2 – 3d4p	^{3}P – ^{3}F°	1 – 2		227
3	160	1498.695	8.4735 – 75.19821	3d^2 – 3d4p	^{1}D – ^{1}D°	2 – 2		227
	80	1499.176	10.7212 – 77.42445	3d^2 – 3d4p	^{3}P – ^{3}D°	2 – 3		227
	25	1502.318	10.6036 – 77.16743	3d^2 – 3d4p	^{3}P – ^{3}D°	1 – 2		227
	15	1504.624	10.5384 – 77.00023	3d^2 – 3d4p	^{3}P – ^{3}D°	0 – 1		227
	7	1504.977	10.7212 – 77.16743	3d^2 – 3d4p	^{3}P – ^{3}D°	2 – 2		227
	15	1506.101	10.6036 – 77.00023	3d^2 – 3d4p	^{3}P – ^{3}D°	1 – 1		227
	1	1652.256	75.19821 – 135.72151	3d4p – 3d4d	^{1}D° – ^{3}P	2 – 2		227
	25	1660.935	75.19821 – 135.40527	3d4p – 3d4d	^{1}D° – ^{1}D	2 – 2		227
	1	1684.647	75.19821 – 134.55784	3d4p – 3d5s	^{1}D° – ^{1}D	2 – 2		227
	0	1689.501	102.66515 – 161.85424	4s^2 – 3d4f	^{1}S – ^{1}P°	0 – 1		227
	1	1711.331	77.16743 – 135.60147	3d4p – 3d4d	^{3}D° – ^{3}P	2 – 1		227
	3	1715.352	77.42445 – 135.72151	3d4p – 3d4d	^{3}D° – ^{3}P	3 – 2		227
	1	1757.523	77.00023 – 133.89850	3d4p – 3d5s	^{3}D° – ^{3}D	1 – 1		227
	15	1758.994	77.42445 – 134.27512	3d4p – 3d5s	^{3}D° – ^{3}D	3 – 3		227
	3	1759.561	77.16743 – 133.99979	3d4p – 3d5s	^{3}D° – ^{3}D	2 – 2		227
	7	1770.644	77.42186 – 133.89850	3d4p – 3d5s	^{3}F° – ^{3}D	2 – 1		227
	15	1777.672	77.74644 – 133.99979	3d4p – 3d5s	^{3}F° – ^{3}D	3 – 2		227
	3	1778.651	83.79686 – 140.01924	3d4p – 3d4d	^{1}P° – ^{1}S	1 – 0		227
	15	1782.007	78.15861 – 134.27512	3d4p – 3d5s	^{3}F° – ^{3}D	4 – 3		227
	25	1783.644	77.00023 – 133.06524	3d4p – 3d4d	^{3}D° – ^{3}F	1 – 2		227
	25	1784.450	77.16743 – 133.20710	3d4p – 3d4d	^{3}D° – ^{3}F	2 – 3		227
	40	1787.418	77.42445 – 133.37107	3d4p – 3d4d	^{3}D° – ^{3}F	3 – 4		227
	7	1788.979	77.16743 – 133.06524	3d4p – 3d4d	^{3}D° – ^{3}F	2 – 2		227
	3	1792.589	77.42186 – 133.20710	3d4p – 3d4d	^{3}F° – ^{3}F	2 – 3		227
	3	1792.672	77.42445 – 133.20710	3d4p – 3d4d	^{3}D° – ^{3}F	3 – 3		227
	3	1797.159	77.42186 – 133.06524	3d4p – 3d4d	^{3}F° – ^{3}F	2 – 2		227
	7	1797.765	77.74644 – 133.37107	3d4p – 3d4d	^{3}F° – ^{3}F	3 – 4		227
	3	1803.080	77.74644 – 133.20710	3d4p – 3d4d	^{3}F° – ^{3}F	3 – 3		227
	40	1811.185	78.15861 – 133.37107	3d4p – 3d4d	^{3}F° – ^{3}F	4 – 4		227
	1	1825.406	80.93919 – 135.72151	3d4p – 3d4d	^{3}P° – ^{3}P	1 – 2		227
	15	1828.252	81.02447 – 135.72151	3d4p – 3d4d	^{3}P° – ^{3}P	2 – 2		227
	1	1829.415	80.93919 – 135.60147	3d4p – 3d4d	^{3}P° – ^{3}P	1 – 1		227

Ti III — Continued

Multiplet	Rel. Int.	λ_{vac} (in Å)	Levels (in 10^3 cm^{-1})	Configurations	Terms	J - J	Notes	References
	1	1829.605	80.94487 – 135.60147	3d4p – 3d4d	$^3P^\circ - {}^3P$	0 – 1		227
	1	1831.426	80.93919 – 135.54146	3d4p – 3d4d	$^3P^\circ - {}^3P$	1 – 0		227
	3	1832.274	81.02447 – 135.60147	3d4p – 3d4d	$^3P^\circ - {}^3P$	2 – 1		227
	1	1833.550	102.66515 – 157.20416	$4s^2$ – 4s4p	$^1S - {}^1P^\circ$	0 – 1		227
	3	1849.961	75.19821 – 129.25341	3d4p – 3d4d	$^1D^\circ - {}^1P$	2 – 1		227
	3	1877.911	81.02447 – 134.27512	3d4p – 3d5s	$^3P^\circ - {}^3D$	2 – 3		227
	80	1878.894	83.11693 – 136.33974	3d4p – 3d4d	$^1F^\circ - {}^1G$	3 – 4		227
	1	1884.638	80.93919 – 133.99979	3d4p – 3d5s	$^3P^\circ - {}^3D$	1 – 2		227
	10	1897.27						604
	80	1901.417	75.19821 – 127.79057	3d4p – 3d4d	$^1D^\circ - {}^1F$	2 – 3		227
	3	1925.823	77.16743 – 129.09328	3d4p – 3d4d	$^3D^\circ - {}^3G$	2 – 3		227
	7	1929.448	77.42445 – 129.25274	3d4p – 3d4d	$^3D^\circ - {}^3G$	3 – 4		227
	80	1935.306	77.42186 – 129.09328	3d4p – 3d4d	$^3F^\circ - {}^3G$	2 – 3		227
	3	1940.009	77.00023 – 128.54638	3d4p – 3d4d	$^3D^\circ - {}^3D$	1 – 2		227
	3	1940.909	77.16743 – 128.68967	3d4p – 3d4d	$^3D^\circ - {}^3D$	2 – 3		227
	80	1941.510	77.74644 – 129.25274	3d4p – 3d4d	$^3F^\circ - {}^3G$	3 – 4		227
	7	1943.978	83.11693 – 134.55784	3d4p – 3d5s	$^1F^\circ - {}^1D$	3 – 2		227
	7	1944.271	77.00023 – 128.43340	3d4p – 3d4d	$^3D^\circ - {}^3D$	1 – 1		227
	15	1946.322	77.16743 – 128.54638	3d4p – 3d4d	$^3D^\circ - {}^3D$	2 – 2		227
	1	1947.540	77.74644 – 129.09328	3d4p – 3d4d	$^3F^\circ - {}^3G$	3 – 3		227
	40	1948.508	32.4755 – 83.79686	$3d^2$ – 3d4p	$^1S - {}^1P^\circ$	0 – 1		227
	100	1948.909	78.15861 – 129.46937	3d4p – 3d4d	$^3F^\circ - {}^3G$	4 – 5		227
		1950.612	77.16743 – 128.43340	3d4p – 3d4d	$^3D^\circ - {}^3D$	2 – 1		227
	40	1950.640	77.42445 – 128.68967	3d4p – 3d4d	$^3D^\circ - {}^3D$	3 – 3		227
	3	1956.009	77.42186 – 128.54638	3d4p – 3d4d	$^3F^\circ - {}^3D$	2 – 2		227
	3	1956.108	77.42445 – 128.54638	3d4p – 3d4d	$^3D^\circ - {}^3D$	3 – 2		227
	3	1957.172	78.15861 – 129.25274	3d4p – 3d4d	$^3F^\circ - {}^3G$	4 – 4		227
	7	1962.969	77.74644 – 128.68967	3d4p – 3d4d	$^3F^\circ - {}^3D$	3 – 3		227
	1	1965.298	83.11693 – 133.99979	3d4p – 3d5s	$^1F^\circ - {}^3D$	3 – 2		227
	25	1970.017	83.79686 – 134.55784	3d4p – 3d5s	$^1P^\circ - {}^1D$	1 – 2		227
	1	1978.981	78.15861 – 128.68967	3d4p – 3d4d	$^3F^\circ - {}^3D$	4 – 3		227

TITANIUM IV (Ti^{3+}), Z = 22
Ground State $1s^22s^22p^63s^23p^63d(^2D_{3/2})$ (19 electrons)
Ionization Potential 348 973.3 cm^{-1}; 43.2675 eV

Multiplet	Rel. Int.	λ_{vac} (in Å)	Levels (in 10^3 cm^{-1})	Configurations	Terms	J - J	Notes	References
	1	362.520	0.0 – 275.84701	$3p^63d - 3p^65f$	$^2D - {}^2F^\circ$	$\frac{3}{2} - \frac{5}{2}$		714
	1	363.003	0.3821 – 275.86194	$3p^63d - 3p^65f$	$^2D - {}^2F^\circ$	$\frac{5}{2} - \frac{7}{2}$		714
		363.023	0.3821 – 275.84701	$3p^63d - 3p^65f$	$^2D - {}^2F^\circ$	$\frac{5}{2} - \frac{5}{2}$	P	721
		363.794	0.0 – 274.88121	$3p^63d - 3p^66p$	$^2D - {}^2P^\circ$	$\frac{3}{2} - \frac{3}{2}$	P	721
		363.848	0.0 – 274.83982	$3p^63d - 3p^53d^2$	$^2D - {}^2F^\circ$	$\frac{3}{2} - \frac{5}{2}$	P	721
		363.999	0.0 – 274.72629	$3p^63d' - 3p^66p$	$^2D - {}^2P^\circ$	$\frac{3}{2} - \frac{1}{2}$	P	721
		364.300	0.3821 – 274.88121	$3p^63d - 3p^66p$	$^2D - {}^2P^\circ$	$\frac{5}{2} - \frac{3}{2}$	P	721
		364.355	0.3821 – 274.83982	$3p^63d - 3p^53d^2$	$^2D - {}^2F^\circ$	$\frac{5}{2} - \frac{5}{2}$	P	721
	6	423.487	0.0 – 236.13529	$3p^63d - 3p^64f$	$^2D - {}^2F^\circ$	$\frac{3}{2} - \frac{5}{2}$		714
	6	424.160	0.3821 – 236.14230	$3p^63d - 3p^64f$	$^2D - {}^2F^\circ$	$\frac{5}{2} - \frac{7}{2}$		714
		424.172	0.3821 – 236.13529	$3p^63d - 3p^64f$	$^2D - {}^2F^\circ$	$\frac{5}{2} - \frac{5}{2}$	P	721
		433.042	0.0 – 230.92438	$3p^63d - 3p^65p$	$^2D - {}^2P^\circ$	$\frac{3}{2} - \frac{3}{2}$	P	721

Ti IV — Continued

Multiplet	Rel. Int.	λ_{vac} (in Å)	Levels (in 10^3 cm^{-1})	Configurations	Terms	J - J	Notes	References
		433.635	0.0 – 230.60889	$3p^63d - 3p^65p$	$^2D - ^2P^\circ$	$\frac{3}{2}-\frac{1}{2}$	P	721
		433.760	0.3821 – 230.92438	$3p^63d - 3p^65p$	$^2D - ^2P^\circ$	$\frac{5}{2}-\frac{3}{2}$	P	721
		664.295	80.38893 – 230.92438	$3p^64s - 3p^65p$	$^2S - ^2P^\circ$	$\frac{1}{2}-\frac{3}{2}$	P	721
		665.690	80.38893 – 230.60889	$3p^64s - 3p^65p$	$^2S - ^2P^\circ$	$\frac{1}{2}-\frac{1}{2}$	P	721
	1	725.026	127.92136 – 265.84742	$3p^64p - 3p^66s$	$^2P^\circ - ^2S$	$\frac{1}{2}-\frac{1}{2}$	P	721
	4	729.353	128.73959 – 265.84742	$3p^64p - 3p^66s$	$^2P^\circ - ^2S$	$\frac{3}{2}-\frac{1}{2}$	P	721
		763.842	127.92136 – 258.83848	$3p^64p - 3p^65d$	$^2P^\circ - ^2D$	$\frac{1}{2}-\frac{3}{2}$	P	721
		768.418	128.73959 – 258.87708	$3p^64p - 3p^65d$	$^2P^\circ - ^2D$	$\frac{3}{2}-\frac{5}{2}$	P	721
		768.646	128.73959 – 258.83848	$3p^64p - 3p^65d$	$^2P^\circ - ^2D$	$\frac{3}{2}-\frac{3}{2}$	P	721
1	250	776.762	0.0 – 128.73959	$3p^63d - 3p^64p$	$^2D - ^2P^\circ$	$\frac{3}{2}-\frac{3}{2}$		721
1	800	779.074	0.3821 – 128.73959	$3p^63d - 3p^64p$	$^2D - ^2P^\circ$	$\frac{5}{2}-\frac{3}{2}$		721
1	650	781.730	0.0 – 127.92136	$3p^63d - 3p^64p$	$^2D - ^2P^\circ$	$\frac{3}{2}-\frac{1}{2}$		721
	150	1183.635	127.92136 – 212.40704	$3p^64p - 3p^65s$	$^2P^\circ - ^2S$	$\frac{1}{2}-\frac{1}{2}$		721
	250	1195.208	128.73959 – 212.40704	$3p^64p - 3p^65s$	$^2P^\circ - ^2S$	$\frac{3}{2}-\frac{1}{2}$		721
	4	1265.138	196.80427 – 275.84701	$3p^64d - 3p^65f$	$^2D - ^2F^\circ$	$\frac{3}{2}-\frac{5}{2}$	P	721
	10	1266.272	196.88996 – 275.86194	$3p^64d - 3p^65f$	$^2D - ^2F^\circ$	$\frac{5}{2}-\frac{7}{2}$	P	721
		1280.788	196.80427 – 274.88121	$3p^64d - 3p^66p$	$^2D - ^2P^\circ$	$\frac{3}{2}-\frac{3}{2}$	P	721
	10	1282.195	196.88996 – 274.88121	$3p^64d - 3p^66p$	$^2D - ^2P^\circ$	$\frac{5}{2}-\frac{3}{2}$	P	721
	4	1283.334	196.80427 – 274.72629	$3p^64d - 3p^66p$	$^2D - ^2P^\circ$	$\frac{3}{2}-\frac{1}{2}$	P	721
3	800	1451.736	127.92136 – 196.80427	$3p^64p - 3p^64d$	$^2P^\circ - ^2D$	$\frac{1}{2}-\frac{3}{2}$		721
3	1000	1467.338	128.73959 – 196.88996	$3p^64p - 3p^64d$	$^2P^\circ - ^2D$	$\frac{3}{2}-\frac{5}{2}$		721
3	350	1469.188	128.73959 – 196.80427	$3p^64p - 3p^64d$	$^2P^\circ - ^2D$	$\frac{3}{2}-\frac{3}{2}$		721
	4	1564.685	236.13529 – 300.0459	$3p^64f - 3p^66g$	$^2F^\circ - ^2G$	$\frac{5}{2}-\frac{7}{2}$	P	721
	10	1564.850	236.14230 – 300.0462	$3p^64f - 3p^66g$	$^2F^\circ - ^2G$	$\frac{7}{2}-\frac{9}{2}$	P	721

TITANIUM V (Ti^{4+}), Z = 22
Ground State $1s^22s^22p^63s^23p^6(^1S_0)$ (18 electrons)
Ionization Potential 800 900 cm^{-1}; 99.300 eV

Multiplet	Rel. Int.	λ_{vac} (in Å)	Levels (in 10^3 cm^{-1})	Configurations	Terms	J - J	Notes	References
	0	103.059	0.000 – 970.32	$3s^23p^6 - 3s3p^611p$	$g^1S - ^1P^\circ$	0 – 1	A	440
	1	103.733	0.000 – 964.01	$3s^23p^6 - 3s3p^610p$	$g^1S - ^1P^\circ$	0 – 1	A	440
	1	103.754	0.000 – 963.82	$3s^23p^6 - 3s3p^610p$	$g^1S - ^3P^\circ$	0 – 1	A	440
	1	104.711	0.000 – 955.01	$3s^23p^6 - 3s3p^69p$	$g^1S - ^1P^\circ$	0 – 1	A	440
	0	104.732	0.000 – 954.82	$3s^23p^6 - 3s3p^69p$	$g^1S - ^3P^\circ$	0 – 1	A	440
	3	106.154	0.000 – 942.03	$3s^23p^6 - 3s3p^68p$	$g^1S - ^1P^\circ$	0 – 1	A	440
	0	106.308	0.000 – 940.66	$3s^23p^6 - 3s3p^68p$	$g^1S - ^3P^\circ$	0 – 1	A	440
	6	108.443	0.000 – 922.14	$3s^23p^6 - 3s3p^67p$	$g^1S - ^1P^\circ$	0 – 1	A	440
	0	108.611	0.000 – 920.72	$3s^23p^6 - 3s3p^67p$	$g^1S - ^3P^\circ$	0 – 1	A	440
	11	112.495	0.000 – 888.93	$3s^23p^6 - 3s3p^66p$	$g^1S - ^1P^\circ$	0 – 1	A	440
	0	112.896	0.000 – 885.77	$3s^23p^6 - 3s3p^66p$	$g^1S - ^3P^\circ$	0 – 1	A	440
	12	120.824	0.000 – 827.65	$3s^23p^6 - 3s3p^65p$	$g^1S - ^1P^\circ$	0 – 1	A	440
	2	121.138	0.000 – 825.50	$3s^23p^6 - 3s3p^65p$	$g^1S - ^3P^\circ$	0 – 1	A	440
	12	144.551	0.000 – 691.797	$3s^23p^6 - 3s3p^64p$	$g^1S - ^1P^\circ$	0 – 1		727
	6	145.354	0.000 – 687.98	$3s^23p^6 - 3s3p^64p$	$g^1S - ^3P^\circ$	0 – 1		440
	0	145.79	0.000 – 685.940	$3s^23p^6 - 3s^23p^5(^2P^\circ_{1/2})6s$	$g^1S - \frac{1}{2}[\frac{1}{2}]^\circ$	0 – 1		727
	4	146.897	0.000 – 680.748	$3s^23p^6 - 3s^23p^5(^2P^\circ_{3/2})6s$	$g^1S - \frac{3}{2}[\frac{3}{2}]^\circ$	0 – 1		727
	50	162.984	0.000 – 613.5582	$3s^23p^6 - 3s^23p^5(^2P^\circ_{1/2})5s$	$g^1S - \frac{1}{2}[\frac{1}{2}]^\circ$	0 – 1		727

Tl V — Continued

Multiplet	Rel. Int.	λ_{vac} (in Å)	Levels (in 10^3 cm^{-1})	Configurations	Terms	J - J	Notes	References
	80	164.446	0.000 – 608.1007	$3s^23p^6 - 3s^23p^5(^2P^\circ_{3/2})5s$	$g^1S - \frac{3}{2}[\frac{3}{2}]^\circ$	0 – 1		727
	450	225.347	0.000 – 443.7527	$3s^23p^6 - 3s^23p^54s$	$g^1S - {}^1P^\circ$	0 – 1		727
	300	228.909	0.000 – 436.8498	$3s^23p^6 - 3s^23p^54s$	$g^1S - {}^3P^\circ$	0 – 1		727
	1	241.240	506.2247 – 920.72	$3s3p^63d - 3s3p^67p$	${}^1D - {}^3P^\circ$	2 – 1	Q	714
	1	241.271	506.2247 – 920.72	$3s3p^63d - 3s3p^67p$	${}^1D - {}^3P^\circ$	2 – 1	Q	714
	1	246.235	514.6087 – 920.72	$3s^23p^54p - 3s3p^67p$	${}^1S - {}^3P^\circ$	0 – 1	Q	714
	3	249.589	488.2257 – 888.93	$3s^23p^54p - 3s3p^66p$	${}^3D - {}^1P^\circ$	2 – 1	Q	714
	3	249.984	488.9287 – 888.93	$3s3p^63d - 3s3p^66p$	${}^3D - {}^1P^\circ$	1 – 1	Q	714
	6	251.533	488.2257 – 885.77	$3s^23p^54p - 3s3p^66p$	${}^3D - {}^3P^\circ$	2 – 1	Q	714
	900	252.958	0.000 – 395.3209	$3s^23p^6 - 3s^23p^53d$	$g^1S - {}^1P^\circ$	0 – 1		727
	1	253.674	491.5587 – 885.77	$3s3p^63d - 3s3p^66p$	${}^3D - {}^3P^\circ$	2 – 1	Q	714
	3	256.685	499.3362 – 888.93	$3s^23p^54p - 3s3p^66p$	${}^3P - {}^1P^\circ$	1 – 1	Q	714
	6	257.155	496.8907 – 885.77	$3s^23p^54p - 3s3p^66p$	${}^1P - {}^3P^\circ$	1 – 1	Q	714
	1	261.280	506.2247 – 888.93	$3s3p^63d - 3s3p^66p$	${}^1D - {}^1P^\circ$	2 – 1	Q	714
	150	323.365	0.000 – 309.2521	$3s^23p^6 - 3s^23p^53d$	$g^1S - {}^3D^\circ$	0 – 1		727
	1	363.145	0.000 – 275.3719	$3s^23p^6 - 3s^23p^53d$	$g^1S - {}^3P^\circ$	0 – 1		727
	0	433.202	275.3719 – 506.2247	$3s^23p^53d - 3s3p^63d$	${}^3P^\circ - {}^1D$	1 – 2		727
	0	436.839	277.3106 – 506.2247	$3s^23p^53d - 3s3p^63d$	${}^3P^\circ - {}^1D$	2 – 2		727
	12	444.643	274.4397 – 499.3362	$3s^23p^53d - 3s^23p^54p$	${}^3P^\circ - {}^3P$	0 – 1		727
	4	446.493	275.3719 – 499.3362	$3s^23p^53d - 3s^23p^54p$	${}^3P^\circ - {}^3P$	1 – 1		727
	30	448.822	275.3719 – 498.1764	$3s^23p^53d - 3s^23p^54p$	${}^3P^\circ - {}^3P$	1 – 0		727
	30	449.063	275.3719 – 498.0572	$3s^23p^53d - 3s^23p^54p$	${}^3P^\circ - {}^3P$	1 – 2		727
	2	449.541	274.4397 – 496.8907	$3s^23p^53d - 3s^23p^54p$	${}^3P^\circ - {}^1P$	0 – 1		727
	50	450.397	277.3106 – 499.3362	$3s^23p^53d - 3s^23p^54p$	${}^3P^\circ - {}^3P$	2 – 1		727
	0	451.429	275.3719 – 496.8907	$3s^23p^53d - 3s^23p^54p$	${}^3P^\circ - {}^1P$	1 – 1		727
	80	453.006	277.3106 – 498.0572	$3s^23p^53d - 3s^23p^54p$	${}^3P^\circ - {}^3P$	2 – 2		727
	4	455.419	277.3106 – 496.8907	$3s^23p^53d - 3s^23p^54p$	${}^3P^\circ - {}^1P$	2 – 1		727
	4	457.321	275.3719 – 494.0357	$3s^23p^53d - 3s^23p^54p$	${}^3P^\circ - {}^1D$	1 – 2		727
	12	458.861	275.3719 – 493.3005	$3s^23p^53d - 3s^23p^54p$	${}^3P^\circ - {}^3D$	1 – 1		727
	150	461.414	277.3106 – 494.0357	$3s^23p^53d - 3s^23p^54p$	${}^3P^\circ - {}^1D$	2 – 2		727
	30	462.565	275.3719 – 491.5587	$3s^23p^53d - 3s3p^63d$	${}^3P^\circ - {}^3D$	1 – 2		727
	30	462.982	277.3106 – 493.3005	$3s^23p^53d - 3s^23p^54p$	${}^3P^\circ - {}^3D$	2 – 1		727
	0	464.143	290.7787 – 506.2247	$3s^23p^53d - 3s3p^63d$	${}^3F^\circ - {}^1D$	2 – 2		727
	80	464.562	277.3106 – 492.5671	$3s^23p^53d - 3s3p^63d$	${}^3P^\circ - {}^3D$	2 – 3		727
	50	466.224	274.4397 – 488.9287	$3s^23p^53d - 3s3p^63d$	${}^3P^\circ - {}^3D$	0 – 1		727
	4	466.749	277.3106 – 491.5587	$3s^23p^53d - 3s3p^63d$	${}^3P^\circ - {}^3D$	2 – 2		727
	30	468.257	275.3719 – 488.9287	$3s^23p^53d - 3s3p^63d$	${}^3P^\circ - {}^3D$	1 – 1		727
	110	469.808	275.3719 – 488.2257	$3s^23p^53d - 3s^23p^54p$	${}^3P^\circ - {}^3D$	1 – 2		727
	12	474.124	277.3106 – 488.2257	$3s^23p^53d - 3s^23p^54p$	${}^3P^\circ - {}^3D$	2 – 2		727
	200	474.690	277.3106 – 487.9746	$3s^23p^53d - 3s^23p^54p$	${}^3P^\circ - {}^3D$	2 – 3		727
	30	478.455	289.0502 – 498.0572	$3s^23p^53d - 3s^23p^54p$	${}^3F^\circ - {}^3P$	3 – 2		727
	0	479.497	290.7787 – 499.3362	$3s^23p^53d - 3s^23p^54p$	${}^3F^\circ - {}^3P$	2 – 1		727
	80	481.818	274.4397 – 481.9877	$3s^23p^53d - 3s^23p^54p$	${}^3P^\circ - {}^3S$	0 – 1		727
	0	482.447	290.7787 – 498.0572	$3s^23p^53d - 3s^23p^54p$	${}^3F^\circ - {}^3P$	2 – 2		727
	200	483.992	275.3719 – 481.9877	$3s^23p^53d - 3s^23p^54p$	${}^3P^\circ - {}^3S$	1 – 1		727
	30	485.175	290.7787 – 496.8907	$3s^23p^53d - 3s^23p^54p$	${}^3F^\circ - {}^1P$	2 – 1		727
	50	487.115	287.2765 – 492.5671	$3s^23p^53d - 3s3p^63d$	${}^3F^\circ - {}^3D$	4 – 3		727
	50	487.845	289.0502 – 494.0357	$3s^23p^53d - 3s^23p^54p$	${}^3F^\circ - {}^1D$	3 – 2		727
	300	488.582	277.3106 – 481.9877	$3s^23p^53d - 3s^23p^54p$	${}^3P^\circ - {}^3S$	2 – 1		727
	4	491.358	289.0502 – 492.5671	$3s^23p^53d - 3s3p^63d$	${}^3F^\circ - {}^3D$	3 – 3		727
	1	491.981	290.7787 – 494.0357	$3s^23p^53d - 3s^23p^54p$	${}^3F^\circ - {}^1D$	2 – 2		727
	110	493.783	289.0502 – 491.5587	$3s^23p^53d - 3s3p^63d$	${}^3F^\circ - {}^3D$	3 – 2		727
	1	498.050	290.7787 – 491.5587	$3s^23p^53d - 3s3p^63d$	${}^3F^\circ - {}^3D$	2 – 2		727
	700	498.260	287.2765 – 487.9746	$3s^23p^53d - 3s^23p^54p$	${}^3F^\circ - {}^3D$	4 – 3		727

Ti V — Continued

Multiplet	Rel. Int.	λ_{vac} (in Å)	Levels (in 10^3 cm^{-1})	Configurations	Terms	J - J	Notes	References
	12	501.631	306.8745 – 506.2247	$3s^23p^53d - 3s3p^63d$	$^1D^o - {}^1D$	2 – 2		727
	600	502.077	289.0502 – 488.2257	$3s^23p^53d - 3s^23p^54p$	$^3F^o - {}^3D$	3 – 2		727
	150	502.711	289.0502 – 487.9746	$3s^23p^53d - 3s^23p^54p$	$^3F^o - {}^3D$	3 – 3		727
	30	503.031	307.4292 – 506.2247	$3s^23p^53d - 3s3p^63d$	$^3D^o - {}^1D$	3 – 2		727
	450	504.665	290.7787 – 488.9287	$3s^23p^53d - 3s3p^63d$	$^3F^o - {}^3D$	2 – 1		727
	150	506.468	290.7787 – 488.2257	$3s^23p^53d - 3s^23p^54p$	$^3F^o - {}^3D$	2 – 2		727
	110	507.683	309.2521 – 506.2247	$3s^23p^53d - 3s3p^63d$	$^3D^o - {}^1D$	1 – 2		727
	200	513.374	311.4338 – 506.2247	$3s^23p^53d - 3s3p^63d$	$^1F^o - {}^1D$	3 – 2		727
	4	519.575	306.8745 – 499.3362	$3s^23p^53d - 3s^23p^54p$	$^1D^o - {}^3P$	2 – 1		727
	150	523.050	306.8745 – 498.0572	$3s^23p^53d - 3s^23p^54p$	$^1D^o - {}^3P$	2 – 2		727
	450	524.578	307.4292 – 498.0572	$3s^23p^53d - 3s^23p^54p$	$^3D^o - {}^3P$	3 – 2		727
	110	526.076	309.2521 – 499.3362	$3s^23p^53d - 3s^23p^54p$	$^3D^o - {}^3P$	1 – 1		727
	110	526.266	306.8745 – 496.8907	$3s^23p^53d - 3s^23p^54p$	$^1D^o - {}^1P$	2 – 1		727
	520	526.570	309.4331 – 499.3362	$3s^23p^53d - 3s^23p^54p$	$^3D^o - {}^3P$	2 – 1		727
	200	529.315	309.2521 – 498.1764	$3s^23p^53d - 3s^23p^54p$	$^3D^o - {}^3P$	1 – 0		727
	2	529.635	309.2521 – 498.0572	$3s^23p^53d - 3s^23p^54p$	$^3D^o - {}^3P$	1 – 2		727
	4	530.167	309.4331 – 498.0572	$3s^23p^53d - 3s^23p^54p$	$^3D^o - {}^3P$	2 – 2		727
	1	532.935	309.2521 – 496.8907	$3s^23p^53d - 3s^23p^54p$	$^3D^o - {}^1P$	1 – 1		727
	4	533.457	309.4331 – 496.8907	$3s^23p^53d - 3s^23p^54p$	$^3D^o - {}^1P$	2 – 1		727
	1	534.297	306.8745 – 494.0357	$3s^23p^53d - 3s^23p^54p$	$^1D^o - {}^1D$	2 – 2		727
	300	535.836	311.4338 – 498.0572	$3s^23p^53d - 3s^23p^54p$	$^1F^o - {}^3P$	3 – 2		727
	300	535.888	307.4292 – 494.0357	$3s^23p^53d - 3s^23p^54p$	$^3D^o - {}^1D$	3 – 2		727
	50	536.406	306.8745 – 493.3005	$3s^23p^53d - 3s^23p^54p$	$^1D^o - {}^3D$	2 – 1		727
	1	538.511	306.8745 – 492.5671	$3s^23p^53d - 3s3p^63d$	$^1D^o - {}^3D$	2 – 3		727
	200	540.145	307.4292 – 492.5671	$3s^23p^53d - 3s3p^63d$	$^3D^o - {}^3D$	3 – 3		727
	30	541.181	309.2521 – 494.0357	$3s^23p^53d - 3s^23p^54p$	$^3D^o - {}^1D$	1 – 2		727
	200	541.459	306.8745 – 491.5587	$3s^23p^53d - 3s3p^63d$	$^1D^o - {}^3D$	2 – 2		727
	250	541.711	309.4331 – 494.0357	$3s^23p^53d - 3s^23p^54p$	$^3D^o - {}^1D$	2 – 2		727
	150	543.103	307.4292 – 491.5587	$3s^23p^53d - 3s3p^63d$	$^3D^o - {}^3D$	3 – 2		727
	150	543.339	309.2521 – 493.3005	$3s^23p^53d - 3s^23p^54p$	$^3D^o - {}^3D$	1 – 1		727
	1	543.858	309.4331 – 493.3005	$3s^23p^53d - 3s^23p^54p$	$^3D^o - {}^3D$	2 – 1		727
	80	546.062	309.4331 – 492.5671	$3s^23p^53d - 3s3p^63d$	$^3D^o - {}^3D$	2 – 3		727
	30	547.642	311.4338 – 494.0357	$3s^23p^53d - 3s^23p^54p$	$^1F^o - {}^1D$	3 – 2		727
	50	548.533	309.2521 – 491.5587	$3s^23p^53d - 3s3p^63d$	$^3D^o - {}^3D$	1 – 2		727
	110	549.083	309.4331 – 491.5587	$3s^23p^53d - 3s3p^63d$	$^3D^o - {}^3D$	2 – 2		727
	4	551.410	306.8745 – 488.2257	$3s^23p^53d - 3s^23p^54p$	$^1D^o - {}^3D$	2 – 2		727
	0	552.079	311.4338 – 492.5671	$3s^23p^53d - 3s3p^63d$	$^1F^o - {}^3D$	3 – 3		727
	0	552.185	306.8745 – 487.9746	$3s^23p^53d - 3s^23p^54p$	$^1D^o - {}^3D$	2 – 3		727
	4	553.122	307.4292 – 488.2257	$3s^23p^53d - 3s^23p^54p$	$^3D^o - {}^3D$	3 – 2		727
	0	553.857	307.4292 – 487.9746	$3s^23p^53d - 3s^23p^54p$	$^3D^o - {}^3D$	3 – 3		727
	80	555.164	311.4338 – 491.5587	$3s^23p^53d - 3s3p^63d$	$^1F^o - {}^3D$	3 – 2		727
	1	556.562	309.2521 – 488.9287	$3s^23p^53d - 3s3p^63d$	$^3D^o - {}^3D$	1 – 1		727
	0	557.115	309.4331 – 488.9287	$3s^23p^53d - 3s3p^63d$	$^3D^o - {}^3D$	2 – 1		727
	0	559.323	309.4331 – 488.2257	$3s^23p^53d - 3s^23p^54p$	$^3D^o - {}^3D$	2 – 2		727
	1	560.056	309.4331 – 487.9746	$3s^23p^53d - 3s^23p^54p$	$^3D^o - {}^3D$	2 – 3	Q	727
	30	565.627	311.4338 – 488.2257	$3s^23p^53d - 3s^23p^54p$	$^1F^o - {}^3D$	3 – 2		727
	0	566.461	311.4338 – 487.9746	$3s^23p^53d - 3s^23p^54p$	$^1F^o - {}^3D$	3 – 3		727
	12	571.095	306.8745 – 481.9877	$3s^23p^53d - 3s^23p^54p$	$^1D^o - {}^3S$	2 – 1	Q	727
	0	578.905	309.2521 – 481.9877	$3s^23p^53d - 3s^23p^54p$	$^3D^o - {}^3S$	1 – 1		727
	1	579.518	309.4331 – 481.9877	$3s^23p^53d - 3s^23p^54p$	$^3D^o - {}^3S$	2 – 1		727
	0	792.948	481.9877 – 608.1007	$3s^23p^54p - 3s^23p^5(^2P^o_{3/2})5s$	$^3S - \frac{3}{2}[\frac{3}{2}]^o$	1 – 1		727
	4	799.714	481.9877 – 607.0330	$3s^23p^54p - 3s^23p^5(^2P^o_{3/2})5s$	$^3S - \frac{3}{2}[\frac{3}{2}]^o$	1 – 2		727
	0	807.347	488.9287 – 612.7932	$3s3p^63d - 3s^23p^5(^2P^o_{1/2})5s$	$^3D - \frac{1}{2}[\frac{1}{2}]^o$	1 – 0		727
	4	834.199	488.2257 – 608.1007	$3s^23p^54p - 3s^23p^5(^2P^o_{3/2})5s$	$^3D - \frac{3}{2}[\frac{3}{2}]^o$	2 – 1		727

Tl V — Continued

Multiplet	Rel. Int.	λ_{vac} (in Å)	Levels (in 10^3 cm^{-1})	Configurations	Terms	J - J	Notes	References
	0	836.656	494.0357 – 613.5582	$3s^23p^54p - 3s^23p^5(^2P^\circ_{1/2})5s$	$^1D - \frac{1}{2}[\frac{1}{2}]^\circ$	2 – 1		727
	30	838.315	395.3209 – 514.6087	$3s^23p^53d - 3s^23p^54p$	$^1P^\circ - ^1S$	1 – 0		727
	12	839.926	487.9746 – 607.0330	$3s^23p^54p - 3s^23p^5(^2P^\circ_{3/2})5s$	$^3D - \frac{3}{2}[\frac{3}{2}]^\circ$	3 – 2		727
	0	841.691	488.2257 – 607.0330	$3s^23p^54p - 3s^23p^5(^2P^\circ_{3/2})5s$	$^3D - \frac{3}{2}[\frac{3}{2}]^\circ$	2 – 2		727
	1	857.136	496.8907 – 613.5582	$3s^23p^54p - 3s^23p^5(^2P^\circ_{1/2})5s$	$^1P - \frac{1}{2}[\frac{1}{2}]^\circ$	1 – 1		727
	4	858.073	491.5587 – 608.1007	$3s3p^63d - 3s^23p^5(^2P^\circ_{3/2})5s$	$^3D - \frac{3}{2}[\frac{3}{2}]^\circ$	2 – 1		727
	1	862.786	496.8907 – 612.7932	$3s^23p^54p - 3s^23p^5(^2P^\circ_{1/2})5s$	$^1P - \frac{1}{2}[\frac{1}{2}]^\circ$	1 – 0		727
	4	865.806	498.0572 – 613.5582	$3s^23p^54p - 3s^23p^5(^2P^\circ_{1/2})5s$	$^3P - \frac{1}{2}[\frac{1}{2}]^\circ$	2 – 1		727
	0	866.676	498.1764 – 613.5582	$3s^23p^54p - 3s^23p^5(^2P^\circ_{1/2})5s$	$^3P - \frac{1}{2}[\frac{1}{2}]^\circ$	0 – 1		727
	4	871.085	493.3005 – 608.1007	$3s^23p^54p - 3s^23p^5(^2P^\circ_{3/2})5s$	$^3D - \frac{3}{2}[\frac{3}{2}]^\circ$	1 – 1		727
	4	873.618	492.5671 – 607.0330	$3s3p^63d - 3s^23p^5(^2P^\circ_{3/2})5s$	$^3D - \frac{3}{2}[\frac{3}{2}]^\circ$	3 – 2		727
	1	875.489	499.3362 – 613.5582	$3s^23p^54p - 3s^23p^5(^2P^\circ_{1/2})5s$	$^3P - \frac{1}{2}[\frac{1}{2}]^\circ$	1 – 1		727
	0	876.686	494.0357 – 608.1007	$3s^23p^54p - 3s^23p^5(^2P^\circ_{3/2})5s$	$^1D - \frac{3}{2}[\frac{3}{2}]^\circ$	2 – 1		727
	0	879.268	493.3005 – 607.0330	$3s^23p^54p - 3s^23p^5(^2P^\circ_{3/2})5s$	$^3D - \frac{3}{2}[\frac{3}{2}]^\circ$	1 – 2		727
	0	881.379	499.3362 – 612.7932	$3s^23p^54p - 3s^23p^5(^2P^\circ_{1/2})5s$	$^3P - \frac{1}{2}[\frac{1}{2}]^\circ$	1 – 0		727
	4	884.982	494.0357 – 607.0330	$3s^23p^54p - 3s^23p^5(^2P^\circ_{3/2})5s$	$^1D - \frac{3}{2}[\frac{3}{2}]^\circ$	2 – 2		727
	0	899.171	496.8907 – 608.1007	$3s^23p^54p - 3s^23p^5(^2P^\circ_{3/2})5s$	$^1P - \frac{3}{2}[\frac{3}{2}]^\circ$	1 – 1		727
	4	901.692	395.3209 – 506.2247	$3s^23p^53d - 3s3p^63d$	$^1P^\circ - ^1D$	1 – 2		727
	0	908.740	498.0572 – 608.1007	$3s^23p^54p - 3s^23p^5(^2P^\circ_{3/2})5s$	$^3P - \frac{3}{2}[\frac{3}{2}]^\circ$	2 – 1		727
	1	928.507	499.3362 – 607.0330	$3s^23p^54p - 3s^23p^5(^2P^\circ_{3/2})5s$	$^3P - \frac{3}{2}[\frac{3}{2}]^\circ$	1 – 2		727
	0	931.652	506.2247 – 613.5582	$3s3p^63d - 3s^23p^5(^2P^\circ_{1/2})5s$	$^1D - \frac{1}{2}[\frac{1}{2}]^\circ$	2 – 1		727
	0	961.376	395.3209 – 499.3362	$3s^23p^53d - 3s^23p^54p$	$^1P^\circ - ^3P$	1 – 1		727
	0	972.188	395.3209 – 498.1764	$3s^23p^53d - 3s^23p^54p$	$^1P^\circ - ^3P$	1 – 0	Q	727
	0	973.357	395.3209 – 498.0572	$3s^23p^53d - 3s^23p^54p$	$^1P^\circ - ^3P$	1 – 2		727
	0	981.585	506.2247 – 608.1007	$3s3p^63d - 3s^23p^5(^2P^\circ_{3/2})5s$	$^1D - \frac{3}{2}[\frac{3}{2}]^\circ$	2 – 1	P	727
	1	984.530	395.3209 – 496.8907	$3s^23p^53d - 3s^23p^54p$	$^1P^\circ - ^1P$	1 – 1		727
	1	1039.125	395.3209 – 491.5587	$3s^23p^53d - 3s3p^63d$	$^1P^\circ - ^3D$	1 – 2		727
	30	1094.583	487.9746 – 579.3346	$3s^23p^54p - 3s^23p^5(^2P^\circ_{3/2})4d$	$^3D - \frac{3}{2}[\frac{5}{2}]^\circ$	3 – 3		727
	1	1097.585	488.2257 – 579.3346	$3s^23p^54p - 3s^23p^5(^2P^\circ_{3/2})4d$	$^3D - \frac{3}{2}[\frac{5}{2}]^\circ$	2 – 3		727
	50	1113.952	488.9287 – 578.6985	$3s3p^63d - 3s^23p^5(^2P^\circ_{3/2})4d$	$^3D - \frac{3}{2}[\frac{5}{2}]^\circ$	1 – 2		727
	4	1123.288	488.2257 – 577.2498	$3s^23p^54p - 3s^23p^5(^2P^\circ_{3/2})4d$	$^3D - \frac{3}{2}[\frac{3}{2}]^\circ$	2 – 1		727
	150	1128.546	481.9877 – 570.5978	$3s^23p^54p - 3s^23p^5(^2P^\circ_{3/2})4d$	$^3S - \frac{3}{2}[\frac{3}{2}]^\circ$	1 – 2		727
	80	1132.237	488.9287 – 577.2498	$3s3p^63d - 3s^23p^5(^2P^\circ_{1/2})4d$	$^3D - \frac{1}{2}[\frac{3}{2}]^\circ$	1 – 1		727
	4	1136.050	491.5587 – 579.5842	$3s3p^63d - 3s^23p^5(^2P^\circ_{1/2})4d$	$^3D - \frac{1}{2}[\frac{3}{2}]^\circ$	2 – 2		727
	4	1139.275	491.5587 – 579.3346	$3s3p^63d - 3s^23p^5(^2P^\circ_{3/2})4d$	$^3D - \frac{3}{2}[\frac{5}{2}]^\circ$	2 – 3		727
	80	1145.256	481.9877 – 569.3045	$3s^23p^54p - 3s^23p^5(^2P^\circ_{3/2})4d$	$^3S - \frac{3}{2}[\frac{1}{2}]^\circ$	1 – 1		727
	1	1147.571	491.5587 – 578.6985	$3s3p^63d - 3s^23p^5(^2P^\circ_{3/2})4d$	$^3D - \frac{3}{2}[\frac{5}{2}]^\circ$	2 – 2		727
	0	1152.509	492.5671 – 579.3346	$3s3p^63d - 3s^23p^5(^2P^\circ_{3/2})4d$	$^3D - \frac{3}{2}[\frac{5}{2}]^\circ$	3 – 3		727
	80	1153.274	487.9746 – 574.6838	$3s^23p^54p - 3s^23p^5(^2P^\circ_{3/2})4d$	$^3D - \frac{3}{2}[\frac{5}{2}]^\circ$	3 – 3		727
	50	1163.520	496.8907 – 582.8365	$3s^23p^54p - 3s^23p^5(^2P^\circ_{1/2})4d$	$^1P - \frac{1}{2}[\frac{3}{2}]^\circ$	1 – 1		727
	1	1164.634	487.9746 – 573.8383	$3s^23p^54p - 3s^23p^5(^2P^\circ_{3/2})4d$	$^3D - \frac{3}{2}[\frac{5}{2}]^\circ$	3 – 2		727
	0	1166.982	491.5587 – 577.2498	$3s3p^63d - 3s^23p^5(^2P^\circ_{3/2})4d$	$^3D - \frac{3}{2}[\frac{3}{2}]^\circ$	2 – 1		727
	50	1168.043	488.2257 – 573.8383	$3s^23p^54p - 3s^23p^5(^2P^\circ_{3/2})4d$	$^3D - \frac{3}{2}[\frac{5}{2}]^\circ$	2 – 2		727
	30	1168.927	494.0357 – 579.5842	$3s^23p^54p - 3s^23p^5(^2P^\circ_{1/2})4d$	$^1D - \frac{1}{2}[\frac{3}{2}]^\circ$	2 – 2		727
	1	1172.340	494.0357 – 579.3346	$3s^23p^54p - 3s^23p^5(^2P^\circ_{3/2})4d$	$^1D - \frac{3}{2}[\frac{5}{2}]^\circ$	2 – 3		727
	50	1177.719	488.9287 – 573.8383	$3s3p^63d - 3s^23p^5(^2P^\circ_{3/2})4d$	$^3D - \frac{3}{2}[\frac{5}{2}]^\circ$	1 – 2		727
	0	1179.541	498.0572 – 582.8365	$3s^23p^54p - 3s^23p^5(^2P^\circ_{1/2})4d$	$^3P - \frac{1}{2}[\frac{3}{2}]^\circ$	2 – 1		727
	12	1181.192	498.1764 – 582.8365	$3s^23p^54p - 3s^23p^5(^2P^\circ_{1/2})4d$	$^3P - \frac{1}{2}[\frac{3}{2}]^\circ$	0 – 1		727
	30	1188.796	487.9746 – 572.0939	$3s^23p^54p - 3s^23p^5(^2P^\circ_{3/2})4d$	$^3D - \frac{3}{2}[\frac{7}{2}]^\circ$	3 – 3		727
	80	1191.195	493.3005 – 577.2498	$3s^23p^54p - 3s^23p^5(^2P^\circ_{3/2})4d$	$^3D - \frac{3}{2}[\frac{3}{2}]^\circ$	1 – 1		727
	200	1192.353	488.2257 – 572.0939	$3s^23p^54p - 3s^23p^5(^2P^\circ_{3/2})4d$	$^3D - \frac{3}{2}[\frac{7}{2}]^\circ$	2 – 3		727
	50	1197.598	499.3362 – 582.8365	$3s^23p^54p - 3s^23p^5(^2P^\circ_{1/2})4d$	$^3P - \frac{1}{2}[\frac{3}{2}]^\circ$	1 – 1		727
	250	1198.659	487.9746 – 571.4011	$3s^23p^54p - 3s^23p^5(^2P^\circ_{3/2})4d$	$^3D - \frac{3}{2}[\frac{7}{2}]^\circ$	3 – 4		727
	50	1203.011	491.5587 – 574.6838	$3s3p^63d - 3s^23p^5(^2P^\circ_{3/2})4d$	$^3D - \frac{3}{2}[\frac{5}{2}]^\circ$	2 – 3		727

Tl V — Continued

Multiplet	Rel. Int.	λ_{vac} (in Å)	Levels (in 10^3 cm^{-1})	Configurations	Terms	J - J	Notes	References
	0	1210.290	487.9746 – 570.5978	$3s^23p^54p - 3s^23p^5(^2P^\circ_{3/2})4d$	$^3D - \frac{3}{2}[\frac{3}{2}]^\circ$	3 – 2		727
	0	1214.000	488.2257 – 570.5978	$3s^23p^54p - 3s^23p^5(^2P^\circ_{3/2})4d$	$^3D - \frac{3}{2}[\frac{3}{2}]^\circ$	2 – 2		727
	50	1215.373	491.5587 – 573.8383	$3s3p^63d - 3s^23p^5(^2P^\circ_{3/2})4d$	$^3D - \frac{3}{2}[\frac{5}{2}]^\circ$	2 – 2		727
	30	1217.779	492.5671 – 574.6838	$3s3p^63d - 3s^23p^5(^2P^\circ_{3/2})4d$	$^3D - \frac{3}{2}[\frac{5}{2}]^\circ$	3 – 3		727
	250	1222.359	496.8907 – 578.6985	$3s^23p^54p - 3s^23p^5(^2P^\circ_{3/2})4d$	$^1P - \frac{3}{2}[\frac{5}{2}]^\circ$	1 – 2		727
	0	1224.469	488.9287 – 570.5978	$3s3p^63d - 3s^23p^5(^2P^\circ_{3/2})4d$	$^3D - \frac{3}{2}[\frac{3}{2}]^\circ$	1 – 2		727
	1	1226.588	498.0572 – 579.5842	$3s^23p^54p - 3s^23p^5(^2P^\circ_{1/2})4d$	$^3P - \frac{1}{2}[\frac{3}{2}]^\circ$	2 – 2		727
	300	1230.361	498.0572 – 579.3346	$3s^23p^54p - 3s^23p^5(^2P^\circ_{3/2})4d$	$^3P - \frac{3}{2}[\frac{5}{2}]^\circ$	2 – 3		727
	0	1233.387	488.2257 – 569.3045	$3s^23p^54p - 3s^23p^5(^2P^\circ_{3/2})4d$	$^3D - \frac{3}{2}[\frac{1}{2}]^\circ$	2 – 1		727
	375	1239.958	494.0357 – 574.6838	$3s^23p^54p - 3s^23p^5(^2P^\circ_{3/2})4d$	$^1D - \frac{3}{2}[\frac{5}{2}]^\circ$	2 – 3		727
	300	1241.671	491.5587 – 572.0939	$3s3p^63d - 3s^23p^5(^2P^\circ_{3/2})4d$	$^3D - \frac{3}{2}[\frac{7}{2}]^\circ$	2 – 3		727
	0	1244.405	496.8907 – 577.2498	$3s^23p^54p - 3s^23p^5(^2P^\circ_{3/2})4d$	$^1P - \frac{3}{2}[\frac{3}{2}]^\circ$	1 – 1		727
	150	1246.131	499.3362 – 579.5842	$3s^23p^54p - 3s^23p^5(^2P^\circ_{1/2})4d$	$^3P - \frac{1}{2}[\frac{3}{2}]^\circ$	1 – 2		727
	1	1253.079	494.0357 – 573.8383	$3s^23p^54p - 3s^23p^5(^2P^\circ_{3/2})4d$	$^1D - \frac{3}{2}[\frac{5}{2}]^\circ$	2 – 2		727
	30	1257.442	492.5671 – 572.0939	$3s3p^63d - 3s^23p^5(^2P^\circ_{3/2})4d$	$^3D - \frac{3}{2}[\frac{7}{2}]^\circ$	3 – 3		727
	80	1264.659	498.1764 – 577.2498	$3s^23p^54p - 3s^23p^5(^2P^\circ_{3/2})4d$	$^3P - \frac{3}{2}[\frac{3}{2}]^\circ$	0 – 1		727
	200	1268.490	492.5671 – 571.4011	$3s3p^63d - 3s^23p^5(^2P^\circ_{3/2})4d$	$^3D - \frac{3}{2}[\frac{7}{2}]^\circ$	3 – 4		727
	0	1281.091	494.0357 – 572.0939	$3s^23p^54p - 3s^23p^5(^2P^\circ_{3/2})4d$	$^1D - \frac{3}{2}[\frac{7}{2}]^\circ$	2 – 3		727
	2	1281.541	492.5671 – 570.5978	$3s3p^63d - 3s^23p^5(^2P^\circ_{3/2})4d$	$^3D - \frac{3}{2}[\frac{3}{2}]^\circ$	3 – 2		727
	1	1283.463	499.3362 – 577.2498	$3s^23p^54p - 3s^23p^5(^2P^\circ_{3/2})4d$	$^3P - \frac{3}{2}[\frac{3}{2}]^\circ$	1 – 1		727
	12	1286.036	436.8498 – 514.6087	$3s^23p^54s - 3s^23p^54p$	$^3P^\circ - {}^1S$	1 – 0		727
	4	1293.710	493.3005 – 570.5978	$3s^23p^54p - 3s^23p^5(^2P^\circ_{3/2})4d$	$^3D - \frac{3}{2}[\frac{3}{2}]^\circ$	1 – 2		727
	0	1305.018	498.0572 – 574.6838	$3s^23p^54p - 3s^23p^5(^2P^\circ_{3/2})4d$	$^3P - \frac{3}{2}[\frac{5}{2}]^\circ$	2 – 3		727
	200	1306.108	494.0357 – 570.5978	$3s^23p^54p - 3s^23p^5(^2P^\circ_{3/2})4d$	$^1D - \frac{3}{2}[\frac{3}{2}]^\circ$	2 – 2		727
	0	1315.712	493.3005 – 569.3045	$3s^23p^54p - 3s^23p^5(^2P^\circ_{3/2})4d$	$^3D - \frac{3}{2}[\frac{1}{2}]^\circ$	1 – 1		727
	1	1326.279	493.3005 – 568.6985	$3s^23p^54p - 3s^23p^5(^2P^\circ_{3/2})4d$	$^3D - \frac{3}{2}[\frac{1}{2}]^\circ$	1 – 0		727
	50	1328.572	494.0357 – 569.3045	$3s^23p^54p - 3s^23p^5(^2P^\circ_{3/2})4d$	$^1D - \frac{3}{2}[\frac{1}{2}]^\circ$	2 – 1		727
	1	1356.724	496.8907 – 570.5978	$3s^23p^54p - 3s^23p^5(^2P^\circ_{3/2})4d$	$^1P - \frac{3}{2}[\frac{3}{2}]^\circ$	1 – 2		727
	0	1363.148	506.2247 – 579.5842	$3s3p^63d - 3s^23p^5(^2P^\circ_{1/2})4d$	$^1D - \frac{1}{2}[\frac{3}{2}]^\circ$	2 – 2		727
	12	1367.797	506.2247 – 579.3346	$3s3p^63d - 3s^23p^5(^2P^\circ_{3/2})4d$	$^1D - \frac{3}{2}[\frac{5}{2}]^\circ$	2 – 3		727
	110	1378.552	498.0572 – 570.5978	$3s^23p^54p - 3s^23p^5(^2P^\circ_{3/2})4d$	$^3P - \frac{3}{2}[\frac{3}{2}]^\circ$	2 – 2		727
	0	1380.935	496.8907 – 569.3045	$3s^23p^54p - 3s^23p^5(^2P^\circ_{3/2})4d$	$^1P - \frac{3}{2}[\frac{1}{2}]^\circ$	1 – 1		727
	0	1403.280	499.3362 – 570.5978	$3s^23p^54p - 3s^23p^5(^2P^\circ_{3/2})4d$	$^3P - \frac{3}{2}[\frac{3}{2}]^\circ$	1 – 2		727
	4	1403.562	498.0572 – 569.3045	$3s^23p^54p - 3s^23p^5(^2P^\circ_{3/2})4d$	$^3P - \frac{3}{2}[\frac{1}{2}]^\circ$	2 – 1		727
	12	1405.911	498.1764 – 569.3045	$3s^23p^54p - 3s^23p^5(^2P^\circ_{3/2})4d$	$^3P - \frac{3}{2}[\frac{1}{2}]^\circ$	0 – 1		727
	200	1411.309	443.7527 – 514.6087	$3s^23p^54s - 3s^23p^54p$	$^1P^\circ - {}^1S$	1 – 0		727
	12	1429.222	499.3362 – 569.3045	$3s^23p^54p - 3s^23p^5(^2P^\circ_{3/2})4d$	$^3P - \frac{3}{2}[\frac{1}{2}]^\circ$	1 – 1		727
	2	1441.426	436.8498 – 506.2247	$3s^23p^54s - 3s3p^63d$	$^3P^\circ - {}^1D$	1 – 2		727
	50	1441.713	499.3362 – 568.6985	$3s^23p^54p - 3s^23p^5(^2P^\circ_{3/2})4d$	$^3P - \frac{3}{2}[\frac{1}{2}]^\circ$	1 – 0		727
	12	1460.723	506.2247 – 574.6838	$3s3p^63d - 3s^23p^5(^2P^\circ_{3/2})4d$	$^1D - \frac{3}{2}[\frac{5}{2}]^\circ$	2 – 3		727
	110	1465.683	514.6087 – 582.8365	$3s^23p^54p - 3s^23p^5(^2P^\circ_{1/2})4d$	$^1S - \frac{1}{2}[\frac{3}{2}]^\circ$	0 – 1		727
	0	1518.181	506.2247 – 572.0939	$3s3p^63d - 3s^23p^5(^2P^\circ_{3/2})4d$	$^1D - \frac{3}{2}[\frac{7}{2}]^\circ$	2 – 3		727
	80	1538.546	434.3394 – 499.3362	$3s^23p^54s - 3s^23p^54p$	$^3P^\circ - {}^3P$	2 – 1		727
	80	1569.423	434.3394 – 498.0572	$3s^23p^54s - 3s^23p^54p$	$^3P^\circ - {}^3P$	2 – 2		727
	4	1598.697	434.3394 – 496.8907	$3s^23p^54s - 3s^23p^54p$	$^3P^\circ - {}^1P$	2 – 1		727
	1	1600.353	436.8498 – 499.3362	$3s^23p^54s - 3s^23p^54p$	$^3P^\circ - {}^3P$	1 – 1		727
	80	1600.726	443.7527 – 506.2247	$3s^23p^54s - 3s3p^63d$	$^1P^\circ - {}^1D$	1 – 2		727
	80	1630.613	436.8498 – 498.1764	$3s^23p^54s - 3s^23p^54p$	$^3P^\circ - {}^3P$	1 – 0		727
	110	1633.780	436.8498 – 498.0572	$3s^23p^54s - 3s^23p^54p$	$^3P^\circ - {}^3P$	1 – 2		727
	250	1675.150	434.3394 – 494.0357	$3s^23p^54s - 3s^23p^54p$	$^3P^\circ - {}^1D$	2 – 2		727
	200	1687.165	440.0652 – 499.3362	$3s^23p^54s - 3s^23p^54p$	$^3P^\circ - {}^3P$	0 – 1		727
	30	1696.031	434.3394 – 493.3005	$3s^23p^54s - 3s^23p^54p$	$^3P^\circ - {}^3D$	2 – 1		727
	375	1717.396	434.3394 – 492.5671	$3s^23p^54s - 3s3p^63d$	$^3P^\circ - {}^3D$	2 – 3		727
	50	1747.639	434.3394 – 491.5587	$3s^23p^54s - 3s3p^63d$	$^3P^\circ - {}^3D$	2 – 2		727

Ti V — Continued

Multiplet	Rel. Int.	λ_{vac} (in Å)	Levels (in 10^3 cm^{-1})	Configurations	Terms	J - J	Notes	References
	30	1748.671	436.8498 - 494.0357	$3s^23p^54s - 3s^23p^54p$	$^3P^\circ - {}^1D$	1 - 2		727
	200	1759.757	440.0652 - 496.8907	$3s^23p^54s - 3s^23p^54p$	$^3P^\circ - {}^1P$	0 - 1		727
	150	1771.452	436.8498 - 493.3005	$3s^23p^54s - 3s^23p^54p$	$^3P^\circ - {}^3D$	1 - 1		727
	110	1799.082	443.7527 - 499.3362	$3s^23p^54s - 3s^23p^54p$	$^1P^\circ - {}^3P$	1 - 1		727
	110	1827.899	436.8498 - 491.5587	$3s^23p^54s - 3s3p^63d$	$^3P^\circ - {}^3D$	1 - 2		727
	110	1828.292	514.6087 - 569.3045	$3s^23p^54p - 3s^23p^5(^2P^\circ_{3/2})4d$	$^1S - \frac{3}{2}[\frac{1}{2}]^\circ$	0 - 1		727
	12	1831.875	434.3394 - 488.9287	$3s^23p^54s - 3s3p^63d$	$^3P^\circ - {}^3D$	2 - 1		727
	30	1837.436	443.7527 - 498.1764	$3s^23p^54s - 3s^23p^54p$	$^1P^\circ - {}^3P$	1 - 0		727
	300	1841.490	443.7527 - 498.0572	$3s^23p^54s - 3s^23p^54p$	$^1P^\circ - {}^3P$	1 - 2		727
	30	1855.765	434.3394 - 488.2257	$3s^23p^54s - 3s^23p^54p$	$^3P^\circ - {}^3D$	2 - 2		727
	150	1864.451	434.3394 - 487.9746	$3s^23p^54s - 3s^23p^54p$	$^3P^\circ - {}^3D$	2 - 3		727
	12	1878.458	440.0652 - 493.3005	$3s^23p^54s - 3s^23p^54p$	$^3P^\circ - {}^3D$	0 - 1		727
	150	1881.886	443.7527 - 496.8907	$3s^23p^54s - 3s^23p^54p$	$^1P^\circ - {}^1P$	1 - 1		727
	150	1920.163	436.8498 - 488.9287	$3s^23p^54s - 3s3p^63d$	$^3P^\circ - {}^3D$	1 - 1		727
	50	1946.434	436.8498 - 488.2257	$3s^23p^54s - 3s^23p^54p$	$^3P^\circ - {}^3D$	1 - 2		727
	150	1988.750	443.7527 - 494.0357	$3s^23p^54s - 3s^23p^54p$	$^1P^\circ - {}^1D$	1 - 2		727

TITANIUM VI (Ti^{5+}), Z = 22
Ground State $1s^22s^22p^63s^23p^5(^2P^\circ_{3/2})$ (17 electrons)
Ionization Potential 964 100 cm^{-1}; 119.53 eV

Multiplet	Rel. Int.	λ_{vac} (in Å)	Levels (in 10^3 cm^{-1})	Configurations	Terms	J - J	Notes	References
	10	125.456	0.0 - 797.092	$3s^23p^5 - 3s^23p^4(^1D)5d$	$g^2P^\circ - {}^2D$	$\frac{3}{2} - \frac{5}{2}$		711
	6	125.689	0.0 - 795.615	$3s^23p^5 - 3s^23p^4(^1D)5d$	$g^2P^\circ - {}^2P$	$\frac{3}{2} - \frac{3}{2}$		711
	3	126.330	5.8293 - 797.406	$3s^23p^5 - 3s^23p^4(^1D)5d$	$g^2P^\circ - {}^2D$	$\frac{1}{2} - \frac{3}{2}$		711
	1	128.450	0.0 - 778.513	$3s^23p^5 - 3s^23p^4(^3P)5d$	$g^2P^\circ - {}^4F$	$\frac{3}{2} - \frac{5}{2}$		711
	3	129.148	0.0 - 774.306	$3s^23p^5 - 3s^23p^4(^3P)5d$	$g^2P^\circ - {}^2D$	$\frac{3}{2} - \frac{3}{2}$		711
	6	129.249	0.0 - 773.702	$3s^23p^5 - 3s^23p^4(^3P)5d$	$g^2P^\circ - {}^2D$	$\frac{3}{2} - \frac{5}{2}$		711
	3	130.113	5.8293 - 774.306	$3s^23p^5 - 3s^23p^4(^3P)5d$	$g^2P^\circ - {}^2D$	$\frac{1}{2} - \frac{3}{2}$		714
	6	136.714	0.0 - 731.455	$3s^23p^5 - 3s^23p^4(^1D)5s$	$g^2P^\circ - {}^2D$	$\frac{3}{2} - \frac{5}{2}$		711
	3	137.813	5.8293 - 731.453	$3s^23p^5 - 3s^23p^4(^1D)5s$	$g^2P^\circ - {}^2D$	$\frac{1}{2} - \frac{3}{2}$		711
	3	139.911	0.0 - 714.742	$3s^23p^5 - 3s^23p^4(^3P)5s$	$g^2P^\circ - {}^2P$	$\frac{3}{2} - \frac{1}{2}$		711
	20	140.443	0.0 - 712.034	$3s^23p^5 - 3s^23p^4(^3P)5s$	$g^2P^\circ - {}^2P$	$\frac{3}{2} - \frac{3}{2}$		711
	3	141.061	5.8293 - 714.742	$3s^23p^5 - 3s^23p^4(^3P)5s$	$g^2P^\circ - {}^2P$	$\frac{1}{2} - \frac{1}{2}$		711
	10	141.113	0.0 - 708.652	$3s^23p^5 - 3s^23p^4(^3P)5s$	$g^2P^\circ - {}^4P$	$\frac{3}{2} - \frac{3}{2}$		711
	3	141.988	0.0 - 704.283	$3s^23p^5 - 3s^23p^4(^1S)4d$	$g^2P^\circ - {}^2D$	$\frac{3}{2} - \frac{5}{2}$		711
	1	143.176	5.8293 - 704.270	$3s^23p^5 - 3s^23p^4(^1S)4d$	$g^2P^\circ - {}^2D$	$\frac{1}{2} - \frac{3}{2}$		711
	3	148.104	0.0 - 675.207	$3s^23p^5 - 3s^23p^4(^1D)4d$	$g^2P^\circ - {}^2D$	$\frac{3}{2} - \frac{3}{2}$		711
	20	148.303	0.0 - 674.297	$3s^23p^5 - 3s^23p^4(^1D)4d$	$g^2P^\circ - {}^2D$	$\frac{3}{2} - \frac{5}{2}$		711
	20	149.010	0.0 - 671.096	$3s^23p^5 - 3s^23p^4(^1D)4d$	$g^2P^\circ - {}^2P$	$\frac{3}{2} - \frac{3}{2}$		711
	10	149.392	5.8293 - 675.207	$3s^23p^5 - 3s^23p^4(^1D)4d$	$g^2P^\circ - {}^2D$	$\frac{1}{2} - \frac{3}{2}$		711
	10	149.560	0.0 - 668.630	$3s^23p^5 - 3s^23p^4(^1D)4d$	$g^2P^\circ - {}^2S$	$\frac{3}{2} - \frac{1}{2}$		711
	3	150.213	5.8293 - 671.549	$3s^23p^5 - 3s^23p^4(^1D)4d$	$g^2P^\circ - {}^2P$	$\frac{1}{2} - \frac{1}{2}$		711
	3	150.315	5.8293 - 671.096	$3s^23p^5 - 3s^23p^4(^1D)4d$	$g^2P^\circ - {}^2P$	$\frac{1}{2} - \frac{3}{2}$		711
	1	151.897	0.0 - 658.339	$3s^23p^5 - 3s^23p^4(^3P)4d$	$g^2P^\circ - {}^2P$	$\frac{3}{2} - \frac{3}{2}$		711
	10	152.338	0.0 - 656.437	$3s^23p^5 - 3s^23p^4(^3P)4d$	$g^2P^\circ - {}^2F$	$\frac{3}{2} - \frac{5}{2}$		711
	10	152.960	0.0 - 653.766	$3s^23p^5 - 3s^23p^4(^3P)4d$	$g^2P^\circ - {}^4F$	$\frac{3}{2} - \frac{5}{2}$		711
	3	153.255	5.8293 - 658.339	$3s^23p^5 - 3s^23p^4(^3P)4d$	$g^2P^\circ - {}^2P$	$\frac{1}{2} - \frac{3}{2}$		711
	3	153.384	0.0 - 651.960	$3s^23p^5 - 3s^23p^4(^3P)4d$	$g^2P^\circ - {}^2D$	$\frac{3}{2} - \frac{3}{2}$		711
	35	153.550	0.0 - 651.255	$3s^23p^5 - 3s^23p^4(^3P)4d$	$g^2P^\circ - {}^2D$	$\frac{3}{2} - \frac{5}{2}$		711
	1	154.161	5.8293 - 654.503	$3s^23p^5 - 3s^23p^4(^3P)4d$	$g^2P^\circ - {}^4F$	$\frac{1}{2} - \frac{3}{2}$		711
	6	154.768	5.8293 - 651.960	$3s^23p^5 - 3s^23p^4(^3P)4d$	$g^2P^\circ - {}^2D$	$\frac{1}{2} - \frac{3}{2}$		711

Ti VI — Continued

Multiplet	Rel. Int.	λ_{vac} (in Å)	Levels (in 10^3 cm^{-1})	Configurations	Terms	J - J	Notes	References
	90	182.151	0.0 – 548.995	$3s^23p^5 - 3s^23p^4(^1S)4s$	$g^2P^\circ - {}^2S$	$\frac{3}{2}-\frac{1}{2}$		711
	35	184.106	5.8293 – 548.995	$3s^23p^5 - 3s^23p^4(^1S)4s$	$g^2P^\circ - {}^2S$	$\frac{1}{2}-\frac{1}{2}$		711
	20	192.710	0.0 – 518.914	$3s^23p^5 - 3s^23p^4(^1D)4s$	$g^2P^\circ - {}^2D$	$\frac{3}{2}-\frac{3}{2}$		182
	250	192.754	0.0 – 518.797	$3s^23p^5 - 3s^23p^4(^1D)4s$	$g^2P^\circ - {}^2D$	$\frac{3}{2}-\frac{5}{2}$		711
	200	194.900	5.8293 – 518.914	$3s^23p^5 - 3s^23p^4(^1D)4s$	$g^2P^\circ - {}^2D$	$\frac{1}{2}-\frac{3}{2}$		711
	200	197.460	0.0 – 506.432	$3s^23p^5 - 3s^23p^4(^3P)4s$	$g^2P^\circ - {}^2P$	$\frac{3}{2}-\frac{1}{2}$		711
	400	198.977	0.0 – 502.571	$3s^23p^5 - 3s^23p^4(^3P)4s$	$g^2P^\circ - {}^2P$	$\frac{3}{2}-\frac{3}{2}$		711
	200	199.759	5.8293 – 506.432	$3s^23p^5 - 3s^23p^4(^3P)4s$	$g^2P^\circ - {}^2P$	$\frac{1}{2}-\frac{1}{2}$		711
	90	201.311	5.8293 – 502.571	$3s^23p^5 - 3s^23p^4(^3P)4s$	$g^2P^\circ - {}^2P$	$\frac{1}{2}-\frac{3}{2}$		711
	125	201.865	0.0 – 495.380	$3s^23p^5 - 3s^23p^4(^3P)4s$	$g^2P^\circ - {}^4P$	$\frac{3}{2}-\frac{3}{2}$		711
	6	203.200	0.0 – 492.126	$3s^23p^5 - 3s^23p^4(^3P)4s$	$g^2P^\circ - {}^4P$	$\frac{3}{2}-\frac{5}{2}$		711
	3	203.434	5.8293 – 497.389	$3s^23p^5 - 3s^23p^4(^3P)4s$	$g^2P^\circ - {}^4P$	$\frac{1}{2}-\frac{1}{2}$		711
	10	226.561	81.+D – 522.382+D	$3s^23p^4(^3P)3d - 3s^23p^4(^3P)4f$	${}^4D - {}^4F^\circ$	$\frac{7}{2}-\frac{9}{2}$	Q	714
		235.066	86.382+S – 511.794+S	$3s^23p^4(^3P)3d - 3s^23p^4(^3P)4f$	${}^4F - {}^4G^\circ$	$\frac{5}{2}-\frac{7}{2}$		854
	3	235.316	100.+L – 524.971+L	$3s^23p^4(^1D)3d - 3s^23p^4(^1D)4f$	${}^2G - {}^2H^\circ$	$\frac{9}{2}-\frac{11}{2}$		714,854
		235.408	87.+S – 511.794+S	$3s^23p^4(^3P)3d - 3s^23p^4(^3P)4f$	${}^4F - {}^4G^\circ$	$\frac{9}{2}-\frac{11}{2}$		854
		235.836	87.771+S – 511.794+S	$3s^23p^4(^3P)3d - 3s^23p^4(^3P)4f$	${}^4F - {}^4G^\circ$	$\frac{7}{2}-\frac{9}{2}$		854
	250	247.450	0.0 – 404.123	$3s^23p^5 - 3s^23p^4(^1D)3d$	$g^2P^\circ - {}^2D$	$\frac{3}{2}-\frac{3}{2}$		711
	1000	250.482	0.0 – 399.231	$3s^23p^5 - 3s^23p^4(^1D)3d$	$g^2P^\circ - {}^2D$	$\frac{3}{2}-\frac{5}{2}$		711
	700	251.071	5.8293 – 404.123	$3s^23p^5 - 3s^23p^4(^1D)3d$	$g^2P^\circ - {}^2D$	$\frac{1}{2}-\frac{3}{2}$		711
	200	254.037	0.0 – 393.644	$3s^23p^5 - 3s^23p^4(^1D)3d$	$g^2P^\circ - {}^2P$	$\frac{3}{2}-\frac{1}{2}$	P	256
	300	255.375	0.0 – 391.583	$3s^23p^5 - 3s^23p^4(^1D)3d$	$g^2P^\circ - {}^2P$	$\frac{3}{2}-\frac{3}{2}$		711
	250	257.855	5.8293 – 393.644	$3s^23p^5 - 3s^23p^4(^1D)3d$	$g^2P^\circ - {}^2P$	$\frac{1}{2}-\frac{1}{2}$		711
	250	259.232	5.8293 – 391.583	$3s^23p^5 - 3s^23p^4(^1D)3d$	$g^2P^\circ - {}^2P$	$\frac{1}{2}-\frac{3}{2}$		711
	250	263.246	0.0 – 379.874	$3s^23p^5 - 3s^23p^4(^1D)3d$	$g^2P^\circ - {}^2S$	$\frac{3}{2}-\frac{1}{2}$		711
	200	267.343	5.8293 – 379.874	$3s^23p^5 - 3s^23p^4(^1D)3d$	$g^2P^\circ - {}^2S$	$\frac{1}{2}-\frac{1}{2}$		711
	1	282.215	0.0 – 354.340	$3s^23p^5 - 3s^23p^4(^1S)3d$	$g^2P^\circ - {}^2D$	$\frac{3}{2}-\frac{5}{2}$		711
	20	283.586	0.0 – 352.625	$3s^23p^5 - 3s^23p^4(^1S)3d$	$g^2P^\circ - {}^2D$	$\frac{3}{2}-\frac{3}{2}$		711
	60	288.355	5.8293 – 352.625	$3s^23p^5 - 3s^23p^4(^1S)3d$	$g^2P^\circ - {}^2D$	$\frac{1}{2}-\frac{3}{2}$		711
	20	301.913	0.0 – 331.221	$3s^23p^5 - 3s^23p^4(^1D)3d$	$g^2P^\circ - {}^2F$	$\frac{3}{2}-\frac{5}{2}$		711
	60	330.703	0.0 – 302.386	$3s^23p^5 - 3s^23p^4(^3P)3d$	$g^2P^\circ - {}^2D$	$\frac{3}{2}-\frac{5}{2}$		711
	6	331.767	0.0 – 301.417	$3s^23p^5 - 3s^23p^4(^3P)3d$	$g^2P^\circ - {}^4P$	$\frac{3}{2}-\frac{1}{2}$		711
	20	334.457	0.0 – 298.991	$3s^23p^5 - 3s^23p^4(^3P)3d$	$g^2P^\circ - {}^2D$	$\frac{3}{2}-\frac{3}{2}$		711
	20	341.109	5.8293 – 298.991	$3s^23p^5 - 3s^23p^4(^3P)3d$	$g^2P^\circ - {}^2D$	$\frac{1}{2}-\frac{3}{2}$		711
	35	342.595	0.0 – 291.890	$3s^23p^5 - 3s^23p^4(^3P)3d$	$g^2P^\circ - {}^2P$	$\frac{3}{2}-\frac{3}{2}$		711
	1	346.728	0.0 – 288.412	$3s^23p^5 - 3s^23p^4(^3P)3d$	$g^2P^\circ - {}^2P$	$\frac{3}{2}-\frac{1}{2}$		711
	6	349.574	5.8293 – 291.890	$3s^23p^5 - 3s^23p^4(^3P)3d$	$g^2P^\circ - {}^2P$	$\frac{1}{2}-\frac{3}{2}$		711
	6	353.877	5.8293 – 288.412	$3s^23p^5 - 3s^23p^4(^3P)3d$	$g^2P^\circ - {}^2P$	$\frac{1}{2}-\frac{1}{2}$		711
	1000	508.575	0.0 – 196.628	$3s^23p^5 - 3s3p^6$	$g^2P^\circ - {}^2S$	$\frac{3}{2}-\frac{1}{2}$		718
	900	524.113	5.8293 – 196.628	$3s^23p^5 - 3s3p^6$	$g^2P^\circ - {}^2S$	$\frac{1}{2}-\frac{1}{2}$		718

TITANIUM VII (Ti^{6+}), Z = 22
Ground State $1s^22s^22p^63s^23p^4(^3P_2)$ (16 electrons)
Ionization Potential 1 136 000 cm^{-1}; 140.8 eV

Multiplet	Rel. Int.	λ_{vac} (in Å)	Levels (in 10^3 cm^{-1})	Configurations	Terms	J - J	Notes	References
	1	128.269	0. – 779.699	$3s^23p^4 - 3s^23p^3(^2P^\circ)4d$	$g^3P - {}^3D^\circ$	2 – 3		302
	1	129.603	4.5333 – 776.118	$3s^23p^4 - 3s^23p^3(^2P^\circ)4d$	$g^3P - {}^3D^\circ$	1 – 1		711
	3	129.722	4.5333 – 775.412	$3s^23p^4 - 3s^23p^3(^2P^\circ)4d$	$g^3P - {}^3D^\circ$	1 – 2		711
	1	131.284	24.123 – 785.717	$3s^23p^4 - 3s^23p^3(^2P^\circ)4d$	${}^1D - {}^1P^\circ$	2 – 1	Q	714
	6	131.937	0. – 757.984	$3s^23p^4 - 3s^23p^3(^2D^\circ)4d$	$g^3P - {}^1D^\circ$	2 – 2	Q	714
	1	132.093	24.123 – 781.17	$3s^23p^4 - 3s^23p^3(^2P^\circ)4d$	${}^1D - {}^1F^\circ$	2 – 3		711

Ti VII — Continued

Multiplet	Rel. Int.	λ_{vac} (in Å)	Levels (in 10^3 cm^{-1})	Configurations	Terms	J - J	Notes	References
	3	132.149	24.123 - 780.853	$3s^23p^4 - 3s^23p^3(^2P^\circ)4d$	$^1D - {}^1D^\circ$	2 - 2		711
	1	132.322	0. - 755.732	$3s^23p^4 - 3s^23p^3(^2D^\circ)4d$	$g^3P - {}^3P^\circ$	2 - 1		711
	1	132.351	24.123 - 779.699	$3s^23p^4 - 3s^23p^3(^2P^\circ)4d$	$^1D - {}^3D^\circ$	2 - 3		711
	6	132.522	0. - 754.591	$3s^23p^4 - 3s^23p^3(^2D^\circ)4d$	$g^3P - {}^3D^\circ$	2 - 2		711
	10	132.733	0. - 753.393	$3s^23p^4 - 3s^23p^3(^2D^\circ)4d$	$g^3P - {}^3D^\circ$	2 - 3		711
	3	132.837	0. - 752.846	$3s^23p^4 - 3s^23p^3(^2D^\circ)4d$	$g^3P - {}^3P^\circ$	2 - 2		714
	1	132.982	4.5333 - 756.514	$3s^23p^4 - 3s^23p^3(^2D^\circ)4d$	$g^3P - {}^3S^\circ$	1 - 1		711
	6	133.218	5.8871 - 756.514	$3s^23p^4 - 3s^23p^3(^2D^\circ)4d$	$g^3P - {}^3S^\circ$	0 - 1		714
	1	133.385	5.8871 - 755.732	$3s^23p^4 - 3s^23p^3(^2D^\circ)4d$	$g^3P - {}^3P^\circ$	0 - 1		714
	3	133.633	4.5333 - 752.846	$3s^23p^4 - 3s^23p^3(^2D^\circ)4d$	$g^3P - {}^3P^\circ$	1 - 2		711
	20	135.801	24.123 - 760.504	$3s^23p^4 - 3s^23p^3(^2D^\circ)4d$	$^1D - {}^1F^\circ$	2 - 3		711
	6	136.267	24.123 - 757.984	$3s^23p^4 - 3s^23p^3(^2D^\circ)4d$	$^1D - {}^1D^\circ$	2 - 2		711
	3	136.815	54.794 - 785.717	$3s^23p^4 - 3s^23p^3(^2P^\circ)4d$	$^1S - {}^1P^\circ$	0 - 1		711
	20	137.661	0. - 726.424	$3s^23p^4 - 3s^23p^3(^4S^\circ)4d$	$g^3P - {}^3D^\circ$	2 - 3		711
	10	138.548	4.5333 - 726.299	$3s^23p^4 - 3s^23p^3(^4S^\circ)4d$	$g^3P - {}^3D^\circ$	1 - 2		711
	1	138.814	5.8871 - 726.273	$3s^23p^4 - 3s^23p^3(^4S^\circ)4d$	$g^3P - {}^3D^\circ$	0 - 1		711
	10	164.173	0. - 609.115	$3s^23p^4 - 3s^23p^3(^2P^\circ)4s$	$g^3P - {}^3P^\circ$	2 - 2		711
	3	164.478	0. - 607.979	$3s^23p^4 - 3s^23p^3(^2P^\circ)4s$	$g^3P - {}^3P^\circ$	2 - 1		711
	6	165.403	4.5333 - 609.115	$3s^23p^4 - 3s^23p^3(^2P^\circ)4s$	$g^3P - {}^3P^\circ$	1 - 2		711
	1	165.716	4.5333 - 607.979	$3s^23p^4 - 3s^23p^3(^2P^\circ)4s$	$g^3P - {}^3P^\circ$	1 - 1		711
	3	165.836	4.5333 - 607.534	$3s^23p^4 - 3s^23p^3(^2P^\circ)4s$	$g^3P - {}^3P^\circ$	1 - 0		711
	10	166.087	5.8871 - 607.979	$3s^23p^4 - 3s^23p^3(^2P^\circ)4s$	$g^3P - {}^3P^\circ$	0 - 1		711
	10	168.652	0. - 592.918	$3s^23p^4 - 3s^23p^3(^2D^\circ)4s$	$g^3P - {}^1D^\circ$	2 - 2		711
	20	169.301	24.123 - 614.795	$3s^23p^4 - 3s^23p^3(^2P^\circ)4s$	$^1D - {}^1P^\circ$	2 - 1		711
	125	170.358	0. - 586.998	$3s^23p^4 - 3s^23p^3(^2D^\circ)4s$	$g^3P - {}^3D^\circ$	2 - 3		711
	20	170.559	0. - 586.306	$3s^23p^4 - 3s^23p^3(^2D^\circ)4s$	$g^3P - {}^3D^\circ$	2 - 2		711
	3	170.938	24.123 - 609.115	$3s^23p^4 - 3s^23p^3(^2P^\circ)4s$	$^1D - {}^3P^\circ$	2 - 2		711
	20	171.888	4.5333 - 586.306	$3s^23p^4 - 3s^23p^3(^2D^\circ)4s$	$g^3P - {}^3D^\circ$	1 - 2		711
	6	171.952	4.5333 - 586.088	$3s^23p^4 - 3s^23p^3(^2D^\circ)4s$	$g^3P - {}^3D^\circ$	1 - 1		711
	6	172.353	5.8871 - 586.088	$3s^23p^4 - 3s^23p^3(^2D^\circ)4s$	$g^3P - {}^3D^\circ$	0 - 1		711
	90	175.812	24.123 - 592.918	$3s^23p^4 - 3s^23p^3(^2D^\circ)4s$	$^1D - {}^1D^\circ$	2 - 2		711
	60	177.238	0. - 564.214	$3s^23p^4 - 3s^23p^3(^4S^\circ)4s$	$g^3P - {}^3S^\circ$	2 - 1		711
	10	178.572	54.794 - 614.795	$3s^23p^4 - 3s^23p^3(^2P^\circ)4s$	$^1S - {}^1P^\circ$	0 - 1		711
	20	178.673	4.5333 - 564.214	$3s^23p^4 - 3s^23p^3(^4S^\circ)4s$	$g^3P - {}^3S^\circ$	1 - 1		711
	10	179.107	5.8871 - 564.214	$3s^23p^4 - 3s^23p^3(^4S^\circ)4s$	$g^3P - {}^3S^\circ$	0 - 1		711
	3	192.102	618.994+S - 1139.55+S	$3s^23p^3(^2D^\circ)3d - 3s^23p^3(^2D^\circ)4f$	$^3F^\circ - {}^3G$	2 - 3	Q	714
	3	192.272	619.454+S - 1139.55+S	$3s^23p^3(^2D^\circ)3d - 3s^23p^3(^2D^\circ)4f$	$^3F^\circ - {}^3G$	3 - 4	Q	714
	6	192.474	620.+S - 1139.55+S	$3s^23p^3(^2D^\circ)3d - 3s^23p^3(^2D^\circ)4f$	$^3F^\circ - {}^3G$	4 - 5	Q	714
	1	193.501	529.554+D - 1046.347+D	$3s^23p^3(^4S^\circ)3d - 3s^23p^3(^4S^\circ)4f$	$^5D^\circ - {}^5F$	1 - 2	Q	714
	3	193.534	529.642+D - 1046.347+D	$3s^23p^3(^4S^\circ)3d - 3s^23p^3(^4S^\circ)4f$	$^5D^\circ - {}^5F$	2 - 3	Q	714
	6	193.585	529.779+D - 1046.347+D	$3s^23p^3(^4S^\circ)3d - 3s^23p^3(^4S^\circ)4f$	$^5D^\circ - {}^5F$	3 - 4	Q	714
	10	193.668	530.+D - 1046.347+D	$3s^23p^3(^4S^\circ)3d - 3s^23p^3(^4S^\circ)4f$	$^5D^\circ - {}^5F$	4 - 5	Q	714
	1	245.258	0. - 407.701	$3s^23p^4 - 3s^23p^3(^2P^\circ)3d$	$g^3P - {}^1D^\circ$	2 - 2	Q	714
	3	248.037	4.5333 - 407.701	$3s^23p^4 - 3s^23p^3(^2P^\circ)3d$	$g^3P - {}^1D^\circ$	1 - 2		711
	3	250.913	0. - 398.524	$3s^23p^4 - 3s^23p^3(^2P^\circ)3d$	$g^3P - {}^3D^\circ$	2 - 1		711
	200	252.162	0. - 396.571	$3s^23p^4 - 3s^23p^3(^2P^\circ)3d$	$g^3P - {}^3D^\circ$	2 - 2		711
	800	252.275	24.123 - 420.522	$3s^23p^4 - 3s^23p^3(^2P^\circ)3d$	$^1D - {}^1F^\circ$	2 - 3		711
	60	252.571	54.794 - 450.73	$3s^23p^4 - 3s^23p^3(^2P^\circ)3d$	$^1S - {}^1P^\circ$	0 - 1		711
	200	253.811	4.5333 - 398.524	$3s^23p^4 - 3s^23p^3(^2P^\circ)3d$	$g^3P - {}^3D^\circ$	1 - 1		711
	800	254.022	0. - 393.667	$3s^23p^4 - 3s^23p^3(^2P^\circ)3d$	$g^3P - {}^3D^\circ$	2 - 3		711
	200	254.687	5.8871 - 398.524	$3s^23p^4 - 3s^23p^3(^2P^\circ)3d$	$g^3P - {}^3D^\circ$	0 - 1		711
	250	255.076	4.5333 - 396.571	$3s^23p^4 - 3s^23p^3(^2P^\circ)3d$	$g^3P - {}^3D^\circ$	1 - 2		711
	250	260.704	24.123 - 407.701	$3s^23p^4 - 3s^23p^3(^2P^\circ)3d$	$^1D - {}^1D^\circ$	2 - 2		711
	60	261.851	0. - 381.893	$3s^23p^4 - 3s^23p^3(^2D^\circ)3d$	$g^3P - {}^1P^\circ$	2 - 1		711

Ti VII — Continued

Multiplet	Rel. Int.	λ_{vac} (in Å)	Levels (in 10^3 cm^{-1})	Configurations	Terms	J - J	Notes	References
	35	263.944	0. – 378.872	$3s^23p^4 - 3s^23p^3(^2P^\circ)3d$	$g^3P - {}^3P^\circ$	2 – 1		711
	250	264.823	0. – 377.613	$3s^23p^4 - 3s^23p^3(^2P^\circ)3d$	$g^3P - {}^3P^\circ$	2 – 2		711
	35	264.997	4.5333 – 381.893	$3s^23p^4 - 3s^23p^3(^2D^\circ)3d$	$g^3P - {}^1P^\circ$	1 – 1		711
	90	265.059	4.5333 – 381.804	$3s^23p^4 - 3s^23p^3(^2P^\circ)3d$	$g^3P - {}^3P^\circ$	1 – 0		711
	60	265.951	5.8871 – 381.893	$3s^23p^4 - 3s^23p^3(^2D^\circ)3d$	$g^3P - {}^1P^\circ$	0 – 1		711
	200	266.502	0. – 375.232	$3s^23p^4 - 3s^23p^3(^2D^\circ)3d$	$g^3P - {}^3S^\circ$	2 – 1		711
	60	267.136	4.5333 – 378.872	$3s^23p^4 - 3s^23p^3(^2P^\circ)3d$	$g^3P - {}^3P^\circ$	1 – 1		711
	200	268.035	4.5333 – 377.613	$3s^23p^4 - 3s^23p^3(^2P^\circ)3d$	$g^3P - {}^3P^\circ$	1 – 2		711
	35	268.106	5.8871 – 378.872	$3s^23p^4 - 3s^23p^3(^2P^\circ)3d$	$g^3P - {}^3P^\circ$	0 – 1		711
	1	268.493	24.123 – 396.571	$3s^23p^4 - 3s^23p^3(^2P^\circ)3d$	${}^1D - {}^3D^\circ$	2 – 2		711
	90	269.759	4.5333 – 375.232	$3s^23p^4 - 3s^23p^3(^2D^\circ)3d$	$g^3P - {}^3S^\circ$	1 – 1		711
	10	270.748	5.8871 – 375.232	$3s^23p^4 - 3s^23p^3(^2D^\circ)3d$	$g^3P - {}^3S^\circ$	0 – 1		711
	200	279.516	24.123 – 381.893	$3s^23p^4 - 3s^23p^3(^2D^\circ)3d$	${}^1D - {}^1P^\circ$	2 – 1		711
	200	281.898	24.123 – 378.872	$3s^23p^4 - 3s^23p^3(^2P^\circ)3d$	${}^1D - {}^3P^\circ$	2 – 1		711
	1	282.898	24.123 – 377.613	$3s^23p^4 - 3s^23p^3(^2P^\circ)3d$	${}^1D - {}^3P^\circ$	2 – 2		711
	1	284.829	24.123 – 375.232	$3s^23p^4 - 3s^23p^3(^2D^\circ)3d$	${}^1D - {}^3S^\circ$	2 – 1	Q	714
	35	296.056	24.123 – 361.904	$3s^23p^4 - 3s^23p^3(^2D^\circ)3d$	${}^1D - {}^1F^\circ$	2 – 3		711
	1	305.730	54.794 – 381.893	$3s^23p^4 - 3s^23p^3(^2D^\circ)3d$	${}^1S - {}^1P^\circ$	0 – 1		711
	6	332.081	24.123 – 325.261	$3s^23p^4 - 3s^23p^3(^2D^\circ)3d$	${}^1D - {}^1D^\circ$	2 – 2		711
	200	440.361	24.123 – 251.209	$3s^23p^4 - 3s3p^5$	${}^1D - {}^1P^\circ$	2 – 1		718
	200	499.853	0. – 200.0588	$3s^23p^4 - 3s3p^5$	$g^3P - {}^3P^\circ$	2 – 1		718
	200	505.899	4.5333 – 202.2012	$3s^23p^4 - 3s3p^5$	$g^3P - {}^3P^\circ$	1 – 0		718
	12	509.127	54.794 – 251.209	$3s^23p^4 - 3s3p^5$	${}^1S - {}^1P^\circ$	0 – 1		718
	600	509.511	0. – 196.2666	$3s^23p^4 - 3s3p^5$	$g^3P - {}^3P^\circ$	2 – 2		718
	200	511.442	4.5333 – 200.0588	$3s^23p^4 - 3s3p^5$	$g^3P - {}^3P^\circ$	1 – 1		718
	200	515.008	5.8871 – 200.0588	$3s^23p^4 - 3s3p^5$	$g^3P - {}^3P^\circ$	0 – 1		718
	300	521.561	4.5333 – 196.2666	$3s^23p^4 - 3s3p^5$	$g^3P - {}^3P^\circ$	1 – 2		718
		1825.0	0. – 54.794	$3s^23p^4 - 3s^23p^4$	$g^3P - {}^1S$	2 – 0	F,P	375,726
		1989.6	4.5333 – 54.794	$3s^23p^4 - 3s^23p^4$	$g^3P - {}^1S$	1 – 0	F,P	375,726

TITANIUM VIII (Ti^{7+}), Z = 22
Ground State $1s^22s^22p^63s^23p^3(^4S^\circ_{3/2})$ (15 electrons)
Ionization Potential [1 374 000] cm^{-1}; [170.4] eV

Multiplet	Rel. Int.	λ_{vac} (in Å)	Levels (in 10^3 cm^{-1})	Configurations	Terms	J - J	Notes	References
	1	148.014	0. – 675.631+X	$3s^23p^3 - 3s^23p^2(^3P)4s$	$g^4S^\circ - {}^2P$	$\frac{3}{2}-\frac{3}{2}$	Q	714
	1	148.498						714
	1	148.820						714
	3	149.653	54.1892+X – 722.394+X	$3s^23p^3 - 3s^23p^2(^1S)4s$	${}^2P^\circ - {}^2S$	$\frac{1}{2}-\frac{1}{2}$		213,714
	1	149.981	55.6336+X – 722.394+X	$3s^23p^3 - 3s^23p^2(^1S)4s$	${}^2P^\circ - {}^2S$	$\frac{3}{2}-\frac{1}{2}$		213,714
	60	150.039	0. – 666.493	$3s^23p^3 - 3s^23p^2(^3P)4s$	$g^4S^\circ - {}^4P$	$\frac{3}{2}-\frac{5}{2}$		213
	35	150.867	0. – 662.835	$3s^23p^3 - 3s^23p^2(^3P)4s$	$g^4S^\circ - {}^4P$	$\frac{3}{2}-\frac{3}{2}$		213
	10	151.484	0. – 660.135	$3s^23p^3 - 3s^23p^2(^3P)4s$	$g^4S^\circ - {}^4P$	$\frac{3}{2}-\frac{1}{2}$		213
	10	151.864	32.1905+X – 690.672+X	$3s^23p^3 - 3s^23p^2(^1D)4s$	${}^2D^\circ - {}^2D$	$\frac{3}{2}-\frac{3}{2}$		213
	1	151.915	32.1905+X – 690.446+X	$3s^23p^3 - 3s^23p^2(^1D)4s$	${}^2D^\circ - {}^2D$	$\frac{3}{2}-\frac{5}{2}$		213
	20	152.164	33.2564+X – 690.446+X	$3s^23p^3 - 3s^23p^2(^1D)4s$	${}^2D^\circ - {}^2D$	$\frac{5}{2}-\frac{5}{2}$		213
	20	155.675	33.2564+X – 675.631+X	$3s^23p^3 - 3s^23p^2(^3P)4s$	${}^2D^\circ - {}^2P$	$\frac{5}{2}-\frac{3}{2}$		213
	10	156.444	32.1905+X – 671.405+X	$3s^23p^3 - 3s^23p^2(^3P)4s$	${}^2D^\circ - {}^2P$	$\frac{3}{2}-\frac{1}{2}$		213
	3	157.112	54.1892+X – 690.672+X	$3s^23p^3 - 3s^23p^2(^1D)4s$	${}^2P^\circ - {}^2D$	$\frac{1}{2}-\frac{3}{2}$		213
	3	157.472	55.6336+X – 690.672+X	$3s^23p^3 - 3s^23p^2(^1D)4s$	${}^2P^\circ - {}^2D$	$\frac{3}{2}-\frac{3}{2}$		213
	3	157.528	55.6336+X – 690.446+X	$3s^23p^3 - 3s^23p^2(^1D)4s$	${}^2P^\circ - {}^2D$	$\frac{3}{2}-\frac{5}{2}$		213
	1	160.914	54.1892+X – 675.631+X	$3s^23p^3 - 3s^23p^2(^3P)4s$	${}^2P^\circ - {}^2P$	$\frac{1}{2}-\frac{3}{2}$		213
	6	161.290	55.6336+X – 675.631+X	$3s^23p^3 - 3s^23p^2(^3P)4s$	${}^2P^\circ - {}^2P$	$\frac{3}{2}-\frac{3}{2}$		213

Ti VIII — Continued

Multiplet	Rel. Int.	λ_{vac} (in Å)	Levels (in 10^3 cm^{-1})	Configurations	Terms	J - J	Notes	References
	1	162.016	54.1892+X - 671.405+X	$3s^23p^3 - 3s^23p^2(^3P)4s$	$^2P^\circ - ^2P$	1/2 - 1/2		213
	1	162.401	55.6336+X - 671.405+X	$3s^23p^3 - 3s^23p^2(^3P)4s$	$^2P^\circ - ^2P$	3/2 - 1/2		358
	10	168.162	540.+D - 1134.664+D	$3s^23p^2(^3P)3d - 3s^23p^2(^3P)4f$	$^4F - ^4G^\circ$	7/2 - 9/2	Q	714,854
	10	168.192	540.+D - 1134.558+D	$3s^23p^2(^3P)3d - 3s^23p^2(^3P)4f$	$^4F - ^4G^\circ$	9/2 - 11/2	Q	714,854
	3	171.392	650.+S - 1233.457+S	$3s^23p^2(^1D)3d - 3s^23p^2(^1D)4f$	$^2G - ^2H^\circ$	7/2 - 9/2	Q	714,854
	3	171.723	650.+S - 1232.333+S	$3s^23p^2(^1D)3d - 3s^23p^2(^1D)4f$	$^2G - ^2H^\circ$	9/2 - 11/2	Q	714,854
	1	248.150	33.2564+X - 436.270+X	$3s^23p^3 - 3s^23p^2(^1S)3d$	$^2D^\circ - ^2D$	5/2 - 3/2	Q	714
	20	248.908	33.2564+X - 435.049+X	$3s^23p^3 - 3s^23p^2(^1S)3d$	$^2D^\circ - ^2D$	5/2 - 5/2	Q	714
	700	258.610	33.2564+X - 419.939+X	$3s^23p^3 - 3s^23p^2(^1D)3d$	$^2D^\circ - ^2F$	5/2 - 7/2		213
	6	259.311	33.2564+X - 418.873+X	$3s^23p^3 - 3s^23p^2(^1D)3d$	$^2D^\circ - ^2F$	5/2 - 5/2	Q	714
	1	260.829	32.1905+X - 415.589+X	$3s^23p^3 - 3s^23p^2(^1D)3d$	$^2D^\circ - ^2P$	3/2 - 3/2	Q	714
	1	261.578	33.2564+X - 415.589+X	$3s^23p^3 - 3s^23p^2(^1D)3d$	$^2D^\circ - ^2P$	5/2 - 3/2	Q	714
	60	261.725	54.1892+X - 436.270+X	$3s^23p^3 - 3s^23p^2(^1S)3d$	$^2P^\circ - ^2D$	1/2 - 3/2		213
	10	262.651	32.1905+X - 412.858+X	$3s^23p^3 - 3s^23p^2(^1D)3d$	$^2D^\circ - ^2P$	3/2 - 1/2	Q	714
	10	262.718	55.6336+X - 436.270+X	$3s^23p^3 - 3s^23p^2(^1S)3d$	$^2P^\circ - ^2D$	3/2 - 3/2		213
	120	263.564	55.6336+X - 435.049+X	$3s^23p^3 - 3s^23p^2(^1S)3d$	$^2P^\circ - ^2D$	3/2 - 5/2		213
	60	267.401	0. - 373.971	$3s^23p^3 - 3s^23p^2(^3P)3d$	$g^4S^\circ - ^4P$	3/2 - 1/2		213
	120	268.178	0. - 372.887	$3s^23p^3 - 3s^23p^2(^3P)3d$	$g^4S^\circ - ^4P$	3/2 - 3/2		213
	175	269.533	0. - 371.012	$3s^23p^3 - 3s^23p^2(^3P)3d$	$g^4S^\circ - ^4P$	3/2 - 5/2		213
	1	270.530	54.1892+X - 423.834+X	$3s^23p^3 - 3s^23p^2(^1D)3d$	$^2P^\circ - ^2S$	1/2 - 1/2		213
	3	271.591	55.6336+X - 423.834+X	$3s^23p^3 - 3s^23p^2(^1D)3d$	$^2P^\circ - ^2S$	3/2 - 1/2		213
	90	272.037	32.1905+X - 399.772+X	$3s^23p^3 - 3s^23p^2(^1D)3d$	$^2D^\circ - ^2D$	3/2 - 3/2		213
	10	272.369	32.1905+X - 399.323+X	$3s^23p^3 - 3s^23p^2(^1D)3d$	$^2D^\circ - ^2D$	3/2 - 5/2		213
	6	272.843	33.2564+X - 399.772+X	$3s^23p^3 - 3s^23p^2(^1D)3d$	$^2D^\circ - ^2D$	5/2 - 3/2		213
	90	273.178	33.2564+X - 399.323+X	$3s^23p^3 - 3s^23p^2(^1D)3d$	$^2D^\circ - ^2D$	5/2 - 5/2		213
	3	274.514						714
	10	276.701	54.1892+X - 415.589+X	$3s^23p^3 - 3s^23p^2(^1D)3d$	$^2P^\circ - ^2P$	1/2 - 3/2		213
	35	277.813	55.6336+X - 415.589+X	$3s^23p^3 - 3s^23p^2(^1D)3d$	$^2P^\circ - ^2P$	3/2 - 3/2		213
	20	278.806	54.1892+X - 412.858+X	$3s^23p^3 - 3s^23p^2(^1D)3d$	$^2P^\circ - ^2P$	1/2 - 1/2		213
	20	279.940	55.6336+X - 412.858+X	$3s^23p^3 - 3s^23p^2(^1D)3d$	$^2P^\circ - ^2P$	3/2 - 1/2		213
	1	289.375	54.1892+X - 399.772+X	$3s^23p^3 - 3s^23p^2(^1D)3d$	$^2P^\circ - ^2D$	1/2 - 3/2		213
	6	290.601	55.6336+X - 399.772+X	$3s^23p^3 - 3s^23p^2(^1D)3d$	$^2P^\circ - ^2D$	3/2 - 3/2	Q	714
	35	290.971	55.6336+X - 399.323+X	$3s^23p^3 - 3s^23p^2(^1D)3d$	$^2P^\circ - ^2D$	3/2 - 5/2		213
	20	297.197	32.1905+X - 368.663+X	$3s^23p^3 - 3s^23p^2(^3P)3d$	$^2D^\circ - ^2P$	3/2 - 1/2		213
	6	301.297	32.1905+X - 364.082+X	$3s^23p^3 - 3s^23p^2(^3P)3d$	$^2D^\circ - ^2P$	3/2 - 3/2		213
	60	302.272	33.2564+X - 364.082+X	$3s^23p^3 - 3s^23p^2(^3P)3d$	$^2D^\circ - ^2P$	5/2 - 3/2		213
	1	317.992	54.1892+X - 368.663+X	$3s^23p^3 - 3s^23p^2(^3P)3d$	$^2P^\circ - ^2P$	1/2 - 1/2		213
	1	319.463	55.6336+X - 368.663+X	$3s^23p^3 - 3s^23p^2(^3P)3d$	$^2P^\circ - ^2P$	3/2 - 1/2		213
	1	322.698	54.1892+X - 364.082+X	$3s^23p^3 - 3s^23p^2(^3P)3d$	$^2P^\circ - ^2P$	1/2 - 3/2		213
	1	324.207	55.6336+X - 364.082+X	$3s^23p^3 - 3s^23p^2(^3P)3d$	$^2P^\circ - ^2P$	3/2 - 3/2		213
	160	401.739	32.1905+X - 281.1081+X	$3s^23p^3 - 3s3p^4$	$^2D^\circ - ^2P$	3/2 - 1/2		726
	40	406.756	32.1905+X - 278.0377+X	$3s^23p^3 - 3s3p^4$	$^2D^\circ - ^2P$	3/2 - 3/2		726
	220	408.528	33.2564+X - 278.0377+X	$3s^23p^3 - 3s3p^4$	$^2D^\circ - ^2P$	5/2 - 3/2		726
	40	423.649	54.1892+X - 290.2336+X	$3s^23p^3 - 3s3p^4$	$^2P^\circ - ^2S$	1/2 - 1/2		726
	160	426.258	55.6336+X - 290.2336+X	$3s^23p^3 - 3s3p^4$	$^2P^\circ - ^2S$	3/2 - 1/2		726
	20	440.687	54.1892+X - 281.1081+X	$3s^23p^3 - 3s3p^4$	$^2P^\circ - ^2P$	1/2 - 1/2		726
	5	449.633	55.6336+X - 278.0377+X	$3s^23p^3 - 3s3p^4$	$^2P^\circ - ^2P$	3/2 - 3/2		726
	450	478.971	32.1905+X - 240.9716+X	$3s^23p^3 - 3s3p^4$	$^2D^\circ - ^2D$	3/2 - 3/2		726
	550	480.376	33.2564+X - 241.4260+X	$3s^23p^3 - 3s3p^4$	$^2D^\circ - ^2D$	5/2 - 5/2		726
	40	481.428	33.2564+X - 240.9716+X	$3s^23p^3 - 3s3p^4$	$^2D^\circ - ^2D$	5/2 - 3/2		726
	110	500.116	0. - 199.9536	$3s^23p^3 - 3s3p^4$	$g^4S^\circ - ^4P$	3/2 - 1/2		726
	285	504.801	0. - 198.0979	$3s^23p^3 - 3s3p^4$	$g^4S^\circ - ^4P$	3/2 - 3/2		726
	650	514.206	0. - 194.4746	$3s^23p^3 - 3s3p^4$	$g^4S^\circ - ^4P$	3/2 - 5/2		726
	5	535.381	54.1892+X - 240.9716+X	$3s^23p^3 - 3s3p^4$	$^2P^\circ - ^2D$	1/2 - 3/2		726

Ti VIII — Continued

Multiplet	Rel. Int.	λ_{vac} (in Å)	Levels (in 10^3 cm^{-1})	Configurations	Terms	J - J	Notes	References
	70	538.241	55.6336+X - 241.4260+X	$3s^23p^3$ - $3s3p^4$	$^2P^\circ$ - ^2D	$\frac{3}{2}$ - $\frac{5}{2}$		726
		1797.5	0. - 55.6336+X	$3s^23p^3$ - $3s^23p^3$	g^4S° - $^2P^\circ$	$\frac{3}{2}$ - $\frac{3}{2}$	F,P	375,726
		1845.4	0. - 54.1892+X	$3s^23p^3$ - $3s^23p^3$	g^4S° - $^2P^\circ$	$\frac{3}{2}$ - $\frac{1}{2}$	F,P	375,726

TITANIUM IX (Ti^{8+}), Z = 22
Ground State $1s^22s^22p^63s^23p^2(^3P_0)$ (14 electrons)
Ionization Potential 1 549 000 cm^{-1}; 192.1 eV

Multiplet	Rel. Int.	λ_{vac} (in Å)	Levels (in 10^3 cm^{-1})	Configurations	Terms	J - J	Notes	References
	10	110.283	7.282 - 914.047	$3s^23p^2$ - $3s^23p4d$	g^3P - $^3D^\circ$	2 - 3		714,854
	20	111.345	28.555 - 926.66	$3s^23p^2$ - $3s^23p4d$	^1D - $^1F^\circ$	2 - 3		714,854
	6	136.595	3.119 - 735.213	$3s^23p^2$ - $3s^23p4s$	g^3P - $^3P^\circ$	1 - 2		714,213
	3	137.153	0. - 729.112	$3s^23p^2$ - $3s^23p4s$	g^3P - $^3P^\circ$	0 - 1		714,213
	20	137.377	7.282 - 735.213	$3s^23p^2$ - $3s^23p4s$	g^3P - $^3P^\circ$	2 - 2		714,213
	1	137.743	3.119 - 729.112	$3s^23p^2$ - $3s^23p4s$	g^3P - $^3P^\circ$	1 - 1		714,213
	3	137.991	3.119 - 727.81	$3s^23p^2$ - $3s^23p4s$	g^3P - $^3P^\circ$	1 - 0		714,213
	10	138.548	7.282 - 729.112	$3s^23p^2$ - $3s^23p4s$	g^3P - $^3P^\circ$	2 - 1		714,213
	35	140.443	28.555 - 740.644	$3s^23p^2$ - $3s^23p4s$	^1D - $^1P^\circ$	2 - 1		714,213
	1	147.157	61.100 - 740.644	$3s^23p^2$ - $3s^23p4s$	^1S - $^1P^\circ$	0 - 1		714,213
		149.560	778.35+D - 1446.977+D	$3s^23p3d$ - $3s^23p4f$	$^3F^\circ$ - ^3G	4 - 5		854
	6	260.916	28.555 - 411.817	$3s^23p^2$ - $3s^23p3d$	^1D - $^1P^\circ$	2 - 1		714,213
	120	267.941	28.555 - 401.771	$3s^23p^2$ - $3s^23p3d$	^1D - $^1F^\circ$	2 - 3		714,213
	10	274.411	0. - 364.415	$3s^23p^2$ - $3s^23p3d$	g^3P - $^3D^\circ$	0 - 1		714,213
	60	275.867	3.119 - 365.617	$3s^23p^2$ - $3s^23p3d$	g^3P - $^3D^\circ$	1 - 2		714,213
	20	276.785	3.119 - 364.415	$3s^23p^2$ - $3s^23p3d$	g^3P - $^3D^\circ$	1 - 1		714,213
	225	278.713	7.282 - 366.081	$3s^23p^2$ - $3s^23p3d$	g^3P - $^3D^\circ$	2 - 3		714,213
	20	279.074	7.282 - 365.617	$3s^23p^2$ - $3s^23p3d$	g^3P - $^3D^\circ$	2 - 2		714,213
	20	280.027	7.282 - 364.415	$3s^23p^2$ - $3s^23p3d$	g^3P - $^3D^\circ$	2 - 1	Q	714,213
	3	280.141	0. - 356.963	$3s^23p^2$ - $3s^23p3d$	g^3P - $^3P^\circ$	0 - 1		714,213
	6	281.446	3.119 - 358.432	$3s^23p^2$ - $3s^23p3d$	g^3P - $^3P^\circ$	1 - 0		714,213
		282.613	3.119 - 356.963	$3s^23p^2$ - $3s^23p3d$	g^3P - $^3P^\circ$	1 - 1		714,213
	20	285.128	61.100 - 411.817	$3s^23p^2$ - $3s^23p3d$	^1S - $^1P^\circ$	0 - 1		714,213
	1	285.992	7.282 - 356.963	$3s^23p^2$ - $3s^23p3d$	g^3P - $^3P^\circ$	2 - 1		714,213
	20	286.112	3.119 - 352.635	$3s^23p^2$ - $3s^23p3d$	g^3P - $^3P^\circ$	1 - 2		714,213
	90	289.579	7.282 - 352.635	$3s^23p^2$ - $3s^23p3d$	g^3P - $^3P^\circ$	2 - 2		714,213
	1	304.498	28.555 - 356.963	$3s^23p^2$ - $3s^23p3d$	^1D - $^3P^\circ$	2 - 1		213
	35	308.568	28.555 - 352.635	$3s^23p^2$ - $3s^23p3d$	^1D - $^3P^\circ$	2 - 2		714,213
	1	324.712	3.119 - 311.087	$3s^23p^2$ - $3s3p^3$	g^3P - $^1P^\circ$	1 - 1		726
	20	329.159	7.282 - 311.087	$3s^23p^2$ - $3s3p^3$	g^3P - $^1P^\circ$	2 - 1		726
	110	333.385	0. - 299.944	$3s^23p^2$ - $3s3p^3$	g^3P - $^3S^\circ$	0 - 1		726
	160	336.895	3.119 - 299.944	$3s^23p^2$ - $3s3p^3$	g^3P - $^3S^\circ$	1 - 1		726
	220	341.691	7.282 - 299.944	$3s^23p^2$ - $3s3p^3$	g^3P - $^3S^\circ$	2 - 1		726
	70	353.942	28.555 - 311.087	$3s^23p^2$ - $3s3p^3$	^1D - $^1P^\circ$	2 - 1		726
	1	368.482	28.555 - 299.944	$3s^23p^2$ - $3s3p^3$	^1D - $^3S^\circ$	2 - 1		726
	220	400.041	61.100 - 311.087	$3s^23p^2$ - $3s3p^3$	^1S - $^1P^\circ$	0 - 1		726
	1	405.272	7.282 - 254.028	$3s^23p^2$ - $3s3p^3$	g^3P - $^1D^\circ$	2 - 2		726
	5	433.567	0. - 230.645	$3s^23p^2$ - $3s3p^3$	g^3P - $^3P^\circ$	0 - 1		726
	20	439.302	3.119 - 230.754	$3s^23p^2$ - $3s3p^3$	g^3P - $^3P^\circ$	1 - 2		726
	40	439.513	3.119 - 230.645	$3s^23p^2$ - $3s3p^3$	g^3P - $^3P^\circ$	1 - 1		726
	40	439.745	3.119 - 230.524	$3s^23p^2$ - $3s3p^3$	g^3P - $^3P^\circ$	1 - 0		726
	450	443.512	28.555 - 254.028	$3s^23p^2$ - $3s3p^3$	^1D - $^1D^\circ$	2 - 2		726

Ti IX — Continued

Multiplet	Rel. Int.	λ_{vac} (in Å)	Levels (in 10^3 cm^{-1})	Configurations	Terms	J - J	Notes	References
	160	447.484	7.282 – 230.754	$3s^23p^2 - 3s3p^3$	$g^3P - {}^3P^\circ$	2 – 2		726
	5	447.701	7.282 – 230.645	$3s^23p^2 - 3s3p^3$	$g^3P - {}^3P^\circ$	2 – 1		726
	20	499.479	0. – 200.209	$3s^23p^2 - 3s3p^3$	$g^3P - {}^3D^\circ$	0 – 1		726
	160	507.174	3.119 – 200.293	$3s^23p^2 - 3s3p^3$	$g^3P - {}^3D^\circ$	1 – 2		726
	285	507.365	3.119 – 200.209	$3s^23p^2 - 3s3p^3$	$g^3P - {}^3D^\circ$	1 – 1		726
	1	516.215	7.282 – 201.000	$3s^23p^2 - 3s3p^3$	$g^3P - {}^3D^\circ$	2 – 3		726
	1	518.100	7.282 – 200.293	$3s^23p^2 - 3s3p^3$	$g^3P - {}^3D^\circ$	2 – 2		726
	1	579.896	28.555 – 201.000	$3s^23p^2 - 3s3p^3$	${}^1D - {}^3D^\circ$	2 – 3		726
		1724.7	3.119 – 61.100	$3s^23p^2 - 3s^23p^2$	$g^3P - {}^1S$	1 – 0	F,P	375,726
		1858.1	7.282 – 61.100	$3s^23p^2 - 3s^23p^2$	$g^3P - {}^1S$	2 – 0	F,P	375,726

TITANIUM X (Ti^{9+}), Z = 22
Ground State $1s^22s^22p^63s^23p(^2P^\circ_{1/2})$ (13 electrons)
Ionization Potential 1 741 500 cm^{-1}; 215.9 eV

Multiplet	Rel. Int.	λ_{vac} (in Å)	Levels (in 10^3 cm^{-1})	Configurations	Terms	J - J	Notes	References
	0	70.265	0.0 – 1423.182	$3s^23p - 3s^26d$	$g^2P^\circ - {}^2D$	$\frac{1}{2}-\frac{3}{2}$		213
	1	70.625	7.543 – 1423.471	$3s^23p - 3s^26d$	$g^2P^\circ - {}^2D$	$\frac{3}{2}-\frac{5}{2}$		714,213
	1	78.655	0.0 – 1271.459	$3s^23p - 3s^25d$	$g^2P^\circ - {}^2D$	$\frac{1}{2}-\frac{3}{2}$		714,213
	3	79.110	7.543 – 1271.678	$3s^23p - 3s^25d$	$g^2P^\circ - {}^2D$	$\frac{3}{2}-\frac{5}{2}$		714,213
	6	84.711	0.0 – 1180.393	$3s^23p - 3s^25s$	$g^2P^\circ - {}^2S$	$\frac{1}{2}-\frac{1}{2}$		714,213
	10	85.262	7.543 – 1180.393	$3s^23p - 3s^25s$	$g^2P^\circ - {}^2S$	$\frac{3}{2}-\frac{1}{2}$		714,213
	0	91.806	345.329 – 1434.556	$3s^23d - 3s^26f$	${}^2D - {}^2F^\circ$	$\frac{3}{2}-\frac{5}{2}$		213
	0	91.855	345.856 – 1434.556	$3s^23d - 3s^26f$	${}^2D - {}^2F^\circ$	$\frac{5}{2}-\frac{7}{2}$		213
	35	101.353	0.0 – 986.656	$3s^23p - 3s^24d$	$g^2P^\circ - {}^2D$	$\frac{1}{2}-\frac{3}{2}$		714,213
	20	102.106	7.543 – 986.918	$3s^23p - 3s^24d$	$g^2P^\circ - {}^2D$	$\frac{3}{2}-\frac{5}{2}$		714,213
	0	104.516	345.329 – 1302.120	$3s^23d - 3s^25f$	${}^2D - {}^2F^\circ$	$\frac{3}{2}-\frac{5}{2}$		213
	0	104.568	345.856 – 1302.172	$3s^23d - 3s^25f$	${}^2D - {}^2F^\circ$	$\frac{5}{2}-\frac{7}{2}$		213
	3	108.886	505.134+X – 1423.471	$3s3p(^3P^\circ)3d - 3s^26d$	${}^4D^\circ - {}^2D$	$\frac{5}{2}-\frac{5}{2}$	Q	714
	1	113.374	164.764+X – 1046.694	$3s3p^2 - 3s^24f$	${}^4P - {}^2F^\circ$	$\frac{5}{2}-\frac{7}{2}$	Q	714
	1	119.822	212.055 – 1046.618	$3s3p^2 - 3s^24f$	${}^2D - {}^2F^\circ$	$\frac{3}{2}-\frac{5}{2}$		714,213
	6	119.891	212.606 – 1046.694	$3s3p^2 - 3s^24f$	${}^2D - {}^2F^\circ$	$\frac{5}{2}-\frac{7}{2}$		714,213
	6	123.036	160.655+X – 973.441+X	$3s3p^2 - 3s3p(^3P^\circ)4s$	${}^4P - {}^4P^\circ$	$\frac{3}{2}-\frac{5}{2}$		714,213
	3	123.331	157.850+X – 968.680+X	$3s3p^2 - 3s3p(^3P^\circ)4s$	${}^4P - {}^4P^\circ$	$\frac{1}{2}-\frac{3}{2}$		714,213
	6	123.657	164.764+X – 973.441+X	$3s3p^2 - 3s3p(^3P^\circ)4s$	${}^4P - {}^4P^\circ$	$\frac{5}{2}-\frac{5}{2}$		714,213
	3	123.703	157.850+X – 966.176+X	$3s3p^2 - 3s3p(^3P^\circ)4s$	${}^4P - {}^4P^\circ$	$\frac{1}{2}-\frac{1}{2}$		714,213
	3	124.143	160.655+X – 966.176+X	$3s3p^2 - 3s3p(^3P^\circ)4s$	${}^4P - {}^4P^\circ$	$\frac{3}{2}-\frac{1}{2}$		714,213
	6	124.391	164.764+X – 968.680+X	$3s3p^2 - 3s3p(^3P^\circ)4s$	${}^4P - {}^4P^\circ$	$\frac{5}{2}-\frac{3}{2}$		714,213
	10	125.456	0.0 – 797.112	$3s^23p - 3s^24s$	$g^2P^\circ - {}^2S$	$\frac{1}{2}-\frac{1}{2}$		714,213
	20	126.651	7.543 – 797.112	$3s^23p - 3s^24s$	$g^2P^\circ - {}^2S$	$\frac{3}{2}-\frac{1}{2}$		714,213
	3	142.595	345.329 – 1046.618	$3s^23d - 3s^24f$	${}^2D - {}^2F^\circ$	$\frac{3}{2}-\frac{5}{2}$		714,213
	10	142.687	345.856 – 1046.694	$3s^23d - 3s^24f$	${}^2D - {}^2F^\circ$	$\frac{5}{2}-\frac{7}{2}$		714,213
	6	265.574	1046.618 – 1423.182	$3s^24f - 3s^26d$	${}^2F^\circ - {}^2D$	$\frac{5}{2}-\frac{3}{2}$	Q	714
	1	288.462	157.850+X – 504.516+X	$3s3p^2 - 3s3p(^3P^\circ)3d$	${}^4P - {}^4D^\circ$	$\frac{1}{2}-\frac{3}{2}$		714,213
	90	289.579	0.0 – 345.329	$3s^23p - 3s^23d$	$g^2P^\circ - {}^2D$	$\frac{1}{2}-\frac{3}{2}$		714,213
	1	290.294	160.655+X – 505.134+X	$3s3p^2 - 3s3p(^3P^\circ)3d$	${}^4P - {}^4D^\circ$	$\frac{3}{2}-\frac{5}{2}$		714,213
	1	290.815	160.655+X – 504.516+X	$3s3p^2 - 3s3p(^3P^\circ)3d$	${}^4P - {}^4D^\circ$	$\frac{3}{2}-\frac{3}{2}$		714,213
	10	293.684	164.764+X – 505.266+X	$3s3p^2 - 3s3p(^3P^\circ)3d$	${}^4P - {}^4D^\circ$	$\frac{5}{2}-\frac{7}{2}$		714,213
	1	293.798	164.764+X – 505.134+X	$3s3p^2 - 3s3p(^3P^\circ)3d$	${}^4P - {}^4D^\circ$	$\frac{5}{2}-\frac{5}{2}$		714,213
	3	294.302	164.764+X – 504.516+X	$3s3p^2 - 3s3p(^3P^\circ)3d$	${}^4P - {}^4D^\circ$	$\frac{5}{2}-\frac{3}{2}$	Q	714
	35	295.584	7.543 – 345.856	$3s^23p - 3s^23d$	$g^2P^\circ - {}^2D$	$\frac{3}{2}-\frac{5}{2}$		714,213
	1	316.987	986.656 – 1302.120	$3s^24d - 3s^25f$	${}^2D - {}^2F^\circ$	$\frac{3}{2}-\frac{5}{2}$	Q	714

Ti X — Continued

Multiplet	Rel. Int.	λ_{vac} (in Å)	Levels (in 10^3 cm^{-1})	Configurations	Terms	J - J	Notes	References
	110	350.610	0.0 – 285.218	$3s^23p - 3s3p^2$	$g^2P^\circ - {}^2P$	$\frac{1}{2} - \frac{3}{2}$		726
	160	355.815	0.0 – 281.045	$3s^23p - 3s3p^2$	$g^2P^\circ - {}^2P$	$\frac{1}{2} - \frac{1}{2}$		726
	160	360.133	7.543 – 285.218	$3s^23p - 3s3p^2$	$g^2P^\circ - {}^2P$	$\frac{3}{2} - \frac{3}{2}$		726
	110	365.628	7.543 – 281.045	$3s^23p - 3s3p^2$	$g^2P^\circ - {}^2P$	$\frac{3}{2} - \frac{1}{2}$		726
	110	378.135	0.0 – 264.456	$3s^23p - 3s3p^2$	$g^2P^\circ - {}^2S$	$\frac{1}{2} - \frac{1}{2}$		726
		379.74	157.850+X – 421.188+X	$3s3p^2 - 3p^3$	${}^4P - {}^4S^\circ$	$\frac{1}{2} - \frac{3}{2}$		213
		383.83	160.655+X – 421.188+X	$3s3p^2 - 3p^3$	${}^4P - {}^4S^\circ$	$\frac{3}{2} - \frac{3}{2}$		375
	160	389.237	7.543 – 264.456	$3s^23p - 3s3p^2$	$g^2P^\circ - {}^2S$	$\frac{3}{2} - \frac{1}{2}$		726
		389.99	164.764+X – 421.188+X	$3s3p^2 - 3p^3$	${}^4P - {}^4S^\circ$	$\frac{5}{2} - \frac{3}{2}$		213
	110	471.574	0.0 – 212.055	$3s^23p - 3s3p^2$	$g^2P^\circ - {}^2D$	$\frac{1}{2} - \frac{3}{2}$		726
	160	487.654	7.543 – 212.606	$3s^23p - 3s3p^2$	$g^2P^\circ - {}^2D$	$\frac{3}{2} - \frac{5}{2}$		726
	1	488.971	7.543 – 212.055	$3s^23p - 3s3p^2$	$g^2P^\circ - {}^2D$	$\frac{3}{2} - \frac{3}{2}$		726

TITANIUM XI (Ti^{10+}), Z = 22
Ground State $1s^22s^22p^63s^2({}^1S_0)$ (12 electrons)
Ionization Potential 2 137 400 cm^{-1}; 265.0 eV

Multiplet	Rel. Int.	λ_{vac} (in Å)	Levels (in 10^3 cm^{-1})	Configurations	Terms	J - J	Notes	References
	1	52.218						714
	0	54.322	0.0 – 1840.882	$3s^2 - 3s7p$	$g^1S - {}^1P^\circ$	0 – 1		220
	0	57.891	0.0 – 1727.378	$3s^2 - 3s6p$	$g^1S - {}^1P^\circ$	0 – 1		220
	10	65.403	0.0 – 1528.982	$3s^2 - 3s5p$	$g^1S - {}^1P^\circ$	0 – 1		220
	1	71.201	173.097 – 1577.576	3s3p – 3s5d	${}^3P^\circ - {}^3D$	0 – 1		220
	10	71.323	175.650 – 1577.726	3s3p – 3s5d	${}^3P^\circ - {}^3D$	1 – 2		220
	40	71.603	181.296 – 1577.880	3s3p – 3s5d	${}^3P^\circ - {}^3D$	2 – 3		220
	1	73.281						714
	1	75.415	258.973 – 1584.967	3s3p – 3s5d	${}^1P^\circ - {}^1D$	1 – 2		220
	0	76.403	175.650 – 1484.522	3s3p – 3s5s	${}^3P^\circ - {}^3S$	1 – 1		220
	1	76.731	181.296 – 1484.522	3s3p – 3s5s	${}^3P^\circ - {}^3S$	2 – 1		220
	0	79.027	499.741 – 1765.165	3s3d – 3s6f	${}^3D - {}^3F^\circ$	1 – 2		220
	0	79.076	500.551 – 1765.165	3s3d – 3s6f	${}^3D - {}^3F^\circ$	3 – 4		220
	1	81.119	258.973 – 1491.736	3s3p – 3s5s	${}^1P^\circ - {}^1S$	1 – 0		220
	1	83.732	408.821 – 1603.135	$3p^2 - 3s5f$	${}^1D - {}^1F^\circ$	2 – 3		220
	0	84.321	175.650 – 1361.687	3s3p – 3p4p	${}^3P^\circ - {}^3S$	1 – 1		220
	0	84.433	175.650 – 1360.040	3s3p – 3p4p	${}^3P^\circ - {}^3P$	1 – 2		220
	0	84.525	173.097 – 1356.186	3s3p – 3p4p	${}^3P^\circ - {}^3P$	0 – 1		220
	40	84.711	181.296 – 1361.687	3s3p – 3p4p	${}^3P^\circ - {}^3S$	2 – 1		220
	40	84.835	181.296 – 1360.040	3s3p – 3p4p	${}^3P^\circ - {}^3P$	2 – 2		220
	0	84.876	175.650 – 1353.84	3s3p – 3p4p	${}^3P^\circ - {}^3P$	1 – 0		220
	0	85.114	181.296 – 1356.186	3s3p – 3p4p	${}^3P^\circ - {}^3P$	2 – 1		220
	10	85.290	181.296 – 1353.761	3s3p – 3p4p	${}^3P^\circ - {}^3D$	2 – 3		220
	250	87.725	0.0 – 1139.922	$3s^2 - 3s4p$	$g^1S - {}^1P^\circ$	0 – 1		220
	0	90.908	499.741 – 1599.75	3s3d – 3s5f	${}^3D - {}^3F^\circ$	1 – 2		220
	10	90.927	500.062 – 1599.841	3s3d – 3s5f	${}^3D - {}^3F^\circ$	2 – 3		220
	10	90.966	500.551 – 1599.86	3s3d – 3s5f	${}^3D - {}^3F^\circ$	3 – 4		220
	40	93.395	173.097 – 1243.822	3s3p – 3s4d	${}^3P^\circ - {}^3D$	0 – 1		220
	160	93.589	175.650 – 1244.159	3s3p – 3s4d	${}^3P^\circ - {}^3D$	1 – 2		220
	90	93.626	175.650 – 1243.822	3s3p – 3s4d	${}^3P^\circ - {}^3D$	1 – 1		220

Ti XI — Continued

Multiplet	Rel. Int.	λ_{vac} (in Å)	Levels (in 10^3 cm^{-1})	Configurations	Terms	J - J	Notes	References
	10	93.909	408.821 - 1473.62	$3p^2$ - 3p4d	^1D - $^1F^\circ$	2 - 3		714,970
	250	94.053	181.296 - 1244.532	3s3p - 3s4d	$^3P^\circ$ - ^3D	2 - 3		220
	10	94.085	181.296 - 1244.159	3s3p - 3s4d	$^3P^\circ$ - ^3D	2 - 2		220
	3	95.640	408.821 - 1454.38	$3p^2$ - 3p4d	^1D - $^3D^\circ$	2 - 3	Q	714,970
	3	95.929	410.535 - 1453.00	$3p^2$ - 3p4d	^3P - $^3D^\circ$	0 - 1		714,970
	1	96.170	414.049 - 1453.88	$3p^2$ - 3p4d	^3P - $^3D^\circ$	1 - 2	Q	714
	1	96.246	414.049 - 1453.00	$3p^2$ - 3p4d	^3P - $^3D^\circ$	1 - 1		714,970
	1	96.288	564.604 - 1603.135	3s3d - 3s5f	^1D - $^1F^\circ$	2 - 3		220
	3	96.731	420.598 - 1454.38	$3p^2$ - 3p4d	^3P - $^3D^\circ$	2 - 3		714,970
	1	97.142	499.741 - 1528.982	3s3d - 3s5p	^3D - $^1P^\circ$	1 - 1	Q	714,970
	40	100.591	258.973 - 1253.095	3s3p - 3s4d	$^1P^\circ$ - ^1D	1 - 2		220
	20	100.835	482.84 - 1474.56	$3p^2$ - 3p4d	^1S - $^1P^\circ$	0 - 1		714,970
	6	102.576	499.741 - 1474.56	3s3d - 3p4d	^3D - $^1P^\circ$	1 - 1	Q	714
	6	109.904	564.604 - 1474.56	3s3d - 3p4d	^1D - $^1P^\circ$	2 - 1	Q	714,970
	1	110.019	564.604 - 1473.62	3s3d - 3p4d	^1D - $^1F^\circ$	2 - 3		714,970
	40	111.664	408.821 - 1304.362	$3p^2$ - 3s4f	^1D - $^1F^\circ$	2 - 3		220
	40	113.940	173.097 - 1050.752	3s3p - 3s4s	$^3P^\circ$ - ^3S	0 - 1		220
	90	114.272	175.650 - 1050.752	3s3p - 3s4s	$^3P^\circ$ - ^3S	1 - 1		220
	160	115.015	181.296 - 1050.752	3s3p - 3s4s	$^3P^\circ$ - ^3S	2 - 1		220
	0	116.028	414.049 - 1275.944	$3p^2$ - 3p4s	^3P - $^3P^\circ$	1 - 2		220
	0	116.387	410.535 - 1269.740	$3p^2$ - 3p4s	^3P - $^3P^\circ$	0 - 1		220
	40	116.910	420.598 - 1275.944	$3p^2$ - 3p4s	^3P - $^3P^\circ$	2 - 2		220
	0	117.171	414.049 - 1267.503	$3p^2$ - 3p4s	^3P - $^3P^\circ$	1 - 0		220
	10	122.894	691.88 - 1505.52	3p3d - 3p4f	$^3F^\circ$ - ^3G	4 - 5		714,899
	6	123.063	687.48 - 1500.03	3p3d - 3p4f	$^3F^\circ$ - ^3G	3 - 4		714,899
	40	123.946	258.973 - 1065.777	3s3p - 3s4s	$^1P^\circ$ - ^1S	1 - 0		220
	40	125.940	499.741 - 1293.772	3s3d - 3s4f	^3D - $^3F^\circ$	1 - 2		220
	160	125.979	500.062 - 1293.84	3s3d - 3s4f	^3D - $^3F^\circ$	2 - 3		220
	250	126.042	500.551 - 1293.940	3s3d - 3s4f	^3D - $^3F^\circ$	3 - 4		220
	1	126.566	1050.752 - 1840.882	3s4s - 3s7p	^3S - $^1P^\circ$	1 - 1	Q	714
		127.268	728.82 - 1514.56	3p3d - 3p4f	$^3D^\circ$ - ^3D	2 - 2		899
	3	128.871	500.062 - 1275.944	3s3d - 3p4s	^3D - $^3P^\circ$	2 - 2	Q	714,970
		129.055	730.44 - 1505.32	3p3d - 3p4f	$^3D^\circ$ - ^3F	3 - 4		899
	3	134.701	692.00+K - 1434.37+K	3p3d - 3p4f	$^1F^\circ$ - ^1G	3 - 4		714,899
	90	135.179	564.604 - 1304.362	3s3d - 3s4f	^1D - $^1F^\circ$	2 - 3		220
	3	158.042	727.31 - 1360.040	3p3d - 3p4p	$^3P^\circ$ - ^3P	2 - 2	Q	714
	1	190.181	727.31 - 1253.095	3p3d - 3s4d	$^3P^\circ$ - ^1D	2 - 2	Q	714,220
	1	194.039	728.82 - 1244.159	3p3d - 3s4d	$^3D^\circ$ - ^3D	2 - 2	Q	714
	1	258.267	1065.777 - 1453.00	3s4s - 3p4d	^1S - $^3D^\circ$	0 - 1	Q	714,970
	6	285.672	1253.095 - 1603.135	3s4d - 3s5f	^1D - $^1F^\circ$	2 - 3	Q	714
	1	292.901	408.821 - 750.22	$3p^2$ - 3p3d	^1D - $^1P^\circ$	2 - 1	Q	714,375
	1	306.144	173.097 - 499.741	3s3p - 3s3d	$^3P^\circ$ - ^3D	0 - 1		220
	90	308.250	175.650 - 500.062	3s3p - 3s3d	$^3P^\circ$ - ^3D	1 - 2		220
	250	308.568	175.650 - 499.741	3s3p - 3s3d	$^3P^\circ$ - ^3D	1 - 1		220
	90	313.229	181.296 - 500.551	3s3p - 3s3d	$^3P^\circ$ - ^3D	2 - 3		220
	1	313.710	181.296 - 500.062	3s3p - 3s3d	$^3P^\circ$ - ^3D	2 - 2		220
		322.75	420.598 - 730.44	$3p^2$ - 3p3d	^3P - $^3D^\circ$	2 - 3		251
	10	327.192	258.973 - 564.604	3s3p - 3s3d	$^1P^\circ$ - ^1D	1 - 2		220
		349.91	408.821 - 694.61	$3p^2$ - 3p3d	^1D - $^1D^\circ$	2 - 2		251
		374.00	482.84 - 750.22	$3p^2$ - 3p3d	^1S - $^1P^\circ$	0 - 1		251
	10	386.140	0.0 - 258.973	$3s^2$ - 3s3p	g^1S - $^1P^\circ$	0 - 1		220
		408.25	175.650 - 420.598	3s3p - $3p^2$	$^3P^\circ$ - ^3P	1 - 2	P	270
		415.02	173.097 - 414.049	3s3p - $3p^2$	$^3P^\circ$ - ^3P	0 - 1	P	270
		417.88	181.296 - 420.598	3s3p - $3p^2$	$^3P^\circ$ - ^3P	2 - 2	P	270

Ti XI — Continued

Multiplet	Rel. Int.	λ_{vac} (in Å)	Levels (in 10^3 cm^{-1})	Configurations	Terms	J - J	Notes	References
		419.46	175.650 – 414.049	$3s3p - 3p^2$	$^3P^\circ - ^3P$	1 - 1	P	270
		425.74	175.650 – 410.535	$3s3p - 3p^2$	$^3P^\circ - ^3P$	1 – 0		270
		429.64	181.296 – 414.049	$3s3p - 3p^2$	$^3P^\circ - ^3P$	2 – 1	P	270
		434.99	500.551 – 730.44	$3s3d - 3p3d$	$^3D - ^3D^\circ$	3 – 3	P	251
		446.69	258.973 – 482.84	$3s3p - 3p^2$	$^1P^\circ - ^1S$	1 – 0		251
		522.66	500.551 – 691.88	$3s3d - 3p3d$	$^3D - ^3F^\circ$	3 – 4		251
		533.57	500.062 – 687.48	$3s3d - 3p3d$	$^3D - ^3F^\circ$	2 – 3	P	251
		543.24	499.741 – 683.82	$3s3d - 3p3d$	$^3D - ^3F^\circ$	1 – 2	P	251
		569.3	0.0 – 175.650	$3s^2 - 3s3p$	$g^1S - ^3P^\circ$	0 – 1		1131
		667.34	258.973 – 408.821	$3s3p - 3p^2$	$^1P^\circ - ^1D$	1 – 2	P	375,220

TITANIUM XII (Ti^{11+}), Z = 22
Ground State $1s^22s^22p^63s(^2S_{1/2})$ (11 electrons)
Ionization Potential 2 351 100 cm^{-1}; 291.502 eV

Multiplet	Rel. Int.	λ_{vac} (in Å)	Levels (in 10^3 cm^{-1})	Configurations	Terms	J - J	Notes	References
	3	26.574						979
	8	26.733						979
	10	26.847	217.042 – 3941.9	$2p^63p - 2p^53s(^3P^\circ)3p$	$^2P^\circ - ^2D$	$\frac{3}{2}-\frac{3}{2}$		979
	8	26.870	501.922 – 4223.5	$2p^63d - 2p^53s(^3P^\circ)3d$	$^2D - ^2P^\circ$	$\frac{3}{2}-\frac{3}{2}$		979
	6	27.052	502.814 – 4199.4	$2p^63d - 2p^53s(^3P^\circ)3d$	$^2D - ^2F^\circ$	$\frac{5}{2}-\frac{5}{2}$		979
	10	27.125	0. – 3686.6	$2p^63s - 2p^53s^2$	$g^2S - ^2P^\circ$	$\frac{1}{2}-\frac{1}{2}$		979
	10	27.151	502.814 – 4185.9	$2p^63d - 2p^53s(^3P^\circ)3d$	$^2D - ^2D^\circ$	$\frac{5}{2}-\frac{3}{2}$		979
	17	27.228	217.042 – 3889.7	$2p^63p - 2p^53s(^3P^\circ)3p$	$^2P^\circ - ^2D$	$\frac{3}{2}-\frac{5}{2}$		979
	24	27.305	502.814 – 4165.1	$2p^63d - 2p^53s(^1P^\circ)3d$	$^2D - ^2F^\circ$	$\frac{5}{2}-\frac{7}{2}$		979
	9	27.346	501.922 – 4158.8	$2p^63d - 2p^53s(^3P^\circ)3d$	$^2D - ^4D^\circ$	$\frac{3}{2}-\frac{5}{2}$		979
	4	27.434	217.042 – 3863.7	$2p^63p - 2p^53s(^1P^\circ)3p$	$^2P^\circ - ^2S$	$\frac{3}{2}-\frac{1}{2}$		979
	6	27.459	0. – 3641.8	$2p^63s - 2p^53s^2$	$g^2S - ^2P^\circ$	$\frac{1}{2}-\frac{3}{2}$		979
	20	27.499	217.042 – 3853.5	$2p^63p - 2p^53s(^1P^\circ)3p$	$^2P^\circ - ^2D$	$\frac{3}{2}-\frac{5}{2}$		979
	9	27.537	502.814 – 4134.3	$2p^63d - 2p^53s(^1P^\circ)3d$	$^2D - ^2P^\circ$	$\frac{5}{2}-\frac{3}{2}$		979
	20	27.584	501.922 – 4127.2	$2p^63d - 2p^53s(^1P^\circ)3d$	$^2D - ^2P^\circ$	$\frac{3}{2}-\frac{1}{2}$		979
	9	27.601	501.922 – 4124.4	$2p^63d - 2p^53s(^1P^\circ)3d$	$^2D - ^2F^\circ$	$\frac{3}{2}-\frac{5}{2}$		979
	9	27.617	502.814 – 4124.4	$2p^63d - 2p^53s(^1P^\circ)3d$	$^2D - ^2F^\circ$	$\frac{5}{2}-\frac{5}{2}$		979
	5	27.649	501.922 – 4118.7	$2p^63d - 2p^53s(^3P^\circ)3d$	$^2D - ^4F^\circ$	$\frac{3}{2}-\frac{3}{2}$		979
	6	27.707	501.922 – 4111.1	$2p^63d - 2p^53s(^3P^\circ)3d$	$^2D - ^4F^\circ$	$\frac{3}{2}-\frac{5}{2}$		979
	10	27.740	208.385 – 3813.3	$2p^63p - 2p^53s(^1P^\circ)3p$	$^2P^\circ - ^2D$	$\frac{1}{2}-\frac{3}{2}$		979
	5	27.758	502.814 – 4105.4	$2p^63d - 2p^53s(^3P^\circ)3d$	$^2D - ^4F^\circ$	$\frac{5}{2}-\frac{7}{2}$		979
	15	27.803	208.385 – 3805.1	$2p^63p - 2p^53s(^3P^\circ)3p$	$^2P^\circ - ^4D$	$\frac{1}{2}-\frac{1}{2}$		979
	14	27.820	217.042 – 3811.5	$2p^63p - 2p^53s(^3P^\circ)3p$	$^2P^\circ - ^4P$	$\frac{3}{2}-\frac{5}{2}$		979
	10	27.863	208.385 – 3797.4	$2p^63p - 2p^53s(^3P^\circ)3p$	$^2P^\circ - ^4D$	$\frac{1}{2}-\frac{3}{2}$		979
	7	27.971	217.042 – 3792.2	$2p^63p - 2p^53s(^3P^\circ)3p$	$^2P^\circ - ^4D$	$\frac{3}{2}-\frac{5}{2}$		979
	0	28.000						265
	10	28.123						979
	2	28.150						979
		45.167	0. – 2214.005	$2p^63s - 2p^611p$	$g^2S - ^2P^\circ$	$\frac{1}{2}-\frac{3}{2}$		118
		45.783	0. – 2184.216	$2p^63s - 2p^610p$	$g^2S - ^2P^\circ$	$\frac{1}{2}-\frac{3}{2}$		118
		46.641	0. – 2144.036	$2p^63s - 2p^69p$	$g^2S - ^2P^\circ$	$\frac{1}{2}-\frac{3}{2}$		118
		47.906	0. – 2087.421	$2p^63s - 2p^68p$	$g^2S - ^2P^\circ$	$\frac{1}{2}-\frac{3}{2}$		118
		49.912	0. – 2003.526	$2p^63s - 2p^67p$	$g^2S - ^2P^\circ$	$\frac{1}{2}-\frac{3}{2}$		118
		50.448	208.385 – 2190.624	$2p^63p - 2p^610d$	$^2P^\circ - ^2D$	$\frac{1}{2}-\frac{3}{2}$		118
		50.674	217.042 – 2190.440	$2p^63p - 2p^610d$	$^2P^\circ - ^2D$	$\frac{3}{2}-\frac{5}{2}$		118
		51.446	208.385 – 2152.170	$2p^63p - 2p^69d$	$^2P^\circ - ^2D$	$\frac{1}{2}-\frac{3}{2}$		118

Tl XII — Continued

Multiplet	Rel. Int.	λ_{vac} (in Å)	Levels (in 10^3 cm^{-1})	Configurations	Terms	J - J	Notes	References
		51.669	217.042 – 2152.438	$2p^63p - 2p^69d$	$^2P^\circ - ^2D$	$\frac{3}{2} - \frac{5}{2}$		118
	1	52.896	208.385 – 2098.875	$2p^63p - 2p^68d$	$^2P^\circ - ^2D$	$\frac{1}{2} - \frac{3}{2}$		230
	1	53.140	217.042 – 2098.875	$2p^63p - 2p^68d$	$^2P^\circ - ^2D$	$\frac{3}{2} - \frac{5}{2}$		230
	3	53.433	0. – 1871.489	$2p^63s - 2p^66p$	$g^2S - ^2P^\circ$	$\frac{1}{2} - \frac{3}{2}$		230
	1	53.457	0. – 1870.655	$2p^63s - 2p^66p$	$g^2S - ^2P^\circ$	$\frac{1}{2} - \frac{1}{2}$		230
	3	55.443	217.042 – 2020.686	$2p^63p - 2p^67d$	$^2P^\circ - ^2D$	$\frac{3}{2} - \frac{5}{2}$		230
	2	56.161	208.385 – 1989.049	$2p^63p - 2p^67s$	$^2P^\circ - ^2S$	$\frac{1}{2} - \frac{1}{2}$		118
	7	59.133	208.385 – 1899.497	$2p^63p - 2p^66d$	$^2P^\circ - ^2D$	$\frac{1}{2} - \frac{3}{2}$		230
	15	59.435	217.042 – 1899.544	$2p^63p - 2p^66d$	$^2P^\circ - ^2D$	$\frac{3}{2} - \frac{5}{2}$		230
	15	60.701	0. – 1647.436	$2p^63s - 2p^65p$	$g^2S - ^2P^\circ$	$\frac{1}{2} - \frac{3}{2}$		230
	3	60.762	0. – 1645.759	$2p^63s - 2p^65p$	$g^2S - ^2P^\circ$	$\frac{1}{2} - \frac{1}{2}$		230
	1	60.971	208.385 – 1848.641	$2p^63p - 2p^66s$	$^2P^\circ - ^2S$	$\frac{1}{2} - \frac{1}{2}$		230
	1	61.286	217.042 – 1848.641	$2p^63p - 2p^66s$	$^2P^\circ - ^2S$	$\frac{3}{2} - \frac{1}{2}$		230
	1	62.433	501.922 – 2103.592	$2p^63d - 2p^68f$	$^2D - ^2F^\circ$	$\frac{3}{2} - \frac{5}{2}$		230
	1	62.470	502.814 – 2103.612	$2p^63d - 2p^68f$	$^2D - ^2F^\circ$	$\frac{5}{2} - \frac{7}{2}$		230
	1	65.540	501.922 – 2027.701	$2p^63d - 2p^67f$	$^2D - ^2F^\circ$	$\frac{3}{2} - \frac{5}{2}$		230
	3	65.577	502.814 – 2027.730	$2p^63d - 2p^67f$	$^2D - ^2F^\circ$	$\frac{5}{2} - \frac{7}{2}$		230
	15	67.171	208.385 – 1697.112	$2p^63p - 2p^65d$	$^2P^\circ - ^2D$	$\frac{1}{2} - \frac{3}{2}$		230
	40	67.555	217.042 – 1697.315	$2p^63p - 2p^65d$	$^2P^\circ - ^2D$	$\frac{3}{2} - \frac{5}{2}$		230
	3	70.986	501.922 – 1910.628	$2p^63d - 2p^66f$	$^2D - ^2F^\circ$	$\frac{3}{2} - \frac{5}{2}$		230
	7	71.031	502.814 – 1910.675	$2p^63d - 2p^66f$	$^2D - ^2F^\circ$	$\frac{5}{2} - \frac{7}{2}$		230
	1	71.545	208.385 – 1606.155	$2p^63p - 2p^65s$	$^2P^\circ - ^2S$	$\frac{1}{2} - \frac{1}{2}$		230
	3	71.987	217.042 – 1606.155	$2p^63p - 2p^65s$	$^2P^\circ - ^2S$	$\frac{3}{2} - \frac{1}{2}$		230
	80	82.121	0. – 1217.699	$2p^63s - 2p^64p$	$g^2S - ^2P^\circ$	$\frac{1}{2} - \frac{3}{2}$		230
	7	82.307	501.922 – 1716.838	$2p^63d - 2p^65f$	$^2D - ^2F^\circ$	$\frac{3}{2} - \frac{5}{2}$		230
	25	82.344	0. – 1214.388	$2p^63s - 2p^64p$	$g^2S - ^2P^\circ$	$\frac{1}{2} - \frac{1}{2}$		230
	7	82.368	502.814 – 1716.919	$2p^63d - 2p^65f$	$^2D - ^2F^\circ$	$\frac{5}{2} - \frac{7}{2}$		230
	1	87.364	502.814 – 1647.436	$2p^63d - 2p^65p$	$^2D - ^2P^\circ$	$\frac{5}{2} - \frac{3}{2}$		230
	1	87.426	501.922 – 1645.759	$2p^63d - 2p^65p$	$^2D - ^2P^\circ$	$\frac{3}{2} - \frac{1}{2}$		230
	60	89.844	208.385 – 1321.432	$2p^63p - 2p^64d$	$^2P^\circ - ^2D$	$\frac{1}{2} - \frac{3}{2}$		230
	80	90.512	217.042 – 1321.872	$2p^63p - 2p^64d$	$^2P^\circ - ^2D$	$\frac{3}{2} - \frac{5}{2}$		230
	7	90.547	217.042 – 1321.432	$2p^63p - 2p^64d$	$^2P^\circ - ^2D$	$\frac{3}{2} - \frac{3}{2}$		230
	15	108.086	208.385 – 1133.573	$2p^63p - 2p^64s$	$^2P^\circ - ^2S$	$\frac{1}{2} - \frac{1}{2}$		230
	40	109.107	217.042 – 1133.573	$2p^63p - 2p^64s$	$^2P^\circ - ^2S$	$\frac{3}{2} - \frac{1}{2}$		230
	60	116.497	501.922 – 1360.313	$2p^63d - 2p^64f$	$^2D - ^2F^\circ$	$\frac{3}{2} - \frac{5}{2}$		230
	80	116.597	502.814 – 1360.471	$2p^63d - 2p^64f$	$^2D - ^2F^\circ$	$\frac{5}{2} - \frac{7}{2}$		230
	3	121.622	1321.872 – 2144.036	$2p^64d - 2p^69p$	$^2D - ^2P^\circ$	$\frac{5}{2} - \frac{3}{2}$	Q	714
	1	124.555	1217.699 – 2020.686	$2p^64p - 2p^67d$	$^2P^\circ - ^2D$	$\frac{3}{2} - \frac{5}{2}$	Q	714
	1	126.276	1360.471 – 2152.438	$2p^64f - 2p^69d$	$^2F^\circ - ^2D$	$\frac{7}{2} - \frac{5}{2}$	Q	714
	3	139.884	502.814 – 1217.699	$2p^63d - 2p^64p$	$^2D - ^2P^\circ$	$\frac{5}{2} - \frac{3}{2}$		230
	1	140.361	501.922 – 1214.388	$2p^63d - 2p^64p$	$^2D - ^2P^\circ$	$\frac{3}{2} - \frac{1}{2}$		230
	3	229.619	1716.919 – 2152.438	$2p^65f - 2p^69d$	$^2F^\circ - ^2D$	$\frac{7}{2} - \frac{5}{2}$	Q	714
	35	253.142	1321.872 – 1716.919	$2p^64d - 2p^65f$	$^2D - ^2F^\circ$	$\frac{5}{2} - \frac{7}{2}$		714
	3	256.338	1697.315 – 2087.421	$2p^65d - 2p^68p$	$^2D - ^2P^\circ$	$\frac{5}{2} - \frac{3}{2}$	Q	714
	6	257.430	1217.699 – 1606.155	$2p^64p - 2p^65s$	$^2P^\circ - ^2S$	$\frac{3}{2} - \frac{1}{2}$	Q	714
	80	340.672	208.385 – 501.922	$2p^63p - 2p^63d$	$^2P^\circ - ^2D$	$\frac{1}{2} - \frac{3}{2}$		230
	130	349.929	217.042 – 502.814	$2p^63p - 2p^63d$	$^2P^\circ - ^2D$	$\frac{3}{2} - \frac{5}{2}$		230
	7	351.024	217.042 – 501.922	$2p^63p - 2p^63d$	$^2P^\circ - ^2D$	$\frac{3}{2} - \frac{3}{2}$		230
	230	460.741	0. – 217.042	$2p^63s - 2p^63p$	$g^2S - ^2P^\circ$	$\frac{1}{2} - \frac{3}{2}$		230
	160	479.881	0. – 208.385	$2p^63s - 2p^63p$	$g^2S - ^2P^\circ$	$\frac{1}{2} - \frac{1}{2}$		230
	1	959.945	1217.699 – 1321.872	$2p^64p - 2p^64d$	$^2P^\circ - ^2D$	$\frac{3}{2} - \frac{5}{2}$		230

TITANIUM XIII (Ti^{12+}), Z = 22
Ground State $1s^22s^22p^6(^1S_0)$ (10 electrons)
Ionization Potential 6 354 300 cm^{-1}; 787.84 eV

Multiplet	Rel. Int.	λ_{vac} (in Å)	Levels (in 10^3 cm^{-1})	Configurations	Terms	J - J	Notes	References
	100	17.727	0.0 - 5641.1	$2s^22p^6 - 2s^22p^5(^2P^\circ_{1/2})5d$	$g^1S - \frac{1}{2}[\frac{3}{2}]^\circ$	0 - 1		232
	50	17.869	0.0 - 5596.3	$2s^22p^6 - 2s^22p^5(^2P^\circ_{3/2})5d$	$g^1S - \frac{3}{2}[\frac{3}{2}]^\circ$	0 - 1		232
	250	19.204	0.0 - 5207.2	$2s^22p^6 - 2s^22p^5(^2P^\circ_{1/2})4d$	$g^1S - \frac{1}{2}[\frac{3}{2}]^\circ$	0 - 1		232
	200	19.366	0.0 - 5163.7	$2s^22p^6 - 2s^22p^5(^2P^\circ_{3/2})4d$	$g^1S - \frac{3}{2}[\frac{3}{2}]^\circ$	0 - 1		232
	50	19.943	0.0 - 5014.3	$2s^22p^6 - 2s^22p^5(^2P^\circ_{1/2})4s$	$g^1S - (\frac{1}{2},\frac{1}{2})^\circ$	0 - 1		232
	50	20.135	0.0 - 4966.5	$2s^22p^6 - 2s^22p^5(^2P^\circ_{3/2})4s$	$g^1S - (\frac{3}{2},\frac{1}{2})^\circ$	0 - 1		232
	350	21.035	0.0 - 4754.0	$2s^22p^6 - 2s2p^63p$	$g^1S - {}^1P^\circ$	0 - 1		232
	100	21.127	0.0 - 4733.3	$2s^22p^6 - 2s2p^63p$	$g^1S - {}^3P^\circ$	0 - 1		232
		23.356	0.0 - 4281.6	$2s^22p^6 - 2s^22p^5(^2P^\circ_{1/2})3d$	$g^1S - \frac{1}{2}[\frac{3}{2}]^\circ$	0 - 1		189
		23.698	0.0 - 4219.8	$2s^22p^6 - 2s^22p^5(^2P^\circ_{3/2})3d$	$g^1S - \frac{3}{2}[\frac{3}{2}]^\circ$	0 - 1		189
		23.991	0.0 - 4168.2	$2s^22p^6 - 2s^22p^5(^2P^\circ_{3/2})3d$	$g^1S - \frac{3}{2}[\frac{1}{2}]^\circ$	0 - 1		189
		26.641	0.0 - 3753.6	$2s^22p^6 - 2s^22p^5(^2P^\circ_{1/2})3s$	$g^1S - (\frac{1}{2},\frac{1}{2})^\circ$	0 - 1		189
		26.960	0.0 - 3709.2	$2s^22p^6 - 2s^22p^5(^2P^\circ_{3/2})3s$	$g^1S - (\frac{3}{2},\frac{1}{2})^\circ$	0 - 1		189
		70.05	4178.4+C - 5606.0+C	$2s^22p^5(^2P^\circ)3d - 2s^22p^5(^2P^\circ_{3/2})5f$	${}^3F^\circ - \frac{3}{2}[\frac{9}{2}]$	4 - 5		1055
		74.08	3693.3+C - 5043.2+C	$2s^22p^5(^2P^\circ_{3/2})3s - 2s^22p^5(^2P^\circ_{3/2})4p$	$\frac{3}{2}[\frac{3}{2}]^\circ - \frac{3}{2}[\frac{5}{2}]$	2 - 3		1055
		74.42	3753.6 - 5097.3	$2s^22p^5(^2P^\circ_{1/2})3s - 2s^22p^5(^2P^\circ_{3/2})4p$	$(\frac{1}{2},\frac{1}{2})^\circ - \frac{3}{2}[\frac{3}{2}]$	1 - 2		1055
		74.59	3709.2 - 5049.9	$2s^22p^5(^2P^\circ_{3/2})3s - 2s^22p^5(^2P^\circ_{3/2})4p$	$(\frac{3}{2},\frac{1}{2})^\circ - \frac{3}{2}[\frac{3}{2}]$	1 - 1		1055
		74.74	3709.2 - 5047.2	$2s^22p^5(^2P^\circ_{3/2})3s - 2s^22p^5(^2P^\circ_{3/2})4p$	$(\frac{3}{2},\frac{1}{2})^\circ - \frac{3}{2}[\frac{5}{2}]$	1 - 2		1055
		80.290	3904.0+C - 5149.5+C	$2s^22p^5(^2P^\circ)3p - 2s^22p^5(^2P^\circ)4d$	${}^3D - {}^3F^\circ$	3 - 4		395
		80.494	3912.9+C - 5155.2+C	$2s^22p^5(^2P^\circ)3p - 2s^22p^5(^2P^\circ)4d$	${}^1P - {}^1D^\circ$	1 - 2		395
		80.602	3900.7+C - 5141.4+C	$2s^22p^5(^2P^\circ)3p - 2s^22p^5(^2P^\circ)4d$	${}^3D - {}^3D^\circ$	2 - 3		395
		81.153	3964.8+C - 5197.0+C	$2s^22p^5(^2P^\circ)3p - 2s^22p^5(^2P^\circ)4d$	${}^3P - {}^3F^\circ$	1 - 2		395
		81.255	3965.8+C - 5196.5+C	$2s^22p^5(^2P^\circ)3p - 2s^22p^5(^2P^\circ)4d$	${}^1D - {}^1F^\circ$	2 - 3		395
		81.318	3950.2+C - 5179.9+C	$2s^22p^5(^2P^\circ)3p - 2s^22p^5(^2P^\circ)4d$	${}^3D - {}^3D^\circ$	1 - 2		395
		81.611	3921.9+C - 5147.2+C	$2s^22p^5(^2P^\circ)3p - 2s^22p^5(^2P^\circ)4d$	${}^3P - {}^3F^\circ$	2 - 3		395
		94.78	3904.0+C - 4959.1+C	$2s^22p^5(^2P^\circ)3p - 2s^22p^5(^2P^\circ_{3/2})4s$	${}^3D - \frac{3}{2}[\frac{3}{2}]^\circ$	3 - 2		1055
		98.76	4169.9+C - 5182.5+C	$2s^22p^5(^2P^\circ)3d - 2s^22p^5(^2P^\circ_{3/2})4f$	${}^3P^\circ - \frac{3}{2}[\frac{5}{2}]$	2 - 3		1055
		99.09	4169.9+C - 5179.1+C	$2s^22p^5(^2P^\circ)3d - 2s^22p^5(^2P^\circ_{3/2})4f$	${}^3P^\circ - \frac{3}{2}[\frac{3}{2}]$	2 - 2		1055
		99.60	4183.2+C - 5187.2+C	$2s^22p^5(^2P^\circ)3d - 2s^22p^5(^2P^\circ_{3/2})4f$	${}^3F^\circ - \frac{3}{2}[\frac{9}{2}]$	3 - 4		1055
		99.85	4242.8+C - 5244.3+C	$2s^22p^5(^2P^\circ)3d - 2s^22p^5(^2P^\circ_{1/2})4f$	${}^1D^\circ - \frac{1}{2}[\frac{5}{2}]$	2 - 3		1055
		100.16	4226.8+C - 5225.2+C	$2s^22p^5(^2P^\circ)3d - 2s^22p^5(^2P^\circ_{3/2})4f$	${}^3D^\circ - \frac{3}{2}[\frac{7}{2}]$	2 - 3		1055
		100.78	4197.9+C - 5190.2+C	$2s^22p^5(^2P^\circ)3d - 2s^22p^5(^2P^\circ_{3/2})4f$	${}^3D^\circ - \frac{3}{2}[\frac{7}{2}]$	3 - 4		1055

TITANIUM XIV (Ti^{13+}), Z = 22
Ground State $1s^22s^22p^5(^2P^\circ_{3/2})$ (9 electrons)
Ionization Potential [6 961 000] cm^{-1}; [863.1] eV

Multiplet	Rel. Int.	λ_{vac} (in Å)	Levels (in 10^3 cm^{-1})	Configurations	Terms	J - J	Notes	References
		17.58	0.0 - 5688.3	$2s^22p^5 - 2s^22p^4(^3P)4d$	$g^2P^\circ - {}^2P$	$\frac{3}{2} - \frac{3}{2}$		245
		17.73	0.0 - 5640.2	$2s^22p^5 - 2s^22p^4(^3P)4d$	$g^2P^\circ - {}^2D$	$\frac{3}{2} - \frac{5}{2}$		245
		17.80	0.0 - 5618.0	$2s^22p^5 - 2s^22p^4(^3P)4d$	$g^2P^\circ - {}^4P$	$\frac{3}{2} - \frac{5}{2}$		245
		17.88	47.219 - 5640.2	$2s^22p^5 - 2s^22p^4(^3P)4d$	$g^2P^\circ - {}^2D$	$\frac{1}{2} - \frac{3}{2}$		245
	60	21.304	0.0 - 4694.0	$2s^22p^5 - 2s^22p^4(^1S)3d$	$g^2P^\circ - {}^2D$	$\frac{3}{2} - \frac{3}{2}$		850
	400	21.341	0.0 - 4685.8	$2s^22p^5 - 2s^22p^4(^1S)3d$	$g^2P^\circ - {}^2D$	$\frac{3}{2} - \frac{5}{2}$		850
	500	21.522	47.219 - 4694.0	$2s^22p^5 - 2s^22p^4(^1S)3d$	$g^2P^\circ - {}^2D$	$\frac{1}{2} - \frac{3}{2}$		850
	700	21.657	0.0 - 4617.4	$2s^22p^5 - 2s^22p^4(^1D)3d$	$g^2P^\circ - {}^2D$	$\frac{3}{2} - \frac{3}{2}$		850
	700	21.732	0.0 - 4601.5	$2s^22p^5 - 2s^22p^4(^1D)3d$	$g^2P^\circ - {}^2D$	$\frac{3}{2} - \frac{5}{2}$		850
	600	21.818	0.0 - 4583.4	$2s^22p^5 - 2s^22p^4(^1D)3d$	$g^2P^\circ - {}^2S$	$\frac{3}{2} - \frac{1}{2}$		850
	700	21.883	47.219 - 4617.4	$2s^22p^5 - 2s^22p^4(^1D)3d$	$g^2P^\circ - {}^2D$	$\frac{1}{2} - \frac{3}{2}$		850
	500	21.958	47.219 - 4601.5	$2s^22p^5 - 2s^22p^4(^1D)3d$	$g^2P^\circ - {}^2P$	$\frac{1}{2} - \frac{3}{2}$		850

Ti XIV — Continued

Multiplet	Rel. Int.	λ_{vac} (in Å)	Levels (in 10^3 cm^{-1})	Configurations	Terms	J - J	Notes	References
	600	22.066	0.0 – 4531.9	$2s^22p^5 - 2s^22p^4(^3P)3d$	$g\,^2P^\circ - {}^2D$	3/2 – 5/2		850
	200	22.099	0.0 – 4525.1	$2s^22p^5 - 2s^22p^4(^3P)3d$	$g\,^2P^\circ - {}^2P$	3/2 – 3/2		850
	300	22.162	0.0 – 4512.2	$2s^22p^5 - 2s^22p^4(^3P)3d$	$g\,^2P^\circ - {}^2F$	3/2 – 5/2		850
	300	22.190	0.0 – 4506.5	$2s^22p^5 - 2s^22p^4(^3P)3d$	$g\,^2P^\circ - {}^2D$	3/2 – 3/2		850
	300	22.215	0.0 – 4501.5	$2s^22p^5 - 2s^22p^4(^3P)3d$	$g\,^2P^\circ - {}^4P$	3/2 – 3/2		850
	100	22.248	0.0 – 4494.8	$2s^22p^5 - 2s^22p^4(^3P)3d$	$g\,^2P^\circ - {}^2P$	3/2 – 1/2		850
	400	22.279	0.0 – 4488.5	$2s^22p^5 - 2s^22p^4(^3P)3d$	$g\,^2P^\circ - {}^4F$	3/2 – 5/2		850
	300	22.328	0.0 – 4478.7	$2s^22p^5 - 2s^22p^4(^3P)3d$	$g\,^2P^\circ - {}^4P$	3/2 – 1/2		850
	400	22.426	47.219 – 4506.5	$2s^22p^5 - 2s^22p^4(^3P)3d$	$g\,^2P^\circ - {}^2D$	1/2 – 3/2		850
	150	22.486	47.219 – 4494.8	$2s^22p^5 - 2s^22p^4(^3P)3d$	$g\,^2P^\circ - {}^2P$	1/2 – 1/2		850
	200	22.518	47.219 – 4488.5	$2s^22p^5 - 2s^22p^4(^3P)3d$	$g\,^2P^\circ - {}^4P$	1/2 – 3/2		850
	900	23.690	0.0 – 4221.2	$2s^22p^5 - 2s^22p^4(^1S)3s$	$g\,^2P^\circ - {}^2S$	3/2 – 1/2		850
	200	23.960	47.219 – 4221.2	$2s^22p^5 - 2s^22p^4(^1S)3s$	$g\,^2P^\circ - {}^2S$	1/2 – 1/2		850
	600	24.315	0.0 – 4112.6	$2s^22p^5 - 2s^22p^4(^1D)3s$	$g\,^2P^\circ - {}^2D$	3/2 – 5/2		850
	750	24.592	47.219 – 4114.0	$2s^22p^5 - 2s^22p^4(^1D)3s$	$g\,^2P^\circ - {}^2D$	1/2 – 3/2		850
	700	24.728	0.0 – 4043.9	$2s^22p^5 - 2s^22p^4(^3P)3s$	$g\,^2P^\circ - {}^2P$	3/2 – 3/2		850
	600	24.891	47.219 – 4065.1	$2s^22p^5 - 2s^22p^4(^3P)3s$	$g\,^2P^\circ - {}^2P$	1/2 – 1/2		850
	700	24.907	0.0 – 4014.9	$2s^22p^5 - 2s^22p^4(^3P)3s$	$g\,^2P^\circ - {}^4P$	3/2 – 3/2		850
	500	25.025	0.0 – 3996.0	$2s^22p^5 - 2s^22p^4(^3P)3s$	$g\,^2P^\circ - {}^4P$	3/2 – 5/2		850
	40	25.071	47.219 – 4036.2	$2s^22p^5 - 2s^22p^4(^3P)3s$	$g\,^2P^\circ - {}^4P$	1/2 – 1/2		850
	200	25.086	819.766 – 4806.1	$2s2p^6 - 2s2p^5(^3P^\circ)3s$	$^2S - {}^2P^\circ$	1/2 – 1/2		850
	60	25.206	47.219 – 4014.9	$2s^22p^5 - 2s^22p^4(^3P)3s$	$g\,^2P^\circ - {}^4P$	1/2 – 3/2		850
	300	25.260	819.766 – 4778.6	$2s2p^6 - 2s2p^5(^3P^\circ)3s$	$^2S - {}^2P^\circ$	1/2 – 3/2		850
	625	121.986	0.0 – 819.766	$2s^22p^5 - 2s2p^6$	$g\,^2P^\circ - {}^2S$	3/2 – 1/2		1119
	600	129.440	47.219 – 819.766	$2s^22p^5 - 2s2p^6$	$g\,^2P^\circ - {}^2S$	1/2 – 1/2		1119

TITANIUM XV (Ti^{14+}), Z = 22
Ground State $1s^22s^22p^4(^3P_2)$ (8 electrons)
Ionization Potential [7 597 000] cm^{-1}; [941.9] eV

Multiplet	Rel. Int.	λ_{vac} (in Å)	Levels (in 10^3 cm^{-1})	Configurations	Terms	J - J	Notes	References
	65	20.051	0.0 – 4987.0	$2s^22p^4 - 2s^22p^3(^2P^\circ)3d$	$g\,^3P - {}^3D^\circ$	2 – 3		877
	65	20.133	39.284 – 5006.2	$2s^22p^4 - 2s^22p^3(^2P^\circ)3d$	$g\,^3P - {}^3D^\circ$	1 – 2		877
	100	20.169	0.0 – 4965.2	$2s^22p^4 - 2s^22p^3(^2P^\circ)3d$	$g\,^3P - {}^3P^\circ$	2 – 1	Q	834
		20.20	0.0 – 4949.9	$2s^22p^4 - 2s^22p^3(^2P^\circ)3d$	$g\,^3P - {}^3P^\circ$	2 – 2	P	877
	110	20.23	42.345 – 4986.0	$2s^22p^4 - 2s^22p^3(^2P^\circ)3d$	$g\,^3P - {}^3D^\circ$	0 – 1		877
	20	20.312	42.345 – 4965.2	$2s^22p^4 - 2s^22p^3(^2P^\circ)3d$	$g\,^3P - {}^3P^\circ$	0 – 1		947
	300	20.324	0.0 – 4920.3	$2s^22p^4 - 2s^22p^3(^2D^\circ)3d$	$g\,^3P - {}^3S^\circ$	2 – 1		877,834
	10	20.364	39.284 – 4949.9	$2s^22p^4 - 2s^22p^3(^2P^\circ)3d$	$g\,^3P - {}^3P^\circ$	1 – 2		877
	30	20.389	108.720 – 5013.4	$2s^22p^4 - 2s^22p^3(^2P^\circ)3d$	$^1D - {}^1F^\circ$	2 – 3		877
		20.403	0.0 – 4901.24	$2s^22p^4 - 2s^22p^3(^2D^\circ)3d$	$g\,^3P - {}^3P^\circ$	2 – 2	P	877
	175	20.418	0.0 – 4897.6	$2s^22p^4 - 2s^22p^3(^2D^\circ)3d$	$g\,^3P - {}^3D^\circ$	2 – 3		877
	10	20.538	0.0 – 4870.3	$2s^22p^4 - 2s^22p^3(^2D^\circ)3d$	$g\,^3P - {}^1P^\circ$	2 – 1		947
	65	20.611	39.284 – 4891.1	$2s^22p^4 - 2s^22p^3(^2D^\circ)3d$	$g\,^3P - {}^3D^\circ$	1 – 2		877
	30	20.700	215.521 – 5046.4	$2s^22p^4 - 2s^22p^3(^2P^\circ)3d$	$^1S - {}^1P^\circ$	0 – 1		877
	110	20.823	108.720 – 4911.2	$2s^22p^4 - 2s^22p^3(^2D^\circ)3d$	$^1D - {}^1D^\circ$	2 – 2		877
	110	20.897	0.0 – 4785.4	$2s^22p^4 - 2s^22p^3(^4S^\circ)3d$	$g\,^3P - {}^3D^\circ$	2 – 3		877
	50	21.094	39.284 – 4780.0	$2s^22p^4 - 2s^22p^3(^4S^\circ)3d$	$g\,^3P - {}^3D^\circ$	1 – 2		834
	100	22.109	0.0 – 4523.0	$2s^22p^4 - 2s^22p^3(^2P^\circ)3s$	$g\,^3P - {}^3P^\circ$	2 – 2		834

Ti XV — Continued

Multiplet	Rel. Int.	λ_{vac} (in Å)	Levels (in 10^3 cm^{-1})	Configurations	Terms	J - J	Notes	References
	900	22.464	0.0 – 4451.6	$2s^22p^4 - 2s^22p^3(^2D^\circ)3s$	$g^3P - ^3D^\circ$	2 – 3		865
	450	22.482	108.720 – 4556.9	$2s^22p^4 - 2s^22p^3(^2P^\circ)3s$	$^1D - ^1P^\circ$	2 – 1		865
	600	22.518	0.0 – 4440.4	$2s^22p^4 - 2s^22p^3(^2D^\circ)3s$	$g^3P - ^3D^\circ$	2 – 2		865
	450	22.724	39.284 – 4440.0	$2s^22p^4 - 2s^22p^3(^2D^\circ)3s$	$g^3P - ^3D^\circ$	1 – 1		865
	360	22.739	42.345 – 4440.0	$2s^22p^4 - 2s^22p^3(^2D^\circ)3s$	$g^3P - ^3D^\circ$	0 – 1		865
	540	22.936	108.720 – 4468.7	$2s^22p^4 - 2s^22p^3(^2D^\circ)3s$	$^1D - ^1D^\circ$	2 – 2		865
	360	22.966	0.0 – 4354.1	$2s^22p^4 - 2s^22p^3(^4S^\circ)3s$	$g^3P - ^3S^\circ$	2 – 1		865
	180	23.034	215.521 – 4556.9	$2s^22p^4 - 2s^22p^3(^2P^\circ)3s$	$^1S - ^1P^\circ$	0 – 1		865
	360	23.177	39.284 – 4354.1	$2s^22p^4 - 2s^22p^3(^4S^\circ)3s$	$g^3P - ^3S^\circ$	1 – 1		865
	150	23.193	42.345 – 4354.1	$2s^22p^4 - 2s^22p^3(^4S^\circ)3s$	$g^3P - ^3S^\circ$	0 – 1		865
		23.20	0.0 – 4310.6+K	$2s^22p^4 - 2s^22p^3(^4S^\circ)3s$	$g^3P - ^5S^\circ$	2 – 2	P	680
		23.41	39.284 – 4310.6+K	$2s^22p^4 - 2s^22p^3(^4S^\circ)3s$	$g^3P - ^5S^\circ$	1 – 2	P	680
	40	102.247	0.0 – 978.03	$2s^22p^4 - 2s2p^5$	$g^3P - ^1P^\circ$	2 – 1		1119
	2	106.874	42.345 – 978.03	$2s^22p^4 - 2s2p^5$	$g^3P - ^1P^\circ$	0 – 1		1119
		109.48	742.882 – 1656.29	$2s2p^5 - 2p^6$	$^3P^\circ - ^1S$	1 – 0	P	375,1119
	625	115.031	108.720 – 978.03	$2s^22p^4 - 2s2p^5$	$^1D - ^1P^\circ$	2 – 1		1119
	200	131.146	215.521 – 978.03	$2s^22p^4 - 2s2p^5$	$^1S - ^1P^\circ$	0 – 1		1119
	320	134.609	0.0 – 742.882	$2s^22p^4 - 2s2p^5$	$g^3P - ^3P^\circ$	2 – 1		1119
	250	138.357	39.284 – 762.060	$2s^22p^4 - 2s2p^5$	$g^3P - ^3P^\circ$	1 – 0		1119
	600	140.395	0.0 – 712.285	$2s^22p^4 - 2s2p^5$	$g^3P - ^3P^\circ$	2 – 2		1119
	200	142.130	39.284 – 742.882	$2s^22p^4 - 2s2p^5$	$g^3P - ^3P^\circ$	1 – 1		1119
	200	142.750	42.345 – 742.882	$2s^22p^4 - 2s2p^5$	$g^3P - ^3P^\circ$	0 – 1		1119
	80	147.436	978.03 – 1656.29	$2s2p^5 - 2p^6$	$^1P^\circ - ^1S$	1 – 0		1119
	320	148.588	39.284 – 712.285	$2s^22p^4 - 2s2p^5$	$g^3P - ^3P^\circ$	1 – 2		1119
	2	165.690	108.720 – 712.285	$2s^22p^4 - 2s2p^5$	$^1D - ^3P^\circ$	2 – 2		1119
		463.99	0.0 – 215.521	$2s^22p^4 - 2s^22p^4$	$g^3P - ^1S$	2 – 0	F,P	375,1119
		567.42	39.284 – 215.521	$2s^22p^4 - 2s^22p^4$	$g^3P - ^1S$	1 – 0	F,P	375,1119
		919.79	0.0 – 108.720	$2s^22p^4 - 2s^22p^4$	$g^3P - ^1D$	2 – 2	F,P	375,1119
		936.32	108.720 – 215.521	$2s^22p^4 - 2s^22p^4$	$^1D - ^1S$	2 – 0	F,P	375,1119
		1440.	39.284 – 108.720	$2s^22p^4 - 2s^22p^4$	$g^3P - ^1D$	1 – 2	F,P	375,1119
		1507.	42.345 – 108.720	$2s^22p^4 - 2s^22p^4$	$g^3P - ^1D$	0 – 2	F,P	375,1119

TITANIUM XVI (Ti^{15+}), Z = 22
Ground State $1s^22s^22p^3(^4S^\circ_{3/2})$ (7 electrons)
Ionization Potential [8 420 000] cm^{-1}; [1044] eV

Multiplet	Rel. Int.	λ_{vac} (in Å)	Levels (in 10^3 cm^{-1})	Configurations	Terms	J - J	Notes	References
		19.01	197.70 – 5458.5	$2s^22p^3 - 2s^22p^2(^1S)3d$	$^2P^\circ - ^2D$	$\frac{1}{2} - \frac{3}{2}$	P	950
	110	19.089	0.0 – 5238.6	$2s^22p^3 - 2s^22p^2(^3P)3d$	$g^4S^\circ - ^4P$	$\frac{3}{2} - \frac{3}{2}$		877
	110	19.112	0.0 – 5232.3	$2s^22p^3 - 2s^22p^2(^3P)3d$	$g^4S^\circ - ^4P$	$\frac{3}{2} - \frac{5}{2}$		877
	350	19.210	130.72 – 5336.3	$2s^22p^3 - 2s^22p^2(^1D)3d$	$^2D^\circ - ^2F$	$\frac{5}{2} - \frac{7}{2}$		877
		19.24	130.72 – 5329.1	$2s^22p^3 - 2s^22p^2(^1D)3d$	$^2D^\circ - ^2D$	$\frac{5}{2} - \frac{5}{2}$	P	950
	110	19.370	130.72 – 5293.3	$2s^22p^3 - 2s^22p^2(^3P)3d$	$^2D^\circ - ^2D$	$\frac{5}{2} - \frac{5}{2}$		877
		19.45	219.25 – 5360.9	$2s^22p^3 - 2s^22p^2(^1D)3d$	$^2P^\circ - ^2P$	$\frac{3}{2} - \frac{3}{2}$	P	950
	110	19.551	130.72 – 5245.7	$2s^22p^3 - 2s^22p^2(^3P)3d$	$^2D^\circ - ^2F$	$\frac{5}{2} - \frac{7}{2}$		877
		19.57	219.25 – 5329.1	$2s^22p^3 - 2s^22p^2(^1D)3d$	$^2P^\circ - ^2D$	$\frac{3}{2} - \frac{5}{2}$	P	950
	10	19.71	219.25 – 5293.3	$2s^22p^3 - 2s^22p^2(^3P)3d$	$^2P^\circ - ^2D$	$\frac{3}{2} - \frac{5}{2}$		877
	30	20.101	219.25 – 5194.1	$2s^22p^3 - 2s^22p^2(^3P)3d$	$^2P^\circ - ^2P$	$\frac{3}{2} - \frac{3}{2}$		877
	5	102.393	0.0 – 976.65	$2s^22p^3 - 2s2p^4$	$g^4S^\circ - ^2P$	$\frac{3}{2} - \frac{3}{2}$		1140

Ti XVI — Continued

Multiplet	Rel. Int.	λ_{vac} (in Å)	Levels (in 10^3 cm^{-1})	Configurations	Terms	J - J	Notes	References
	200	110.561	116.03 - 1020.50	$2s^22p^3 - 2s2p^4$	$^2D^\circ - ^2P$	$\frac{3}{2}-\frac{1}{2}$		1140
	280	116.198	116.03 - 976.65	$2s^22p^3 - 2s2p^4$	$^2D^\circ - ^2P$	$\frac{3}{2}-\frac{3}{2}$		1140
	315	118.215	130.72 - 976.65	$2s^22p^3 - 2s2p^4$	$^2D^\circ - ^2P$	$\frac{5}{2}-\frac{3}{2}$		1140
	175	121.382	116.03 - 939.92	$2s^22p^3 - 2s2p^4$	$^2D^\circ - ^2S$	$\frac{3}{2}-\frac{1}{2}$		1140
	15	121.538	197.70 - 1020.50	$2s^22p^3 - 2s2p^4$	$^2P^\circ - ^2P$	$\frac{1}{2}-\frac{1}{2}$		1140
	265	124.805	219.25 - 1020.50	$2s^22p^3 - 2s2p^4$	$^2P^\circ - ^2P$	$\frac{3}{2}-\frac{1}{2}$		1140
	50	128.373	197.70 - 976.65	$2s^22p^3 - 2s2p^4$	$^2P^\circ - ^2P$	$\frac{1}{2}-\frac{3}{2}$		1140
	30	129.075	813.08 - 1587.83	$2s2p^4 - 2p^5$	$^2D - ^2P^\circ$	$\frac{3}{2}-\frac{1}{2}$		1140
	100	132.022	219.25 - 976.65	$2s^22p^3 - 2s2p^4$	$^2P^\circ - ^2P$	$\frac{3}{2}-\frac{3}{2}$		1140
	175	134.724	197.70 - 939.92	$2s^22p^3 - 2s2p^4$	$^2P^\circ - ^2S$	$\frac{1}{2}-\frac{1}{2}$		1140
	5	138.020	813.08 - 1537.66	$2s2p^4 - 2p^5$	$^2D - ^2P^\circ$	$\frac{3}{2}-\frac{3}{2}$		1140
	10	138.760	219.25 - 939.92	$2s^22p^3 - 2s2p^4$	$^2P^\circ - ^2S$	$\frac{3}{2}-\frac{1}{2}$		1140
	125	138.800	817.21 - 1537.66	$2s2p^4 - 2p^5$	$^2D - ^2P^\circ$	$\frac{5}{2}-\frac{3}{2}$		1140
	200	143.459	116.03 - 813.08	$2s^22p^3 - 2s2p^4$	$^2D^\circ - ^2D$	$\frac{3}{2}-\frac{3}{2}$		1140
	450	145.665	130.72 - 817.21	$2s^22p^3 - 2s2p^4$	$^2D^\circ - ^2D$	$\frac{5}{2}-\frac{5}{2}$		1140
	30	146.55	130.72 - 813.08	$2s^22p^3 - 2s2p^4$	$^2D^\circ - ^2D$	$\frac{5}{2}-\frac{3}{2}$	P	384
	175	157.812	0.0 - 633.66	$2s^22p^3 - 2s2p^4$	$g^4S^\circ - ^4P$	$\frac{3}{2}-\frac{1}{2}$		1140
	280	161.168	0.0 - 620.47	$2s^22p^3 - 2s2p^4$	$g^4S^\circ - ^4P$	$\frac{3}{2}-\frac{3}{2}$		1140
	20	162.503	197.70 - 813.08	$2s^22p^3 - 2s2p^4$	$^2P^\circ - ^2D$	$\frac{1}{2}-\frac{3}{2}$		1140
	2	163.610	976.65 - 1587.83	$2s2p^4 - 2p^5$	$^2P - ^2P^\circ$	$\frac{3}{2}-\frac{1}{2}$		1140
	70	167.242	219.25 - 817.21	$2s^22p^3 - 2s2p^4$	$^2P^\circ - ^2D$	$\frac{3}{2}-\frac{5}{2}$		1140
	10	167.297	939.92 - 1537.66	$2s2p^4 - 2p^5$	$^2S - ^2P^\circ$	$\frac{1}{2}-\frac{3}{2}$		1140
	550	169.740	0.0 - 589.14	$2s^22p^3 - 2s2p^4$	$g^4S^\circ - ^4P$	$\frac{3}{2}-\frac{5}{2}$		1140
	8	176.267	1020.50 - 1587.83	$2s2p^4 - 2p^5$	$^2P - ^2P^\circ$	$\frac{1}{2}-\frac{1}{2}$		1140
	30	178.240	976.65 - 1537.66	$2s2p^4 - 2p^5$	$^2P - ^2P^\circ$	$\frac{3}{2}-\frac{3}{2}$		1140
		456.1	0.0 - 219.25	$2s^22p^3 - 2s^22p^3$	$g^4S^\circ - ^2P^\circ$	$\frac{3}{2}-\frac{3}{2}$	F,P	375,1140
		505.8	0.0 - 197.70	$2s^22p^3 - 2s^22p^3$	$g^4S^\circ - ^2P^\circ$	$\frac{3}{2}-\frac{1}{2}$	F,P	375,1140
		765.0	0.0 - 130.72	$2s^22p^3 - 2s^22p^3$	$g^4S^\circ - ^2D^\circ$	$\frac{3}{2}-\frac{5}{2}$	F,P	375,1140
		861.8	0.0 - 116.03	$2s^22p^3 - 2s^22p^3$	$g^4S^\circ - ^2D^\circ$	$\frac{3}{2}-\frac{3}{2}$	F,P	375,1140
		968.8	116.03 - 219.25	$2s^22p^3 - 2s^22p^3$	$^2D^\circ - ^2P^\circ$	$\frac{3}{2}-\frac{3}{2}$	F,P	375,1140
		1130.	130.72 - 219.25	$2s^22p^3 - 2s^22p^3$	$^2D^\circ - ^2P^\circ$	$\frac{5}{2}-\frac{3}{2}$	F,P	375,1140
		1224.	116.03 - 197.70	$2s^22p^3 - 2s^22p^3$	$^2D^\circ - ^2P^\circ$	$\frac{3}{2}-\frac{1}{2}$	F,P	375,1140
		1493.	130.72 - 197.70	$2s^22p^3 - 2s^22p^3$	$^2D^\circ - ^2P^\circ$	$\frac{5}{2}-\frac{1}{2}$	F,P	375,1140

TITANIUM XVII (Ti^{16+}), Z = 22
Ground State $1s^22s^22p^2(^3P_0)$ (6 electrons)
Ionization Potential [9 120 000] cm^{-1}; [1131] eV

Multiplet	Rel. Int.	λ_{vac} (in Å)	Levels (in 10^3 cm^{-1})	Configurations	Terms	J - J	Notes	References
		18.043	29.658 - 5572.0	$2s^22p^2 - 2s^22p3d$	$g^3P - ^3P^\circ$	1 - 0	P	949
	80	18.056	29.658 - 5568.0	$2s^22p^2 - 2s^22p3d$	$g^3P - ^3P^\circ$	1 - 2		949,303
		18.127	0.0 - 5517.7	$2s^22p^2 - 2s^22p3d$	$g^3P - ^3D^\circ$	0 - 1		949
		18.134	55.730 - 5570.2	$2s^22p^2 - 2s^22p3d$	$g^3P - ^3P^\circ$	2 - 1	P	949
	10	18.141	55.730 - 5568.0	$2s^22p^2 - 2s^22p3d$	$g^3P - ^3P^\circ$	2 - 2		877
	60	18.154	330.50+U - 5838.9+U	$2s2p^3 - 2s2p^2(^4P)3d$	$^5S^\circ - ^5P$	2 - 3		303
	40	18.172	55.730 - 5558.7	$2s^22p^2 - 2s^22p3d$	$g^3P - ^3D^\circ$	2 - 3		303
	40	18.215	29.658 - 5517.7	$2s^22p^2 - 2s^22p3d$	$g^3P - ^3D^\circ$	1 - 1		303
		18.228	55.730 - 5541.9	$2s^22p^2 - 2s^22p3d$	$g^3P - ^3D^\circ$	2 - 2		949
	100	18.268	140.629 - 5614.4	$2s^22p^2 - 2s^22p3d$	$^1D - ^1F^\circ$	2 - 3		303
		18.279	140.629 - 5611.9	$2s^22p^2 - 2s^22p3d$	$^1D - ^1P^\circ$	2 - 1	P	949
		18.350	55.730 - 5502.3	$2s^22p^2 - 2s^22p3d$	$g^3P - ^1D^\circ$	2 - 2	Q	949

Ti XVII — Continued

Multiplet	Rel. Int.	λ_{vac} (in Å)	Levels (in 10^3 cm^{-1})	Configurations	Terms	J - J	Notes	References
	60	18.387	586.764 - 6025.0	$2s2p^3$ - $2s2p^2(^2D)3d$	$^3D°$ - ^3F	3 - 4		303
		18.426	140.629 - 5568.0	$2s^22p^2$ - $2s^22p3d$	^1D - $^3P°$	2 - 2		949
		18.461	55.730 - 5472.5	$2s^22p^2$ - $2s^22p3d$	g^3P - $^3F°$	2 - 2		949
		18.623	242.151 - 5611.9	$2s^22p^2$ - $2s^22p3d$	^1S - $^1P°$	0 - 1		949
	20	18.651	140.629 - 5502.3	$2s^22p^2$ - $2s^22p3d$	^1D - $^1D°$	2 - 2		949,303
		18.677	140.629 - 5494.9	$2s^22p^2$ - $2s^22p3d$	^1D - $^3F°$	2 - 3		949
		18.757	140.629 - 5472.5	$2s^22p^2$ - $2s^22p3d$	^1D - $^3F°$	2 - 2		949
	10	18.799	586.764 - 5906.2	$2s2p^3$ - $2s2p^2(^4P)3d$	$^3D°$ - ^3F	3 - 4		877
	20	18.939	578.891 - 5859.0	$2s2p^3$ - $2s2p^2(^4P)3d$	$^3D°$ - ^3F	2 - 3		303
	180	19.369	29.658 - 5194.0	$2s^22p^2$ - $2s^22p3s$	g^3P - $^3P°$	1 - 2		303
	40	19.415	330.50+U - 5481.2+U	$2s2p^3$ - $2s2p^2(^4P)3s$	$^5S°$ - ^5P	2 - 3		303
	60	19.459	55.730 - 5194.0	$2s^22p^2$ - $2s^22p3s$	g^3P - $^3P°$	2 - 2		303
	40	19.501	578.891 - 5707.0	$2s2p^3$ - $2s2p^2(^2D)3s$	$^3D°$ - ^3D	2 - 2		303
	20	19.651	55.730 - 5144.5	$2s^22p^2$ - $2s^22p3s$	g^3P - $^3P°$	2 - 1		303
	40	19.718	140.629 - 5212.1	$2s^22p^2$ - $2s^22p3s$	^1D - $^1P°$	2 - 1		303
	20	20.183						303
	1	109.432	29.658 - 943.467	$2s^22p^2$ - $2s2p^3$	g^3P - $^1P°$	1 - 1		1141
	30	119.284	0.0 - 838.338	$2s^22p^2$ - $2s2p^3$	g^3P - $^3S°$	0 - 1		1141
	150	123.654	29.658 - 838.338	$2s^22p^2$ - $2s2p^3$	g^3P - $^3S°$	1 - 1		1141
	245	124.553	140.629 - 943.467	$2s^22p^2$ - $2s2p^3$	^1D - $^1P°$	2 - 1		1141
	15	126.004	586.764 - 1380.34	$2s2p^3$ - $2p^4$	$^3D°$ - ^1D	3 - 2		1141
	25	126.676	55.730 - 845.146	$2s^22p^2$ - $2s2p^3$	g^3P - $^1D°$	2 - 2		1141
	175	127.782	55.730 - 838.338	$2s^22p^2$ - $2s2p^3$	g^3P - $^3S°$	2 - 1		1141
	6	135.202	580.114 - 1319.68	$2s2p^3$ - $2p^4$	$^3D°$ - ^3P	1 - 0		1141
	20	136.160	578.891 - 1313.29	$2s2p^3$ - $2p^4$	$^3D°$ - ^3P	2 - 1		1141
	6	136.393	580.114 - 1313.29	$2s2p^3$ - $2p^4$	$^3D°$ - ^3P	1 - 1		1141
	175	141.948	140.629 - 845.146	$2s^22p^2$ - $2s2p^3$	^1D - $^1D°$	2 - 2		1141
	30	142.589	242.151 - 943.467	$2s^22p^2$ - $2s2p^3$	^1S - $^1P°$	0 - 1		1141
	10	144.405	578.891 - 1271.39	$2s2p^3$ - $2p^4$	$^3D°$ - ^3P	2 - 2		1141
	30	146.067	586.764 - 1271.39	$2s2p^3$ - $2p^4$	$^3D°$ - ^3P	3 - 2		1141
	10	146.856	0.0 - 680.913	$2s^22p^2$ - $2s2p^3$	g^3P - $^3P°$	0 - 1		1141
	1	152.174	29.658 - 686.784	$2s^22p^2$ - $2s2p^3$	g^3P - $^3P°$	1 - 2		1141
	25	153.554	29.658 - 680.913	$2s^22p^2$ - $2s2p^3$	g^3P - $^3P°$	1 - 1		1141
	3	154.133	29.658 - 678.448	$2s^22p^2$ - $2s2p^3$	g^3P - $^3P°$	1 - 0		1141
		156.57	680.913 - 1319.68	$2s2p^3$ - $2p^4$	$^3P°$ - ^3P	1 - 0		1084
	160	158.469	55.730 - 686.784	$2s^22p^2$ - $2s2p^3$	g^3P - $^3P°$	2 - 2		1141
		159.62	686.784 - 1313.29	$2s2p^3$ - $2p^4$	$^3P°$ - ^3P	2 - 1		1084
	1	159.955	55.730 - 680.913	$2s^22p^2$ - $2s2p^3$	g^3P - $^3P°$	2 - 1		1141
	2	163.049	943.467 - 1556.78	$2s2p^3$ - $2p^4$	$^1P°$ - ^1S	1 - 0		1141
		169.34	680.913 - 1271.39	$2s2p^3$ - $2p^4$	$^3P°$ - ^3P	1 - 2		1084
		171.09	686.784 - 1271.39	$2s2p^3$ - $2p^4$	$^3P°$ - ^3P	2 - 2	Q	1084
	20	172.380	0.0 - 580.114	$2s^22p^2$ - $2s2p^3$	g^3P - $^3D°$	0 - 1		1141
	150	182.072	29.658 - 578.891	$2s^22p^2$ - $2s2p^3$	g^3P - $^3D°$	1 - 2		1141
	40	186.863	845.146 - 1380.34	$2s2p^3$ - $2p^4$	$^1D°$ - ^1D	2 - 2		1141
	100	188.312	55.730 - 586.764	$2s^22p^2$ - $2s2p^3$	g^3P - $^3D°$	2 - 3		1141
		230.89	838.338 - 1271.39	$2s2p^3$ - $2p^4$	$^3S°$ - ^3P	1 - 2		1084
		364.	55.730 - 330.50+U	$2s^22p^2$ - $2s2p^3$	g^3P - $^5S°$	2 - 2	P	375,1141
		470.60	29.658 - 242.151	$2s^22p^2$ - $2s^22p^2$	g^3P - ^1S	1 - 0	F,P	375,1141
		536.42	55.730 - 242.151	$2s^22p^2$ - $2s^22p^2$	g^3P - ^1S	2 - 0	F,P	375,1141
		711.09	0.0 - 140.629	$2s^22p^2$ - $2s^22p^2$	g^3P - ^1D	0 - 2	F,P	375,1141
		901.14	29.658 - 140.629	$2s^22p^2$ - $2s^22p^2$	g^3P - ^1D	1 - 2	F,P	375,1141
		985.01	140.629 - 242.151	$2s^22p^2$ - $2s^22p^2$	^1D - ^1S	2 - 0	F,P	375,1141
		1178.	55.730 - 140.629	$2s^22p^2$ - $2s^22p^2$	g^3P - ^1D	2 - 2	F,P	375,1141
		1794.	0.0 - 55.730	$2s^22p^2$ - $2s^22p^2$	g^3P - g^3P	0 - 2	F,P	375,1141

TITANIUM XVIII (Ti^{17+}), Z = 22
Ground State $1s^22s^22p(^2P^\circ_{1/2})$ (5 electrons)
Ionization Potential [9 850 000] cm^{-1}; [1221] eV

Multiplet	Rel. Int.	λ_{vac} (in Å)	Levels (in 10^3 cm^{-1})	Configurations	Terms	J - J	Notes	References
		13.45	56.240 - 7491.3	$2s^22p - 2s^24s$	$g^2P^\circ - {}^2S$	$\frac{3}{2} - \frac{1}{2}$	P	375
	10	16.561	0.00 - 6038.3	$2s^22p - 2s2p(^3P^\circ)3p$	$g^2P^\circ - {}^2D$	$\frac{1}{2} - \frac{3}{2}$		877
	10	16.624	56.240 - 6071.6	$2s^22p - 2s2p(^3P^\circ)3p$	$g^2P^\circ - {}^2D$	$\frac{3}{2} - \frac{5}{2}$		877
	10	16.90	0.00 - 5917.2	$2s^22p - 2s2p(^3P^\circ)3p$	$g^2P^\circ - {}^2P$	$\frac{1}{2} - \frac{1}{2}$		877
	10	16.939	56.240 - 5959.8	$2s^22p - 2s2p(^3P^\circ)3p$	$g^2P^\circ - {}^2P$	$\frac{3}{2} - \frac{3}{2}$		877
	30	17.150	561.704 - 6392.6	$2s2p^2 - 2s2p(^1P^\circ)3d$	${}^2D - {}^2F^\circ$	$\frac{5}{2} - \frac{7}{2}$		877
	30	17.22	0.00 - 5807.2	$2s^22p - 2s^23d$	$g^2P^\circ - {}^2D$	$\frac{1}{2} - \frac{3}{2}$		877
	30	17.28	360.80+X - 6147.8+X	$2s2p^2 - 2s2p(^3P^\circ)3d$	${}^4P - {}^4P^\circ$	$\frac{5}{2} - \frac{5}{2}$		877
	30	17.30	360.80+X - 6141.1+X	$2s2p^2 - 2s2p(^3P^\circ)3d$	${}^4P - {}^4D^\circ$	$\frac{5}{2} - \frac{7}{2}$		877
	65	17.365	56.240 - 5815.0	$2s^22p - 2s^23d$	$g^2P^\circ - {}^2D$	$\frac{3}{2} - \frac{5}{2}$		877
	110	17.587	747.069 - 6433.1	$2s2p^2 - 2s2p(^1P^\circ)3d$	${}^2P - {}^2D^\circ$	$\frac{3}{2} - \frac{5}{2}$		877
	110	17.630	561.704 - 6233.9	$2s2p^2 - 2s2p(^3P^\circ)3d$	${}^2D - {}^2F^\circ$	$\frac{5}{2} - \frac{7}{2}$		877
	30	17.715	555.858 - 6200.9	$2s2p^2 - 2s2p(^3P^\circ)3d$	${}^2D - {}^2F^\circ$	$\frac{3}{2} - \frac{5}{2}$		877
	30	17.920	561.704 - 6142.1	$2s2p^2 - 2s2p(^3P^\circ)3d$	${}^2D - {}^2D^\circ$	$\frac{5}{2} - \frac{5}{2}$		877
		18.38	56.240 - 5497.9	$2s^22p - 2s^23s$	$g^2P^\circ - {}^2S$	$\frac{3}{2} - \frac{1}{2}$	P	375
	5	133.852	0.00 - 747.069	$2s^22p - 2s2p^2$	$g^2P^\circ - {}^2P$	$\frac{1}{2} - \frac{3}{2}$		1142
	6	136.280	0.00 - 733.749	$2s^22p - 2s2p^2$	$g^2P^\circ - {}^2P$	$\frac{1}{2} - \frac{1}{2}$		1142
	40	144.759	56.240 - 747.069	$2s^22p - 2s2p^2$	$g^2P^\circ - {}^2P$	$\frac{3}{2} - \frac{3}{2}$		1142
	15	147.607	56.240 - 733.749	$2s^22p - 2s2p^2$	$g^2P^\circ - {}^2P$	$\frac{3}{2} - \frac{1}{2}$		1142
	20	148.438	0.00 - 673.682	$2s^22p - 2s2p^2$	$g^2P^\circ - {}^2S$	$\frac{1}{2} - \frac{1}{2}$		1142
		148.83	555.858 - 1227.70	$2s2p^2 - 2p^3$	${}^2D - {}^2P^\circ$	$\frac{3}{2} - \frac{3}{2}$		1084
		150.15	561.704 - 1227.70	$2s2p^2 - 2p^3$	${}^2D - {}^2P^\circ$	$\frac{5}{2} - \frac{3}{2}$		1084
		153.15	555.858 - 1208.80	$2s2p^2 - 2p^3$	${}^2D - {}^2P^\circ$	$\frac{3}{2} - \frac{1}{2}$		1084
	10	153.23	309.78+X - 962.39+X	$2s2p^2 - 2p^3$	${}^4P - {}^4S^\circ$	$\frac{1}{2} - \frac{3}{2}$		877
	65	159.00	333.46+X - 962.39+X	$2s2p^2 - 2p^3$	${}^4P - {}^4S^\circ$	$\frac{3}{2} - \frac{3}{2}$		877
	5	166.225	360.80+X - 962.39+X	$2s2p^2 - 2p^3$	${}^4P - {}^4S^\circ$	$\frac{5}{2} - \frac{3}{2}$		1142
	4	179.902	0.00 - 555.858	$2s^22p - 2s2p^2$	$g^2P^\circ - {}^2D$	$\frac{1}{2} - \frac{3}{2}$		1142
		180.52	673.682 - 1227.70	$2s2p^2 - 2p^3$	${}^2S - {}^2P^\circ$	$\frac{1}{2} - \frac{3}{2}$		1084
		187.55	555.858 - 1089.00	$2s2p^2 - 2p^3$	${}^2D - {}^2D^\circ$	$\frac{3}{2} - \frac{5}{2}$		1084
	5	189.663	561.704 - 1089.00	$2s2p^2 - 2p^3$	${}^2D - {}^2D^\circ$	$\frac{5}{2} - \frac{5}{2}$		1142
		191.23	555.858 - 1078.79	$2s2p^2 - 2p^3$	${}^2D - {}^2D^\circ$	$\frac{3}{2} - \frac{3}{2}$		1084
		193.39	561.704 - 1078.79	$2s2p^2 - 2p^3$	${}^2D - {}^2D^\circ$	$\frac{5}{2} - \frac{3}{2}$	P	1084
	4	197.838	56.240 - 561.704	$2s^22p - 2s2p^2$	$g^2P^\circ - {}^2D$	$\frac{3}{2} - \frac{5}{2}$		1142
		208.07	747.069 - 1227.70	$2s2p^2 - 2p^3$	${}^2P - {}^2P^\circ$	$\frac{3}{2} - \frac{3}{2}$		1084
		210.51	733.749 - 1208.80	$2s2p^2 - 2p^3$	${}^2P - {}^2P^\circ$	$\frac{1}{2} - \frac{1}{2}$		1084
		1778.1	0.00 - 56.240	$2s^22p - 2s^22p$	$g^2P^\circ - g^2P^\circ$	$\frac{1}{2} - \frac{3}{2}$	F	1137

TITANIUM XIX (Ti^{18+}), Z = 22
Ground State $1s^22s^2(^1S_0)$ (4 electrons)
Ionization Potential [10 860 000] cm^{-1}; [1346] eV

Multiplet	Rel. Int.	λ_{vac} (in Å)	Levels (in 10^3 cm^{-1})	Configurations	Terms	J - J	Notes	References
		2.6540						624
		15.581	304.566 - 6722.7+B	$1s^22s2p - 1s^22p3p$	${}^3P^\circ - {}^3P$	1 - 2	P	619
	0	15.671	304.566 - 6685.8	$1s^22s2p - 1s^22p3p$	${}^3P^\circ - {}^3P$	1 - 0		643
		15.685	347.204 - 6722.7+B	$1s^22s2p - 1s^22p3p$	${}^3P^\circ - {}^3P$	2 - 2	P	619
	0	15.738	347.204 - 6701.3	$1s^22s2p - 1s^22p3p$	${}^3P^\circ - {}^3S$	2 - 1		643
	30	15.742	347.204 - 6699.6	$1s^22s2p - 1s^22p3p$	${}^3P^\circ - {}^3D$	2 - 3		877

Ti XIX — Continued

Multiplet	Rel. Int.	λ_{vac} (in Å)	Levels (in 10^3 cm^{-1})	Configurations	Terms	J - J	Notes	References
		15.801	288.131 – 6616.8+B	$1s^22s2p - 1s^22p3p$	$^3P^\circ - {}^3D$	0 – 1	P	619
		15.831	0.0 – 6316.7+B	$1s^22s^2 - 1s^22s3p$	$g^1S - {}^3P^\circ$	0 – 1	P	619
		15.842	304.566 – 6616.8+B	$1s^22s2p - 1s^22p3p$	$^3P^\circ - {}^3D$	1 – 1	P	619
	10	15.865	0.0 – 6303.2	$1s^22s^2 - 1s^22s3p$	$g^1S - {}^1P^\circ$	0 – 1		877
		16.002	589.658 – 6838.9+B	$1s^22s2p - 1s^22s3s$	$^1P^\circ - {}^1S$	1 – 0	P	619
	0	16.178	589.658 – 6770.9	$1s^22s2p - 1s^22p3p$	$^1P^\circ - {}^1D$	1 – 2		643
		16.288	304.566 – 6445.8	$1s^22s2p - 1s^22s3d$	$^3P^\circ - {}^1D$	1 – 2	Q	623
	0	16.414	288.131 – 6380.5	$1s^22s2p - 1s^22s3d$	$^3P^\circ - {}^3D$	0 – 1		643
	30	16.430	304.566 – 6391.0	$1s^22s2p - 1s^22s3d$	$^3P^\circ - {}^3D$	1 – 2		877
	65	16.514	347.204 – 6402.7	$1s^22s2p - 1s^22s3d$	$^3P^\circ - {}^3D$	2 – 3		877
		16.637	804.847 – 6815.5+B	$1s^22p^2 - 1s^22p3d$	$^3P - {}^3P^\circ$	1 – 0	P	619
	10	16.70	804.847 – 6792.8	$1s^22p^2 - 1s^22p3d$	$^3P - {}^3D^\circ$	1 – 2		877
	0	16.719	832.361 – 6813.6	$1s^22p^2 - 1s^22p3d$	$^3P - {}^3P^\circ$	2 – 2		643
	10	16.736	832.361 – 6807.5	$1s^22p^2 - 1s^22p3d$	$^3P - {}^3D^\circ$	2 – 3		877
	30	16.802	917.603 – 6869.3	$1s^22p^2 - 1s^22p3d$	$^1D - {}^1F^\circ$	2 – 3		877
	0	16.811	917.603 – 6866.1	$1s^22p^2 - 1s^22p3d$	$^1D - {}^1P^\circ$	2 – 1		643
	0	17.076	589.658 – 6445.8	$1s^22s2p - 1s^22s3d$	$^1P^\circ - {}^1D$	1 – 2		643
	0	17.181	917.603 – 6738.0	$1s^22p^2 - 1s^22p3d$	$^1D - {}^1D^\circ$	2 – 2		643
		17.354	1104.16 – 6866.1	$1s^22p^2 - 1s^22p3d$	$^1S - {}^1P^\circ$	0 – 1	P	619
		17.553	804.847 – 6501.9	$1s^22p^2 - 1s^22p3s$	$^3P - {}^3P^\circ$	1 – 0	P	619
		17.583	917.603 – 6604.9+B	$1s^22p^2 - 1s^22p3s$	$^1D - {}^1P^\circ$	2 – 1	P	619
	300	169.590	0.0 – 589.658	$1s^22s^2 - 1s^22s2p$	$g^1S - {}^1P^\circ$	0 – 1	P	1104,281
		175.316	347.204 – 917.603	$1s^22s2p - 1s^22p^2$	$^3P^\circ - {}^1D$	2 – 2	P	1104
	100	189.468	304.566 – 832.361	$1s^22s2p - 1s^22p^2$	$^3P^\circ - {}^3P$	1 – 2	P	1104,281
	0	193.530	288.131 – 804.847	$1s^22s2p - 1s^22p^2$	$^3P^\circ - {}^3P$	0 – 1	P	1104,281
		194.361	589.658 – 1104.16	$1s^22s2p - 1s^22p^2$	$^1P^\circ - {}^1S$	1 – 0	P	1104
	50	199.888	304.566 – 804.847	$1s^22s2p - 1s^22p^2$	$^3P^\circ - {}^3P$	1 – 1	P	1104,281
	150	206.119	347.204 – 832.361	$1s^22s2p - 1s^22p^2$	$^3P^\circ - {}^3P$	2 – 2	P	1104,281
		212.207	304.566 – 775.804	$1s^22s2p - 1s^22p^2$	$^3P^\circ - {}^3P$	1 – 0	P	1104
	50	218.511	347.204 – 804.847	$1s^22s2p - 1s^22p^2$	$^3P^\circ - {}^3P$	2 – 1	P	1104,281
	150	304.929	589.658 – 917.603	$1s^22s2p - 1s^22p^2$	$^1P^\circ - {}^1D$	1 – 2	P	1104,281
		328.336	0.0 – 304.566	$1s^22s^2 - 1s^22s2p$	$g^1S - {}^3P^\circ$	0 – 1	P	1104

TITANIUM XX (Ti^{19+}), Z = 22
Ground State $1s^22s(^2S_{1/2})$ (3 electrons)
Ionization Potential 11 496 000 cm^{-1}; 1425.3 eV

Multiplet	Rel. Int.	λ_{vac} (in Å)	Levels (in 10^3 cm^{-1})	Configurations	Terms	J - J	Notes	References
		2.6141	6573.58 – 44828.3	$1s^23p - 1s2p3p$	$^2P^\circ - {}^2P$	$\frac{3}{2} - \frac{3}{2}$		624
		2.616	323.516 – 38550.	$1s^22p - 1s2p^2$	$^2P^\circ - {}^2S$	$\frac{1}{2} - \frac{1}{2}$	P	283
		2.6204	0. – 38162.	$1s^22s - 1s(2s2p(^1P^\circ))$	$g^2S - {}^2P^\circ$	$\frac{1}{2} - \frac{1}{2}$		624
		2.6295	0. – 38030.	$1s^22s - 1s(2s2p(^3P^\circ))$	$g^2S - {}^2P^\circ$	$\frac{1}{2} - \frac{1}{2}$		624
		2.6319	323.516 – 38319.	$1s^22p - 1s2p^2$	$^2P^\circ - {}^2D$	$\frac{1}{2} - \frac{3}{2}$		624
		2.6355	385.659 – 38329.	$1s^22p - 1s2p^2$	$^2P^\circ - {}^2D$	$\frac{3}{2} - \frac{5}{2}$		624
		2.6480	0. – 37764.	$1s^22s - 1s(2s2p(^3P^\circ))$	$g^2S - {}^4P^\circ$	$\frac{1}{2} - \frac{3}{2}$		624
		9.128	0. – 10955.3	$1s^22s - 1s^29p$	$g^2S - {}^2P^\circ$	$\frac{1}{2} - \frac{3}{2}$		623
		9.246	0. – 10815.5	$1s^22s - 1s^28p$	$g^2S - {}^2P^\circ$	$\frac{1}{2} - \frac{3}{2}$		623
		9.405	323.516 – 10956.5	$1s^22p - 1s^29d$	$^2P^\circ - {}^2D$	$\frac{1}{2} - \frac{3}{2}$	P	643
		9.434	0. – 10600.0	$1s^22s - 1s^27p$	$g^2S - {}^2P^\circ$	$\frac{1}{2} - \frac{3}{2}$		623
		9.459	385.659 – 10957.7	$1s^22p - 1s^29d$	$^2P^\circ - {}^2D$	$\frac{3}{2} - \frac{5}{2}$	P	643

Ti XX — Continued

Multiplet	Rel. Int.	λ_{vac} (in Å)	Levels (in 10^3 cm^{-1})	Configurations	Terms	J - J	Notes	References
		9.534	323.516 – 10812.1	$1s^22p - 1s^28d$	${}^2P^\circ - {}^2D$	$\frac{1}{2} - \frac{3}{2}$		623
		9.591	385.659 – 10812.4	$1s^22p - 1s^28d$	${}^2P^\circ - {}^2D$	$\frac{3}{2} - \frac{5}{2}$		623
		9.733	0. – 10274.3	$1s^22s - 1s^26p$	$g^2S - {}^2P^\circ$	$\frac{1}{2} - \frac{3}{2}$		623
		9.788	385.659 – 10602.5	$1s^22p - 1s^27d$	${}^2P^\circ - {}^2D$	$\frac{3}{2} - \frac{5}{2}$		623
		10.046	323.516 – 10277.5	$1s^22p - 1s^26d$	${}^2P^\circ - {}^2D$	$\frac{1}{2} - \frac{3}{2}$		623
		10.109	385.659 – 10278.0	$1s^22p - 1s^26d$	${}^2P^\circ - {}^2D$	$\frac{3}{2} - \frac{5}{2}$		623
		10.278	0. – 9729.5	$1s^22s - 1s^25p$	$g^2S - {}^2P^\circ$	$\frac{1}{2} - \frac{3}{2}$		623
		10.620	323.516 – 9739.5	$1s^22p - 1s^25d$	${}^2P^\circ - {}^2D$	$\frac{1}{2} - \frac{3}{2}$		623
		10.690	385.659 – 9740.5	$1s^22p - 1s^25d$	${}^2P^\circ - {}^2D$	$\frac{3}{2} - \frac{5}{2}$		623
		11.451	0. – 8732.61	$1s^22s - 1s^24p$	$g^2S - {}^2P^\circ$	$\frac{1}{2} - \frac{3}{2}$	P	977
		11.462	0. – 8724.84	$1s^22s - 1s^24p$	$g^2S - {}^2P^\circ$	$\frac{1}{2} - \frac{1}{2}$	P	977
		11.872	323.516 – 8746.70	$1s^22p - 1s^24d$	${}^2P^\circ - {}^2D$	$\frac{1}{2} - \frac{3}{2}$	P	977
		11.954	323.516 – 8688.93	$1s^22p - 1s^24s$	${}^2P^\circ - {}^2S$	$\frac{1}{2} - \frac{1}{2}$	P	977
		11.957	385.659 – 8748.96	$1s^22p - 1s^24d$	${}^2P^\circ - {}^2D$	$\frac{3}{2} - \frac{5}{2}$	P	977
		12.043	385.659 – 8688.93	$1s^22p - 1s^24s$	${}^2P^\circ - {}^2S$	$\frac{3}{2} - \frac{1}{2}$	P	977
	20	15.212	0. – 6573.58	$1s^22s - 1s^23p$	$g^2S - {}^2P^\circ$	$\frac{1}{2} - \frac{3}{2}$	P	977,273
	20	15.255	0. – 6555.09	$1s^22s - 1s^23p$	$g^2S - {}^2P^\circ$	$\frac{1}{2} - \frac{1}{2}$	P	977,273
	20	15.912	323.516 – 6608.08	$1s^22p - 1s^23d$	${}^2P^\circ - {}^2D$	$\frac{1}{2} - \frac{3}{2}$	P	977,273
	30	16.056	385.659 – 6613.86	$1s^22p - 1s^23d$	${}^2P^\circ - {}^2D$	$\frac{3}{2} - \frac{5}{2}$	P	977,273
		16.277	323.516 – 6467.22	$1s^22p - 1s^23s$	${}^2P^\circ - {}^2S$	$\frac{1}{2} - \frac{1}{2}$	P	977
		16.443	385.659 – 6467.22	$1s^22p - 1s^23s$	${}^2P^\circ - {}^2S$	$\frac{3}{2} - \frac{1}{2}$	P	977
	30	259.296	0. – 385.659	$1s^22s - 1s^22p$	$g^2S - {}^2P^\circ$	$\frac{1}{2} - \frac{3}{2}$	P	977,730
		309.104	0. – 323.516	$1s^22s - 1s^22p$	$g^2S - {}^2P^\circ$	$\frac{1}{2} - \frac{1}{2}$	P	977

TITANIUM XXI (Ti^{20+}), Z = 22
Ground State $1s^2({}^1S_0)$ (2 electrons)
Ionization Potential 50 405 000 cm^{-1}; 6249.2 eV

Multiplet	Rel. Int.	λ_{vac} (in Å)	Levels (in 10^3 cm^{-1})	Configurations	Terms	J - J	Notes	References
		2.063	0.0 – 48466.5	$1s^2 - 1s5p$	$g^1S - {}^1P^\circ$	0 – 1	P	728
		2.111	0.0 – 47371.2	$1s^2 - 1s4p$	$g^1S - {}^1P^\circ$	0 – 1	P	728
		2.221	0.0 – 45021.9	$1s^2 - 1s3p$	$g^1S - {}^1P^\circ$	0 – 1	P	728
		2.507	37927.5 – 77815.5	$1s2s - 2s2p$	${}^3S - {}^3P^\circ$	1 – 2		618
		2.510	37927.5 – 77768.5	$1s2s - 2s2p$	${}^3S - {}^3P^\circ$	1 – 1		618
		2.513	38311.6 – 78104.6	$1s2p - 2p^2$	${}^1P^\circ - {}^1D$	1 – 2		618
		2.517	37927.5 – 77657.5	$1s2s - 2s2p$	${}^3S - {}^3P^\circ$	1 – 0		618
		2.6101	0.0 – 38311.6	$1s^2 - 1s2p$	$g^1S - {}^1P^\circ$	0 – 1		624
		2.6229	0.0 – 38129.2	$1s^2 - 1s2p$	$g^1S - {}^3P^\circ$	0 – 1		624
		2.637	0.0 – 37927.5	$1s^2 - 1s2s$	$g^1S - {}^3S$	0 – 1	F,P	375,1013
		14.16	37927.5 – 44987.2	$1s2s - 1s3p$	${}^3S - {}^3P^\circ$	1 – 2	P	375
		14.52	38135.0 – 45021.9	$1s2s - 1s3p$	${}^1S - {}^1P^\circ$	0 – 1	P	375
		390.47	37927.5 – 38183.6	$1s2s - 1s2p$	${}^3S - {}^3P^\circ$	1 – 2	P	375
		566.25	38135.0 – 38311.6	$1s2s - 1s2p$	${}^1S - {}^1P^\circ$	0 – 1	P	375
		1386.96	44915.1 – 44987.2	$1s3s - 1s3p$	${}^3S - {}^3P^\circ$	1 – 2	P	375
		1923.08	44969.9 – 45021.9	$1s3s - 1s3p$	${}^1S - {}^1P^\circ$	0 – 1	P	375

TITANIUM XXII (Ti^{21+}), Z = 22
Ground State $1s(^2S_{1/2})$ (1 electron)
Ionization Potential 53 440 400 cm^{-1}; 6625.82 eV

Multiplet	Rel. Int.	λ_{vac} (in Å)	Levels (in 10^3 cm^{-1})	Configurations	Terms	J - J	Notes	References
		1.910	0.0 – 52356.3340	1s – 7p	$g^2S - ^2P^o$	$\frac{1}{2} - \frac{3}{2}$	P	1042
		1.924	0.0 – 51964.7957	1s – 6p	$g^2S - ^2P^o$	$\frac{1}{2} - \frac{3}{2}$	P	1042
		1.949	0.0 – 51312.0728	1s – 5p	$g^2S - ^2P^o$	$\frac{1}{2} - \frac{3}{2}$	P	1042
		1.995	0.0 – 50114.1931	1s – 4p	$g^2S - ^2P^o$	$\frac{1}{2} - \frac{3}{2}$	P	1042
		2.104	0.0 – 47526.3550	1s – 3p	$g^2S - ^2P^o$	$\frac{1}{2} - \frac{3}{2}$	P	1042
		2.105	0.0 – 47500.5240	1s – 3p	$g^2S - ^2P^o$	$\frac{1}{2} - \frac{1}{2}$	P	1042
		2.491	0.0 – 40140.9890	1s – 2p	$g^2S - ^2P^o$	$\frac{1}{2} - \frac{3}{2}$	P	1042
		2.497	0.0 – 40053.8500	1s – 2p	$g^2S - ^2P^o$	$\frac{1}{2} - \frac{1}{2}$	P	1042
		8.130	40056.4800 – 52356.3340	2s – 7p	$^2S - ^2P^o$	$\frac{1}{2} - \frac{3}{2}$	P	1042
		8.186	40140.9890 – 52356.3340	2p – 7d	$^2P^o - ^2D$	$\frac{3}{2} - \frac{5}{2}$	P	1042
		8.398	40056.4800 – 51964.7957	2s – 6p	$^2S - ^2P^o$	$\frac{1}{2} - \frac{3}{2}$	P	1042
		8.458	40140.9890 – 51964.7957	2p – 6d	$^2P^o - ^2D$	$\frac{3}{2} - \frac{5}{2}$	P	1042
		8.885	40056.4800 – 51312.0728	2s – 5p	$^2S - ^2P^o$	$\frac{1}{2} - \frac{3}{2}$	P	1042
		8.950	40140.9890 – 51313.9014	2p – 5d	$^2P^o - ^2D$	$\frac{3}{2} - \frac{5}{2}$	P	1042
		9.943	40056.4800 – 50114.1931	2s – 4p	$^2S - ^2P^o$	$\frac{1}{2} - \frac{3}{2}$	P	1042
		10.023	40140.9890 – 50117.7644	2p – 4d	$^2P^o - ^2D$	$\frac{3}{2} - \frac{5}{2}$	P	1042
		13.387	40056.4800 – 47526.3550	2s – 3p	$^2S - ^2P^o$	$\frac{1}{2} - \frac{3}{2}$	P	1042
		13.525	40140.9890 – 47534.8169	2p – 3d	$^2P^o - ^2D$	$\frac{3}{2} - \frac{5}{2}$	P	1042
		20.597	47501.3130 – 52356.3340	3s – 7p	$^2S - ^2P^o$	$\frac{1}{2} - \frac{3}{2}$	P	1042
		20.704	47526.3550 – 52356.3340	3p – 7d	$^2P^o - ^2D$	$\frac{3}{2} - \frac{5}{2}$	P	1042
		20.740	47534.8169 – 52356.3340	3d – 7f	$^2D - ^2F^o$	$\frac{5}{2} - \frac{7}{2}$	P	1042
		22.404	47501.3130 – 51964.7957	3s – 6p	$^2S - ^2P^o$	$\frac{1}{2} - \frac{3}{2}$	P	1042
		22.530	47526.3550 – 51964.7957	3p – 6d	$^2P^o - ^2D$	$\frac{3}{2} - \frac{5}{2}$	P	1042
		22.574	47534.8169 – 51964.7957	3d – 6f	$^2D - ^2F^o$	$\frac{5}{2} - \frac{7}{2}$	P	1042
		26.242	47501.3130 – 51312.0728	3s – 5p	$^2S - ^2P^o$	$\frac{1}{2} - \frac{3}{2}$	P	1042
		26.402	47526.3550 – 51313.9014	3p – 5d	$^2P^o - ^2D$	$\frac{3}{2} - \frac{5}{2}$	P	1042
		26.455	47534.8169 – 51314.8149	3d – 5f	$^2D - ^2F^o$	$\frac{5}{2} - \frac{7}{2}$	P	1042
		38.272	47501.3130 – 50114.1931	3s – 4p	$^2S - ^2P^o$	$\frac{1}{2} - \frac{3}{2}$	P	1042
		38.589	47526.3550 – 50117.7644	3p – 4d	$^2P^o - ^2D$	$\frac{3}{2} - \frac{5}{2}$	P	1042
		38.689	47534.8169 – 50119.5482	3d – 4f	$^2D - ^2F^o$	$\frac{5}{2} - \frac{7}{2}$	P	1042
		1183.306	40056.4800 – 40140.9890	2s – 2p	$^2S - ^2P^o$	$\frac{1}{2} - \frac{3}{2}$	P	1042

D. Magnetic Dipole Lines for Titanium Ions (Wavelengths, Classifications, and Transition Probabilities)

D. Magnetic Dipole Lines for Titanium Ions

[Excerpted from: V. Kaufman and J. Sugar, J. Phys. Chem. Ref. Data **15**, 321 (1986)]

1. Introduction

The following tables, including the introductory comments, are excerpted from the above cited compilation of observed and predicted wavelengths of magnetic dipole lines arising within ground configurations of the type ns^2np^k ($n=2$ and 3, $k=1$ to 5). The compilation work was done by V. Kaufman and J. Sugar of the National Institute of Standards and Technology (formerly the National Bureau of Standards).

All measured lines that are correctly identified are included. Some are only tentatively classified by the authors, but appear to be reasonable on the basis of predictions along isoelectronic sequences.

Also included is a selected group of electric quadrupole lines (E2) that are frequently observed in ns^2np^2 and ns^2np^4 configurations; these are the $^1D_2-^1S_0$ transitions.

It will probably be difficult to observe the $nsnp$ ($^3P_{0,1,2}$) transitions in the Be and Mg isoelectronic sequences because the very large electric-dipole probability of the $ns^2\,^1S_0-nsnp\,^1P_1$ resonant transition will tend to rapidly deplete the $nsnp\,^1P_1$ level. Similarly, but to a lesser extent, the $^3P_0-^3P_1$ transition can be expected to be weak because of the $ns^2\,^1S_0-nsnp\,^3P_1$ transition. However, these magnetic-dipole transitions have been included for the sake of completeness.

Calculations of line strengths and transition probabilities have been made for all of these lines by both relativistic and non-relativistic methods. Preference has been given to the relativistic results. Calculations by both methods for the $n=3$ shell differ on the average by only 5%.[1]

2. Predicted Wavelengths

For the titanium ions, predicted values for the wavelengths of the M1 and E2 lines were obtained from the known energy levels by the Ritz principle of deriving wavelengths from energy differences. Their uncertainties are derived from the reported level uncertainties. The source of data is given in Sec. 7 below.

3. Observed Wavelengths

All experimental wavelength data for titanium are from tokamak observations. The sources of observed data that have been credited are those providing the best measurements.

4. Predicted Transition Probabilities

In most cases multiconfiguration Dirac-Fock calculations of line strengths are available. These calculations do not generally converge for neutral and singly ionized atoms, but non-relativistic calculations have been made in every such case. Line strengths for the magnetic-dipole lines of the isoelectronic sequences of B I, C I, N I, and F I were taken from Cheng *et al.*[2] Those for the Al I, Si I, P I, and Cl I sequences were taken from Huang[3-5] and Huang *et al.*[6] The relativistic calculations are not available for the Be, Mg, and S isoelectronic sequences. The transition probabilities for all magnetic-dipole lines of the Be-like, Mg-like, and S-like ions were therefore calculated in the manner described by Sugar and Kaufman.[1] These are non-relativistic calculations in intermediate coupling. They agree within a few percent with relativistic calculations in the $n=3$ sequences for which both are available.

The transition probabilities for some electric quadrupole lines in the sulfur sequence, $3s^23p^4$, are from Mendoza and Zeippen.[7] For the Si sequence the line strengths given by Huang[4] have been used.

Relations between transition probabilities $A(s^{-1})$ and line strengths S are given explicitly as

$$A = \frac{2.697\times 10^{13}}{\lambda^3 g}\,S(\mathrm{M1}),$$

$$A = \frac{1.680\times 10^{18}}{\lambda^5 g}\,S(\mathrm{E2}),$$

where λ is the transition wavelength in Å and g is the $2J+1$ degeneracy of the upper level. S(M1) in Bohr magneton units (μ_B) and S(E2) in atomic units (ea_0^2) are the magnetic-dipole and electric-quadrupole line strengths, respectively.

The magnetic-dipole transition rate in almost all cases is a few orders of magnitude greater than the electric-quadrupole transition rate. The E2 rate has been added to the M1 rate in those cases for which the former is greater than 1% of the latter. This is true only for some of the N I ($2p^3$) and P I ($3p^3$) sequence transitions. An asterisk following the transition rate in the tables shows where this occurs.

5. Data Table Information

The tables contain the predicted and observed wavelengths and predicted transition probabilities for magnetic-dipole transitions within ns^2np^k ($k = 1-5$) and $nsnp$ configurations for $n = 2, 3$. The electric quadrupole transition $^1D_2$–$^1S_0$ for $k = 2, 4$ is included because it is frequently observed. The data are presented in order of increasing wavelength. The columns from left to right in order of appearance contain the following information:

Column No.	Description
1	Wavelengths (observed and predicted) in Å below 20 000 Å, and in micrometers (μm) between 2 and 1000 μm. Wavelengths given without units are in Å. Wavelengths in vacuum are given below 2000 Å, in air between 2000 Å and 5 μm, and in vacuum above 5 μm. Each wavelength is followed by its uncertainty in parentheses. Tentative identifications are preceded by "T". E2 transitions are denoted by "Q".
2	Transition probabilities (A) are written as a factor times 10 to a power. The power of ten follows the decimal factor. For example, 2.20 +4 means 2.20×10^4. An asterisk following the transition probability indicates that the E2 rate for the transition is greater than 1% of the M1 rate and has been added to that value.
3	Spectrum.
4	Electronic configuration.
5	Line classification. Lower level is given first.
6	Ionization energy in thousands of electron volts (keV).[8-10]
7	References for observed wavelengths. Definitions of symbols are given in Sec. 8, "References for Observed Wavelengths".

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FBM Finkenthal, M., Bell, R. E., Moos, H. W., and TFR Group (1984), J. Appl. Phys. **56**, 2012.
H Hinnov, E. (Oct. 1985), private communication.
PSS Peacock, N. J., Stamp, M. F., and Silver, J. D. (1984), Phys. Scr. **T8**, 10.
SFH Suckewer, S., Fonck, R., and Hinnov, E. (1980), Phys. Rev. A **22**, 2278.

Magnetic Dipole Lines for Titanium

Wavelength Observed	Wavelength Calculated	A (s^{-1})	Spectrum	Config.	Classification	I.E. (keV)	Ref. (obs. H)
	331.68(3)	4.79 +3	Ti XIX	2s 2p	$^3P_0 - {}^1P_1$	1.35	
	350.78(4)	2.99 +3	Ti XIX	2s 2p	$^3P_1 - {}^1P_1$	1.35	
	412.47(5)	3.11 +3	Ti XIX	2s 2p	$^3P_2 - {}^1P_1$	1.35	
456.1(3)	456.10(5)	7.72 +3	Ti XVI	$2s^2\ 2p^3$	$^4S_{3/2} - {}^2P_{3/2}$	1.04	H
470.4(3)	470.54(11)	2.68 +4	Ti XVII	$2s^2\ 2p^2$	$^3P_1 - {}^1S_0$	1.13	H
505.9(3)	505.82(6)	4.94 +3	Ti XVI	$2s^2\ 2p^3$	$^4S_{3/2} - {}^2P_{1/2}$	1.04	H
	567.41(16)	2.55 +4	Ti XV	$2s^2\ 2p^4$	$^3P_1 - {}^1S_0$	0.94	
	764.99(15)	7.16 +1*	Ti XVI	$2s^2\ 2p^3$	$^4S_{3/2} - {}^2D_{5/2}$	1.04	
861.8(1)	861.85(19)	2.00 +3	Ti XVI	$2s^2\ 2p^3$	$^4S_{3/2} - {}^2D_{3/2}$	1.04	H
T 899.7(3)	900.9(4)	1.84 +3	Ti XVII	$2s^2\ 2p^2$	$^3P_1 - {}^1D_2$	1.13	H
919.73(8)	919.71(9)	2.42 +3	Ti XV	$2s^2\ 2p^4$	$^3P_2 - {}^1D_2$	0.94	PSS
	Q 936.3(4)	2.72 +1	Ti XV	$2s^2\ 2p^4$	$^1D_2 - {}^1S_0$	0.94	
968.9(3)	968.80(20)	5.16 +3	Ti XVI	$2s^2\ 2p^3$	$^2D_{3/2} - {}^2P_{3/2}$	1.04	H
	Q 985.0(7)	1.77 +1	Ti XVII	$2s^2\ 2p^2$	$^1D_2 - {}^1S_0$	1.13	
1129.2(4)	1129.6(3)	1.99 +3	Ti XVI	$2s^2\ 2p^3$	$^2D_{5/2} - {}^2P_{3/2}$	1.04	FBM
	1165.69(19)	2.46 +1	Ti XI	3s 3p	$^3P_0 - {}^1P_1$	0.27	
	1177.4(7)	2.25 +3	Ti XVII	$2s^2\ 2p^2$	$^3P_2 - {}^1D_2$	1.13	
	1201.63(20)	1.68 +1	Ti XI	3s 3p	$^3P_1 - {}^1P_1$	0.27	
1224.1(4)	1224.4(3)	1.60 +3	Ti XVI	$2s^2\ 2p^3$	$^2D_{3/2} - {}^2P_{1/2}$	1.04	FBM
	1289.09(24)	2.27 +1	Ti XI	3s 3p	$^3P_2 - {}^1P_1$	0.27	
1440.2(8)	1440.05(22)	2.23 +2	Ti XV	$2s^2\ 2p^4$	$^3P_1 - {}^1D_2$	0.94	FBM
	1724.7(4)	1.17 +2	Ti IX	$3s^2\ 3p^2$	$^3P_1 - {}^1S_0$	0.19	
1778.1(1)	1778.09(10)	1.59 +3	Ti XVIII	$2s^2\ 2p$	$^2P_{1/2} - {}^2P_{3/2}$	1.22	SFH
	1797.5(6)	3.90 +1	Ti VIII	$3s^2\ 3p^3$	$^4S_{3/2} - {}^2P_{3/2}$	0.17	
	1845.4(7)	1.75 +1	Ti VIII	$3s^2\ 3p^3$	$^4S_{3/2} - {}^2P_{1/2}$	0.17	
	1989.38(18)	1.01 +2	Ti VII	$3s^2\ 3p^4$	$^3P_1 - {}^1S_0$	0.14	
2117.1(2)	2117.12(18)	1.89 +3	Ti XIV	$2s^2\ 2p^5$	$^2P_{3/2} - {}^2P_{1/2}$	0.86	SFH
2344.6(2)	2344.5(2.3)	1.01 +3	Ti XIX	2s 2p	$^3P_1 - {}^3P_2$	1.35	PSS
2544.8(1)	2544.54(19)	1.30 +3	Ti XV	$2s^2\ 2p^4$	$^3P_2 - {}^3P_1$	0.94	SFH
	3006.1(1.8)	6.62 -2*	Ti VIII	$3s^2\ 3p^3$	$^4S_{3/2} - {}^2D_{5/2}$	0.17	
	Q 3071.8(1.3)	8.58 +0	Ti IX	$3s^2\ 3p^2$	$^1D_2 - {}^1S_0$	0.19	
	3105.6(1.9)	2.00 +0	Ti VIII	$3s^2\ 3p^3$	$^4S_{3/2} - {}^2D_{3/2}$	0.17	
	Q 3259.5(6)	4.92 +0	Ti VII	$3s^2\ 3p^4$	$^1D_2 - {}^1S_0$	0.14	
3370.8(2)	3370.80(23)	4.44 +2	Ti XVII	$2s^2\ 2p^2$	$^3P_0 - {}^3P_1$	1.13	SFH
3834.4(2)	3834.4(4)	2.15 +2	Ti XVII	$2s^2\ 2p^2$	$^3P_1 - {}^3P_2$	1.13	SFH
	3930.3(2.2)	4.52 -1	Ti IX	$3s^2\ 3p^2$	$^3P_1 - {}^1D_2$	0.19	
	4143.1(7)	8.46 +0	Ti VII	$3s^2\ 3p^4$	$^3P_2 - {}^1D_2$	0.14	
	4264.4(5)	1.77 +1*	Ti VIII	$3s^2\ 3p^3$	$^2D_{3/2} - {}^2P_{3/2}$	0.17	
	4467.6(6)	9.10 +0*	Ti VIII	$3s^2\ 3p^3$	$^2D_{5/2} - {}^2P_{3/2}$	0.17	
	4544.4(6)	9.44 +0*	Ti VIII	$3s^2\ 3p^3$	$^2D_{3/2} - {}^2P_{1/2}$	0.17	
4635.6(3)	4639.(5)	7.19 +1	Ti XVI	$2s^2\ 2p^3$	$^2P_{1/2} - {}^2P_{3/2}$	1.04	H

Magnetic Dipole Lines for Titanium – Continued

Wavelength Observed	Wavelength Calculated	A (s^{-1})	Spectrum	Config.	Classification	I.E. (keV)	Ref. (obs. H)
	4700.(3)	8.05 +0	Ti IX	$3s^2\ 3p^2$	$^3P_2 - {}^1D_2$	0.19	
	5101.7(1.2)	1.54 +0	Ti VII	$3s^2\ 3p^4$	$^3P_1 - {}^1D_2$	0.14	
	6092.(16)	8.71 +1	Ti XIX	2s 2p	$^3P_0 - {}^3P_1$	1.35	
	6806.(10)	2.80 +1	Ti XVI	$2s^2\ 2p^3$	$^2D_{3/2} - {}^2D_{5/2}$	1.04	
	13254.(7)	3.86 +0	Ti X	$3s^2$ 3p	$^2P_{1/2} - {}^2P_{3/2}$	0.22	
	17150.(30)	3.56 +0	Ti VI	$3s^2\ 3p^5$	$^2P_{3/2} - {}^2P_{1/2}$	0.12	
	17710.(40)	2.43 +0	Ti XI	3s 3p	$^3P_1 - {}^3P_2$	0.27	
	2.2050(10) μm	2.06 +0	Ti VII	$3s^2\ 3p^4$	$^3P_2 - {}^3P_1$	0.14	
	2.401(8) μm	9.55 -1	Ti IX	$3s^2\ 3p^2$	$^3P_1 - {}^3P_2$	0.19	
	3.205(10) μm	5.39 -1	Ti IX	$3s^2\ 3p^2$	$^3P_0 - {}^3P_1$	0.19	
	3.270(22) μm	1.41 +0	Ti XV	$2s^2\ 2p^4$	$^3P_1 - {}^3P_0$	0.94	
	3.896(21) μm	3.00 -1	Ti XI	3s 3p	$^3P_0 - {}^3P_1$	0.27	
	6.923(14) μm	2.57 -2	Ti VIII	$3s^2\ 3p^3$	$^2P_{1/2} - {}^2P_{3/2}$	0.17	
	7.386(15) μm	1.34 -1	Ti VII	$3s^2\ 3p^4$	$^3P_1 - {}^3P_0$	0.14	
	9.382(25) μm	1.24 -2	Ti VIII	$3s^2\ 3p^3$	$^2D_{3/2} - {}^2D_{5/2}$	0.17	

E. Atomic Energy Levels of Titanium, Ti I through Ti XXII

E. Atomic Energy Levels of Titanium, Ti I through Ti XXII

[Excerpted from: J. Sugar and C. Corliss, J. Phys. Chem. Ref. Data **14**, Suppl. 2 (1985)].

1. Introduction

The following tables, including the introductory comments, are excerpted from the iron-period compilation of atomic energy levels by J. Sugar and C. Corliss (1985) of the Atomic Energy Levels Data Center at the National Institute of Standards and Technology (formerly the National Bureau of Standards).

Generally, only published papers have been used as sources of data. Unpublished data are included when they constitute a substantial improvement over material in the literature. For many of the higher ions the original papers do not give energy level values, but only classifications of observed lines. In these cases the level values have been derived from the given data.

All energy levels are given in units of cm^{-1}, beginning with a value of zero for the ground level. Ionization energies found in the literature are usually given in eV or cm^{-1}. The conversion factor, 8065.479(21) cm^{-1}/eV, given by Cohen and Taylor (1973), is used here. In a few cases where adequate data were available but the ionization energy had not been derived, this calculation was carried out. For a number of the ions, no suitable series are known. In these cases values obtained by Lotz (1967), by a method of successive differences along isoelectronic sequences, have been quoted. Although uncertainties are not provided with these extrapolated values, it is estimated that they are accurate to 0.2% by comparing them with recently determined values.

Nearly all of the data are based on observations of various types of laboratory light sources. However, the laboratory data are sometimes supplemented by data obtained from solar observations. This is particularly true where spin-forbidden lines are needed to establish the absolute energy of a system of excited levels and 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.

When no observations are available to connect independent systems of levels, an estimate of the connecting energy is adopted. Those level values affected by the estimate are denoted by $+x$ following the value. The value of x is the systematic error of the estimate.

Included under the heading "Leading Percentages" are the results of calculations that express the eigenvector percentage composition of levels (rounded to the nearest %) in terms of the basis states of a single configuration, or more than one configuration where configuration interaction has been included. First the percentage of the basis state corresponding to the level's name is given; next the second largest percentage together with the related basis state. Sometimes the leading percentage in an alternative coupling scheme is given. Generally, when the leading percentage is less than 40%, no name is given. When the first and second resultant terms are the same and sum to ≥40% the first name is given. When the first and second resultant terms are the same but have different parentages, and their share of the eigenvector composition sums to 40% or more, the level will be named as the higher percentage term. In cases where these percentages differ by one or two units (an insignificant difference), either term may be selected for the level name, and the lower percentage may appear first. For the unnamed level, the term symbol follows the percentage. The user should of course bear in mind that the percentages are model dependent, so that the results of different calculations can yield notably different percentages. In the case of Cr, the 1969 results by Roth are adopted. It was intended to use his new 1980 calculations as well, but it was found that the sum of percentages for a number of states exceeded 100 by significant amounts.

For configurations of equivalent d-electrons, several terms of the same LS type may occur. These are theoretically distinguished by their seniority number. In the present compilations they are designated in the notation of Nielson and Koster (1963). For example, in the $3d^5$ configuration there are three ^{2}D terms with seniorities of 1, 3, and 5. These terms are denoted as ^{2}D1, ^{2}D2, and ^{2}D3, respectively, by Nielson and Koster. Martin, Zalubas, and Hagan (1978) give a complete summary of the coupling notations used here, tables of the allowed terms for equivalent electrons, etc.

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

- i. Papers cited by Moore (1949, 1952)
- ii. C. E. Moore (1968, 1969)
- iii. L. Hagan and W. C. Martin (1972)
- iv. L. Hagan (1977)
- v. R. Zalubas and A. Albright (1980)
- vi. Card file of publications since June 1979 maintained by the NBS Atomic Energy Levels Data Center

He I Isoelectronic Sequence

Spectra of K, Ca, Ti, and V were obtained by Aglitskii *et al.* (1974) with a laser-heated plasma in third and fifth orders of a crystal spectrograph. Reference lines of Mg XI and Al XII published by Flemberg (1942) were used, and an uncertainty of ± 0.0005 Å was reported for the lines of the He I isoelectronic sequence, which fall in the range of $2.3-3.6$ Å. Flemberg's reference wavelengths were in x-units. The equivalence to Å that he used must be increased by 8 parts in 10^5, according to the more recent conversion determined by Deslattes and Henins (1973). With this correction, the data of Aglitskii *et al.* deviate randomly from the calculated wavelengths of Safronova (1981) by ± 0.0008 Å.

In a beam-foil experiment the He-like argon spectrum was observed by Briand et al. (1983a). Their wavelengths for the $1s^2\,{}^1S_0 - 1s2p\,{}^3P_1^\circ$ and ${}^1P_1^\circ$ transitions were 3.9693(3) Å and 3.9491(3) Å, in agreement with the calculated values by Safronova.

The $1s2s\,{}^3S_1 - 1s2p\,{}^3P_2^\circ$ transition has been measured in Ca XIX by Livingston (1983) and in Fe XXV by Buchet *et al.* (1982). The measured wavelengths are 466.78(8) Å for Ca and 271.04(10) Å for Fe. The corresponding energy differences are greater than those predicted by Safronova by 162(37) and 123(136) cm^{-1}, respectively, or 0.07% and 0.03% of the energy difference. A new calculation of these energies by Hata and Grant (1983) predicted values that were 60 cm^{-1} lower in Ca and 154 cm^{-1} lower in Fe than the observed values.

Because of the excellent agreement of Safronova's calculations with the best experimental data available and the paucity of these data, the compilation of this sequence was based on her results. Her calculated energies were quoted for the $1s2s$ and $1s2p$ levels of the He I isoelectronic sequence and for the principal ionization energies (with correction to the Rydberg for finite atomic mass). The observed $1s2s\,{}^3S_1 - 1s2p\,{}^3P_2^\circ$ intervals in Ca XIX mentioned above are incorporated in the respective level lists. For $n = 3-5$ the calculated binding energies reported by Ermolaev and Jones (1974) are subtracted from the binding energy of the ground state by Safronova to arrive at energy level values. The uncertainty in the calculated energy levels and the ionization energies is assumed conservatively to be 2 parts in 10^4, corresponding to the deviations from the Aglitskii *et al.* (corrected) observations. (The deviation from the measurements in Ar is 1 part in 10^4.) The uncertainties in energy differences for levels of the same n-value are estimated to be 2 parts in 10^3. The deviation of the $1s2p\,{}^3P_1^\circ - {}^1P_1^\circ$ intervals measured by Aglitskii *et al.* with resonance lines differ randomly from the calculated values of Safronova by 3%.

The singlet-triplet mixing coefficients for the $1snp\,{}^{1,3}P^\circ$ states are quoted from Ermolaev and Jones.

H I Isoelectronic Sequence

No observations of $1s-np$ transitions have been sufficiently accurate to test the theoretical values. The best measurement available is for the $1s-2p$ energies for Fe XXVI with an uncertainty of ± 5000 cm^{-1}, or 1 part in 10^4, by Briand, Tavernier, and Indelicato (1983b). Erickson (1977) has calculated the absolute binding energies for each of the levels through $n = 5$ and for the ns and np states through $n = 13$. An improved calculation of the Lamb-shift effects was reported by Mohr (1983), who gave the energy separations among the $n = 1$ and 2 levels. Gould and Marrus (1983) have measured the Lamb-shift of the $2s\,{}^2S_{1/2}$ state of Ar XVIII, obtaining the value 1264(13) cm^{-1}. Their results agrees with the value 1275.8(0.8) cm^{-1} calculated by Mohr and is three standard deviations lower than Erickson's value of 1301(2) cm^{-1}.

Mohr's results for the energy separations of $n = 1$ and 2 levels have been compiled, and Erickson's for $n = 3-5$ relative to the $2p\,{}^2P_{3/2}^\circ$ level. This increases Erickson's values for the levels, or, equivalently, increases the binding energy of the ground state (the ionization energy). Assuming that the uncertainty in these compiled values is mainly due to the error in the Lamb shift, the fractional error is taken as equal to the experimental fractional error in the Ar measurement. This contribution to the level values relative to the ground state is about 4 parts in 10^6 for the iron period. This is about 10 times the error estimated by Mohr for his calculated $1s - 2p$ intervals. The corresponding intervals calculated by Erickson are lower than those of Mohr by about the same fractional amount.

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Ti I

$Z = 22$

Ground state: $1s^2 2s^2 2p^6 3s^2 3p^6 3d^2 4s^2\ {}^3F_2$

Ionization energy = 55 010±50 cm^{-1} (6.820±0.006 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. The 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' 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 Catalán 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 give values for 152 Ti I levels with an uncertainty of ±0.005 cm^{-1}. 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 $3d^4$, $a\ {}^5D$, 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 $3d^4$, $d\ {}^3P$.

The g-values for the $a\ {}^3F$ term were measured by Channapa and Pendlebury (1965). The rest were calculated by Moore (1949) from the Zeeman patterns quoted by Russell (1927). Moore has omitted the a ${}^1S_0$ 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 ${}^3H$ term was privately communicated to Moore (1949).

New measurements in the region 2117–3072 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, $s\ {}^3G°$ and $p\ {}^3F°$, which have been assigned to $3d^3({}^2F)4p$ by Smith and Siddall (1969). Smith and Siddall also assigned 7 terms to $3d^2 4s5p$ or $3d^3 5p$.

Levels given with two decimal places from the sources mentioned above are assumed to have an uncertainty of ±0.05 cm^{-1}. The percentage compositions for the even parity configurations $3d^2 4s^2$, $3d^3 4s$, and $3d^4$ were calculated by Dembczynski (1980) with configuration interaction (CI). Those of the odd parity configurations $3d4s^2 4p$, $3d^2 4s4p$, and $3d^3 4p$ were calculated by Roth (1969) with CI. Both calculations were fit to the observed energy levels. Roth's 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. A new calculation by Roth (1980) for the odd parity configurations could not be used because of errors in the eigenstate percentages, which in many cases summed to more than 100.

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Configuration	Term	J	Level (cm^{-1})	g	Leading percentages		
$3d^2 4s^2$	$a\ ^3$F	2	0.000	0.66	100		
		3	170.132	1.08	100		
		4	386.874	1.25	100		
$3d^3(^4$F$)4s$	$a\ ^5$F	1	6 556.828	0.00	100		
		2	6 598.749	0.99	100		
		3	6 661.003	1.25	100		
		4	6 742.757	1.35	100		
		5	6 842.964	1.41	100		
$3d^2 4s^2$	$a\ ^1$D	2	7 255.369	1.02	96	2	$3d^3(^2$D2$)4s\ ^1$D
$3d^2 4s^2$	$a\ ^3$P	0	8 436.618		92	7	$3d^3(^2$P$)4s\ ^3$P
		1	8 492.421	1.50	92	7	
		2	8 602.340	1.49	90	7	
$3d^3(^4$F$)4s$	$b\ ^3$F	2	11 531.760	0.67	100		
		3	11 639.804	1.08	100		
		4	11 776.806	1.26	98	1	$3d^2 3s^2\ ^1$G
$3d^2 4s^2$	$a\ ^1$G	4	12 118.394	0.98	90	8	$3d^3(^2$G$)4s\ ^1$G
$3d^3(^4$P$)4s$	$a\ ^5$P	1	13 981.75	2.50	100		
		2	14 028.47	1.82	100		
		3	14 105.68	1.66	100		
$3d^3(^2$G$)4s$	$a\ ^3$G	3	15 108.121	0.74	100		
		4	15 156.787	1.06	100		
		5	15 220.390	1.21	100		
$3d^2(^3$F$)4s4p(^3$P°$)$	$z\ ^5$G°	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		
$3d^2(^3$F$)4s4p(^3$P°$)$	$z\ ^5$F°	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		
$3d^3(^2$D2$)4s$	$a\ ^3$D	1	17 369.59	0.49	67	30	$(^2$D1$)\ ^3$D
		2	17 423.853	1.17	67	30	
		3	17 540.205	1.34	67	30	
$3d^3(^2$P$)4s$	$b\ ^3$P	0	17 995.75		86	7	$3d^2 3s^2\ ^3$P
		1	18 061.54		87	7	
		2	18 145.40		87	7	
$3d^3(^2$H$)4s$	$a\ ^3$H	4	18 037.225	0.80	52	44	$(^2$G$)\ ^1$G
		5	18 141.229	1.02	100		
		6	18 192.577	1.17	100		
$3d^3(^2$G$)4s$	$b\ ^1$G	4	18 287.560	1.02	48	48	$(^2$H$)\ ^3$H

Ti I—Continued

Configuration	Term	J	Level (cm^{-1})	g	Leading percentages			
$3d^2(^3F)4s4p(^3P^\circ)$	$z\,^5D^\circ$	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		94		5	$3d^3(^2P)4s\ ^3P$
		1	18 825.89	1.54?	94		3	$3d^3(^2P)4s\ ^3P$
		2	18 911.399	1.54	98		1	$3d^4\ ^3P2$
$3d^2(^3F)4s4p(^3P^\circ)$	$z\,^3F^\circ$	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		1	^3P
$3d^3(^2D2)4s$	$b\,^1D$	2	20 209.444	1.01?	67		30	$(^2D1)\ ^1D^\circ$
$3d^3(^2H)4s$	$a\,^1H$	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	$3d^2(^3F)4s4p(^1P^\circ)\ ^3D^\circ$
$3d^2(^1D)4s4p(^3P^\circ)$		2	*25 438.898*	1.17	37	$^3P^\circ$	28	$3d^3(^4F)4p\ ^3D^\circ$
$3d^2(^1D)4s4p(^3P^\circ)$	$z\,^3P^\circ$	2	*25 493.722*	1.47	49		20	$3d^3(^4F)4p\ ^3D^\circ$
		1	*25 537.276*	1.50	64		22	$3d^2(^3P)4s4p(^3P^\circ)\ ^5D^\circ$
$3d^2(^3P)4s4p(^3P^\circ)$	$y\,^5D^\circ$	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	$3d^3(^4F)4p\ ^5D^\circ$
$3d^2(^3P)4s4p(^3P^\circ)$		3	*25 643.695*	1.33	32	$^5D^\circ$	32	$3d^3(^4F)4p\ ^3D^\circ$

Ti I—Continued

Configuration	Term	J	Level (cm^{-1})	g	Leading percentages			
$3d^3(^4F)4p$	$y\ ^5G^\circ$	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	$3d4s^24p\ ^1D^\circ$
$3d^3(^4F)4p$	$y\ ^5F^\circ$	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		100			
		1	28 791.62		100			
		2	28 828.51		100			
		3	28 882.44		100			
		4	28 952.10		100			
$3d^2(^3F)4s4p(^1P^\circ)$	$w\ ^3D^\circ$	1	*29 661.232*	0.51	33		24	$3d^3(^4F)4p\ ^3D^\circ$
		2	*29 768.655*	1.16	29		21	$3d^3(^4F)4p\ ^3D^\circ$
$3d^3(^2F)4s$	$a\ ^1F$	3	29 818.31		98		1	$3d^4\ ^1F$
$3d^3(^4F)4p$	$x\ ^5D^\circ$	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			
$3d^3(^4F)4p$		3	*29 912.262*	1.34	35	$^5D^\circ$	20	$3d^2(^3F)4s4p(^1P^\circ)\ ^3D^\circ$
$3d^2(^1G)4s4p(^3P^\circ)$	$x\ ^3G^\circ$	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	

Ti I—Continued

Configuration	Term	J	Level (cm^{-1})	g	Leading percentages		
$3d^3(^4F)4p$	$w\ ^3G°$	3	*31 373.801*	0.75	70	21	$3d^2(^3F)4s4p(^1P°)\ ^3G°$
		4	*31 489.451*	1.05	69	22	
		5	*31 628.668*	1.19	69	22	
$3d^2(^3P)4s4p(^3P°)$	$y\ ^3P°$	0	*31 685.90*		85	7	$3d^3(^2P)4p\ ^3P°$
		1	*31 725.75*	1.47	85	6	
		2	*31 805.94*		85	6	
$3d^2(^1G)4s4p(^3P°)$	$z\ ^3H°$	4	*31 829.972*	0.80	85	11	$3d^3(^2G)4p\ ^3H°$
		5	*31 914.277*	1.04	86	10	
		6	*32 013.534*	1.17	86	10	
$3d^2(^1D)4s4p(^1P°)$	$y\ ^1F°$	3	*32 857.721*	0.99	36	44	$3d^3(^2G)4p\ ^1F°$
$3d^3(^4P)4p$	$x\ ^3P°$	0	*33 085.153*		33	34	$3d^2(^3P)4s4p(^1P°)\ ^3P°$
		1	*33 090.492*	1.46	33	34	
		2	*33 114.412*	1.46	34	34	
$3d^3(^4F)4p$	$w\ ^3F°$	2	*33 655.853*	0.66	54	30	$3d^2(^3F)4s4p(^1P°)\ ^3F°$
		3	*33 680.130*	1.09	53	30	
		4	*33 700.874*	1.26	53	30	
$3d^2(^1D)4s4p(^1P°)$	$z\ ^1P°$	1	*33 660.671*	0.94	37	29	$(^3P)(^3P°)\ ^1P°$
$3d^2(^1G)4s4p(^3P°)$	$v\ ^3F°$	2	*33 980.639*	0.63	81	9	$3d4s^24p\ ^3F°$
		3	*34 078.580*	1.10	83	9	
		4	*34 204.971*	1.23	84	8	
$3d^4$	$d\ ^3P2$	0	34 170.95		56	41	$^3P1$
		1	34 327.96		56	41	
		2	34 535.04		56	41	
$3d^3(^2G)4p$	$z\ ^1H°$	5	*34 700.212*	1.02	58	26	$(^2H)\ ^1H°$
$3d^2(^3P)4s4p(^3P°)$	$y\ ^1P°$	1	*34 947.120*		54	26	$(^1D)(^1P°)\ ^1P°$
$3d^2(^3P)4s4p(^3P°)$	$x\ ^1D°$	2	*35 035.147*		56	12	$(^3F)(^3P°)\ ^1D°$
	$y\ ^3S°$	1	*35 439.228*	2.18			
$3d^3(^2G)4p$	$y\ ^3H°$	4	*35 454.051*	0.79	84	13	$3d^2(^1G)4s4p(^3P°)\ ^3H°$
		5	*35 559.627*	1.04	85	12	
		6	*35 685.160*	1.17	85	12	
$3d^3(^4P)4p$	$w\ ^5D°$	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		
$3d^2\ 4s(^4F)5s$	$e\ ^5F$	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			
$3d^2(^1G)4s4p(^1P°)$	$y\ ^1G°$	4	*36 000.144*	1.00	45	32	$3d^3(^2G)4p\ ^1G°$

Ti I—Continued

Configuration	Term	J	Level (cm^{-1})	g	Leading percentages		
$3d^4$	$b\ ^3G$	3	36 065.75		100		
		4	36 132.21		100		
		5	36 200.94		100		
$3d^3(^4P)4p$	$y\ ^5P^\circ$	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		
$3d^2\ 4s(^4F)5s$	$e\ ^3F$	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	
$3d\ 4s^2\ 4p$	$x\ ^1F^\circ$	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	
$3d^3(^2H)4p$	$z\ ^3I^\circ$	5	38 572.692	0.81	100		
		6	38 668.832	1.02	100		
		7	38 779.856	1.15	100		
$3d^3(^2P)4p$	$t\ ^3D^\circ$	1	38 654.23	0.54?	37	22	$3d4s^24p\ ^3D^\circ$
		2	38 699.767		32	20	
		3	38 764.832	1.32	32	20	
$3d^3(^2G)4p$	$x\ ^1G^\circ$	4	38 959.499	1.02	50	29	$(^2H)\ ^1G^\circ$
$3d^3(a\ ^2D)4p$	$x\ ^1P^\circ$	1	39 077.713		73	16	$(^2P)\ ^1P^\circ$
$3d^3(^4F)5s$	$f\ ^5F$	1	39 107.25				
		2	39 149.26				
		3	39 214.38				
		4	39 302.36				
		5	39 412.78				
$3d^3(^2H)4p$	$x\ ^3H^\circ$	4	39 115.958	0.88	93		
		5	39 152.057	1.02	85	12	$3d^2(^1G)4s4p(^1P^\circ)\ ^3H^\circ$
		6	39 198.320	1.18	85	12	$3d^2(^1G)4s4p(^1P^\circ)\ ^3H^\circ$

Ti I—Continued

Configuration	Term	J	Level (cm^{-1})	g	Leading percentages			
$3d^3(^2P)4p$	$w\ ^1D^\circ$	2	39 265.80	1.06?	30		28	$3d4s^24p\ ^1D^\circ$
$3d^3(^4F)5s$	$f\ ^3F$	2	39 526.89					
		3	39 640.98					
		4	39 785.94					
$3d^3(a\ ^2D)4p$	$s\ ^3D^\circ$	1	39 662.15	0.52	54		14	$(^2P)\ ^3D^\circ$
		2	39 686.10		60		17	
		3	39 715.437	1.31	55		20	
$3d^3(a\ ^2D)4p$	$w\ ^1F^\circ$	3	40 302.950	1.05	82		7	$3d^2(^1D)4s4p(^1P^\circ)\ ^1F^\circ$
$3d^3(^2H)4p$	$z\ ^1I^\circ$	6	40 319.80	1.03	99			
$3d\ 4s^2\ 4p$	$v\ ^3P^\circ$	0	40 369.76		37		23	$3d^2(^3P)4s4p(^1P^\circ)\ ^3P^\circ$
		2	40 466.979		36		21	$3d^2(^3P)4s4p(^1P^\circ)\ ^3P^\circ$
$3d^3(^2P)4p$		1	40 384.58		30	$^3S^\circ$	24	$3d4s^24p\ ^3P^\circ$
$3d^3(^4P)4p$	$r\ ^3D^\circ$	1	40 556.07	0.49	44		22	$(a\ ^2D)\ ^3D^\circ$
		2	40 670.60		43		24	
		3	40 844.19		40		25	
$3d^3(^2P)4p$	$x\ ^3S^\circ$	1	40 844.19		57		13	$3d4s^24p\ ^3P^\circ$
$3d^3(^2H)4p$	$y\ ^1H^\circ$	5	41 039.874	1.03	47		41	$(^2G)\ ^1H^\circ$
$3d^2\ 4s(^2F)5s$	$e\ ^1F$	3	41 087.31	1.01				
$3d^2\ 4s(^4F)5p$?	$u\ ^3G^\circ$	3	41 170.003	0.73				
		4	41 255.400	1.03				
		5	41 341.553	1.19				
$3d^2\ 4s(^4F)4d$	$e\ ^3G$	3	41 194.42					
		4	41 368.86					
		5	41 481.13					
$3d\ 4s^2\ 4p$	$s\ ^3F^\circ$	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	
$3d^2\ 4s(^4F)4d$	$e\ ^3H$	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	$3d^2(^1D)4s4p(^1P^\circ)\ ^1F^\circ$
$3d^2\ 4s(^4F)4d$	$e\ ^5G$	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				
$3d^2\ 4s(^4F)5p$	$w\ ^3H^\circ$	4	41 780.95					
		5	41 895.15					
		6	41 995.39					

Ti I—Continued

Configuration	Term	J	Level (cm^{-1})	g	Leading percentages		
$3d^2\,4s(^4\mathrm{F})5p$	$v\ ^5\mathrm{D}^\circ$	0	*41 822.99*				
		1	*41 854.01*				
		2	*41 906.51*				
		3	*41 985.83*				
		4	*42 092.42*				
$3d^2\,4s(^4\mathrm{F})4d$	$e\ ^5\mathrm{H}$	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			
$3d^2\,4s(^4\mathrm{F})4d$	$e\ ^5\mathrm{D}$	0	41 871.56				
		1	41 901.36				
		2	41 958.51				
		3	42 052.72				
		4	42 184.66				
$3d^2\,4s(^4\mathrm{F})4d$	$g\ ^3\mathrm{F}$	2	41 871.87				
		3	41 988.39				
		4	42 107.06				
$3d^3(^2\mathrm{P})4p$	$u\ ^3\mathrm{P}^\circ$	2	*41 928.528*		38	37	$(a\ ^2\mathrm{D})\ ^3\mathrm{P}^\circ$
		1	*41 943.95*		36	37	
		0	*41 959.46*		36	36	
$3d\,4s^2\,4p$	$q\ ^3\mathrm{D}^\circ$	1	*42 146.39*		39	20	$3d^2(^3\mathrm{P})4s4p(^1\mathrm{P}^\circ)\ ^3\mathrm{D}^\circ$
		2	*42 206.88*		27	14	
		3	*42 311.269*	1.32	39	20	
$3d^2\,4s(^4\mathrm{F})5p?$	$p\ ^3\mathrm{D}^\circ$	1	*42 194.04*				
		2	*42 269.78*				
		3	*42 376.45*				
$3d^2\,4s(^4\mathrm{F})4d$	$e\ ^5\mathrm{P}$	1	42 611.58				
		2	42 724.11				
		3	42 858.90	1.64			
	$w\ ^1\mathrm{P}^\circ$	1	*42 927.55*	1.00?			
$3d^2\,4s(^4\mathrm{F})4d$	$g\ ^5\mathrm{F}$	1	43 034.08				
		2	43 080.92				
		3	43 148.15				
		4	43 231.99				
		5	43 330.07				
$3d^2\,4s(^4\mathrm{F})5p$	$r\ ^3\mathrm{F}^\circ$	2	*43 467.55*				
		3	*43 583.14*				
		4	*43 744.55*				
$3d^3(^2\mathrm{F})4p$	$v\ ^1\mathrm{G}^\circ$	4	*43 674.130*	0.95	36	30	$(^2\mathrm{H})\ ^1\mathrm{G}^\circ$
	$v\ ^1\mathrm{D}^\circ$	2	*43 710.28*				
$3d^3(a\ ^2\mathrm{D})4p$	$u\ ^1\mathrm{D}^\circ$	2	*43 799.455*	0.98	38	29	$3d^2(^1\mathrm{D})4s4p(^1\mathrm{P}^\circ)\ ^1\mathrm{D}^\circ$

Ti I—Continued

Configuration	Term	J	Level (cm^{-1})	g	Leading percentages		
$3d^3(^4F)4d$	$f\,^5H$	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			
$3d^2\,4s(^4F)5p$	$o\,^3D^\circ$	1	*43 975.71*				
		2	*44 079.84*	1.18?			
		3	*44 233.65*				
$3d^2\,4s(^4F)5p$	$t\,^3G^\circ$	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				
$3d^2\,4s(^2D)5s$	$e\,^1D$	2	44 581.16				
$3d^3(^4F)5p$	$q\,^3F^\circ$	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*				
$3d^2\,4s(^2F)4d$	$e\,^1H$	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				
$3d^2\,4s(^2F)4d$	$f\,^3H$	4	45 721.878	0.80			
		5	45 832.50	1.03			
		6	45 960.439	1.17			
$3d^2\,4s(^4F)6s$	$h\,^5F$	1	45 764.71				
		2	45 813.01				
		3	45 893.26				
		4	46 007.62				
		5	46 157.76				
$3d^2\,4s(^2F)4d$	$e\,^1G$	4	46 068.04				
$3d^2\,4s(^4P)5s$	$e\,^3P$	2	46 244.60				
$3d^2\,4s(^2F)5p$	$u\,^1G^\circ$	4	*46 257.67*	0.95			
$3d^2\,4s(^4F)6s$	$h\,^3F$	4	46 530.45				

Ti I—Continued

Configuration	Term	J	Level (cm^{-1})	g	Leading percentages		
$3d^2\,4s(^2F)4d$	$f\ ^1F$	3	46 650.26				
$3d^3(^2F)4p$	$s\ ^3G°$	3	*46 725.42*		87	11	$(^2F)\ ^3F°$
		4	*46 838.09*		87	10	
		5	*46 974.65*		97		
$3d^2\,4p^2$	$g\ ^5G$	2	46 943.91				
		3	47 030.28				
		4	47 139.86				
		5	47 280.69				
		6	47 446.84				
$3d^2\,4s(^2F)4d$	$i\ ^3F$	3	47 038.16				
		4	47 194.68				
$3d^3(^2F)4p$	$p\ ^3F°$	2	*47 187.54*		97		
		3	*47 281.90*		86	11	$(^2F)\ ^3G°$
		4	*47 463.06*		87	10	
$3d^3(^4F)6s$	$i\ ^5F$	5	47 777.32				
$3d^2\,4s(^4F)5d$	$g\ ^5H$	3	47 840.62				
		4	47 913.61				
		5	47 994.32				
		6	48 106.83				
		7	48 262.83				
$3d^2\,4s(^4F)5d$	$h\ ^5G$	2	47 870.61				
		3	47 936.79				
		4	48 018.08				
		5	48 119.47				
		6	48 233.47				
$3d^2\,4p^2$	$j\ ^5F$	1	48 058.85				
		2	48 107.42				
		3	48 208.87				
		4	48 328.81				
		5	48 462.11				
$3d^2\,4s(^4F)5d$	$g\ ^5D$	3	48 059.82				
		4	48 186.11				
$3d^3(^2F)4p$	$u\ ^1F°$	3	*48 365.09*		48	24	$3d4s^24p\ ^1F°$
$3d^2\,4s(^4F)5d$	$k\ ^5F$	2	48 519.21				
		3	48 588.28				
		4	48 672.66				
		5	48 771.73				
$3d^2\,4p^2$	$e\ ^3D$	2	48 724.34				
		1	48 724.83				
		3	48 839.74				

Ti I—Continued

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

Ti II

$Z = 22$

Sc I isoelectronic sequence

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

Ionization energy = 109 494±20 cm^{-1} (13.5756±0.0025 eV)

An analysis of this spectrum was carried out by Russell (1927). He reported 116 energy levels derived from 464 lines in the range of 1906–6717 Å. New observations by Huldt, Johansson, Litzén, and Wyart (1982) in the region of 1100–11 000 Å with a wavelength uncertainty of ±0.02 Å or better resulted in nearly doubling the known number of lines and energy levels. They have also calculated the percentage compositions for the even configurations $3d^3$, $3d^2 4s$, and $3d4s^2$ with configuration interaction (CI) as well as $3d^2 5s$ and $3d^2 4d$; and for the odd configurations $3d^2 4p$, $3d^2 5p$, and $3d4s4p$ with CI. Their results are quoted here. The level uncertainty is ±0.1 cm^{-1}.

Huldt et al. determined the value for the ionization energy from the $3d^2(^3F)ns\ 4f_{9/2}$ series for $n = 4$, 5, and 6.

References

Huldt, S., Johansson, S., Litzén, U., and Wyart, J.-F. (1982), Phys. Scr. **25**, 401.

Moore, C. E. (1949), Atomic Energy Levels, Natl. Bur. Stand. (U.S.) Circ. 467, Vol. I (reissued in 1971 as Natl. Bur. Stand. (U.S.) Natl. Stand. Ref. Data Ser. 35, Vol. I).

Russell, H. N. (1927), Astrophys. J. **66**, 283.

Ti II

Configuration	Term	J	Level (cm^{-1})	g	Leading percentages		
$3d^2(^3F)4s$	$a\ ^4F$	3/2	0.00		100		
		5/2	94.10		100		
		7/2	225.73		100		
		9/2	393.44		100		
$3d^3$	$b\ ^4F$	3/2	908.02		100		
		5/2	983.89		100		
		7/2	1 087.32		100		
		9/2	1 215.84		100		
$3d^2(^3F)4s$	$a\ ^2F$	5/2	4 628.58		99		
		7/2	4 897.65		99		
$3d^2(^1D)4s$	$a\ ^2D$	3/2	8 710.44	0.80	72	17	$3d^3\ ^2D2$
		5/2	8 744.25		74	16	
$3d^3$	$a\ ^2G$	7/2	8 997.71		96		
		9/2	9 118.26		96		
$3d^3$	$a\ ^4P$	1/2	9 363.62	2.63	96		
		3/2	9 395.71	1.74	93		
		5/2	9 518.06		100		
$3d^3$	$a\ ^2P$	1/2	9 850.90	0.66	62	24	$3d^2(^3P)4s\ ^2P$
		3/2	9 975.92	1.33	48	27	$3d^2(^3P)4s\ ^4P$
$3d^2(^3P)4s$	$b\ ^4P$	1/2	9 872.73	2.60	90		
		3/2	9 930.69		72	18	$3d^3\ ^2P$
		5/2	10 024.73		99		
$3d^3$	$b\ ^2D$	3/2	12 628.73		53	26	$^2D1$
		5/2	12 758.11		54	24	

Ti II—Continued

Configuration	Term	J	Level (cm^{-1})	g	Leading percentages		
$3d^3$	$a\ ^2$H	9/2	12 676.97		100		
		11/2	12 774.69		100		
$3d^2(^1$G$)4s$	$b\ ^2$G	9/2	15 257.43		96		
		7/2	15 265.62		96		
$3d^2(^3$P$)4s$	$b\ ^2$P	1/2	16 515.86	0.66	72	28	$3d^3\ ^2$P
		3/2	16 625.11	1.33	72	28	
$3d^3$	$b\ ^2$F	7/2	20 891.66		99		
		5/2	20 951.62		99		
$3d\ 4s^2$	$c\ ^2$D	3/2	24 961.03		73	14	$3d^3\ ^2$D1
		5/2	25 192.79		71	15	
$3d^2(^3$F$)4p$	$z\ ^4$G°	5/2	*29 544.37*		98		
		7/2	*29 734.54*		99		
		9/2	*29 968.30*		100		
		11/2	*30 240.88*		100		
$3d^2(^3$F$)4p$	$z\ ^4$F°	3/2	*30 836.32*		97		
		5/2	*30 958.50*		98		
		7/2	*31 113.65*		98		
		9/2	*31 301.01*		99		
$3d^2(^3$F$)4p$	$z\ ^2$F°	5/2	*31 207.42*		85		
		7/2	*31 490.82*		88		
$3d^2(^3$F$)4p$	$z\ ^2$D°	3/2	*31 756.51*	0.92	82		
		5/2	*32 025.47*	1.20	77		
$3d^2(^1$S$)4s$	$a\ ^2$S	1/2	31 787.75		100		
$3d^3$	$d\ ^2$D1	3/2	32 275.32		58	25	$3d4s^2\ ^2$D
		5/2	32 332.73		57	27	
$3d^2(^3$F$)4p$	$z\ ^4$D°	1/2	*32 532.21*	0.00	97		
		3/2	*32 602.55*	1.20	94		
		5/2	*32 697.99*	1.37	90		
		7/2	*32 767.07*		96		
$3d^2(^3$F$)4p$	$z\ ^2$G°	7/2	*34 543.26*		95		
		9/2	*34 748.40*		95		
$3d^2(^3$P$)4p$	$z\ ^2$S°	1/2	*37 430.58*	2.09	99		
$3d^2(^1$D$)4p$	$y\ ^2$D°	5/2	*39 476.80*		55	25	$(^1$D$)\ ^2$F°
		3/2	*39 602.75*	1.21	48	36	$(^1$D$)\ ^2$P°
$3d^2(^1$D$)4p$	$z\ ^2$P°	3/2	*39 223.28*		58	36	$(^1$D$)\ ^2$D°
		1/2	*39 674.66*		98		
$3d^2(^1$D$)4p$	$y\ ^2$F°	5/2	*39 926.66*		63	25	$(^1$D$)\ ^2$D°
		7/2	*40 074.52*		85		
$3d^2(^3$P$)4p$	$z\ ^4$S°	3/2	*40 027.11*		95		

Ti II—Continued

Configuration	Term	J	Level (cm^{-1})	g	Leading percentages		
$3d^2(^3P)4p$	$y\ ^4D°$	1/2	*40 330.16*		97		
		3/2	*40 425.59*		96		
		5/2	*40 581.49*		96		
		7/2	*40 798.30*		93		
$3d^2(^3P)4p$	$z\ ^4P°$	1/2	*41 996.57*		97		
		3/2	*42 068.52*		97		
		5/2	*42 208.59*		97		
$3d^2(^1G)4p$	$y\ ^2G°$	7/2	*43 740.65*		95		
		9/2	*43 780.79*		95		
$3d^2(^3P)4p$	$x\ ^2D°$	5/2	*44 902.29*		82		
		3/2	*44 914.70*		80		
$3d^2(^3P)4p$	$y\ ^2P°$	1/2	*45 472.27*		95		
		3/2	*45 548.76*		94		
$3d^2(^1G)4p$	$z\ ^2H°$	9/2	*45 673.62*		99		
		11/2	*45 908.53*		100		
$3d^2(^1G)4p$	$x\ ^2F°$	7/2	*47 466.54*		91		
		5/2	*47 624.88*		92		
$3d(^2D)4s4p(^3P°)$	$^4F°$	3/2	*52 330.33*		95		
		5/2	*52 472.12*		93		
		7/2	*52 705.16*		94		
		9/2	*53 096.83*		99		
$3d(^2D)4s4p(^3P°)$	$^4D°$	1/2	*52 339.34*		97		
		3/2	*52 459.33*		94		
		5/2	*52 631.00*		91		
		7/2	*52 846.65*		92		
$3d(^2D)4s4p(^3P°)$	$w\ ^2D°$	5/2	*53 554.76*		88		
		3/2	*53 597.10*		88		
$3d(^2D)4s4p(^3P°)$	$y\ ^4P°$	1/2	*56 222.81*		97		
		3/2	*56 249.10*		97		
		5/2	*56 325.70*		97		
$3d(^2D)4s4p(^3P°)$	$w\ ^2F°$	5/2	*59 322.65*		94		
		7/2	*59 468.02*		95		
$3d(^2D)4s4p(^3P°)$	$^2P°$	3/2	*59 387.68*		83	16	$3d^2(^1S)4p\ ^2P°$
		1/2	*59 439.94*		79	20	
$3d^2(^3F)5s$	$e\ ^4F$	3/2	62 180.16		100		
		5/2	62 272.16		99		
		7/2	62 410.78		99		
		9/2	62 595.03		100		
$3d^2(^3F)5s$	$e\ ^2F$	5/2	63 169.02		99		
		7/2	63 445.88		99		
$3d^2(^1S)4p$	$^2P°$	1/2	*63 276.60*		76	20	$3d(^2D)4s4p(^3P°)\ ^2P°$
		3/2	*63 375.08*		81	16	

Ti II—Continued

Configuration	Term	J	Level (cm^{-1})	g	Leading percentages		
$3d^2(^3F)4d$	$e\ ^4G$	5/2	64 886.48		96		
		7/2	64 979.15		95		
		9/2	65 095.80		93		
		11/2	65 243.46		93		
$3d^2(^3F)4d$	$e\ ^4H$	7/2	65 186.75		96		
		9/2	65 308.30		93		
		11/2	65 446.27		93		
		13/2	65 590.19		100		
$3d^2(^3F)4d$	^4D	1/2	65 213.80		99		
		3/2	65 274.60		99		
		5/2	65 397.57		80	18	$3d^2(^3F)4d\ ^2F$
		7/2	65 598.73		49	49	$3d^2(^3F)4d\ ^2F$
$3d^2(^3F)4d$	$f\ ^2F$	5/2	65 314.27		75	19	^4D
		7/2	65 460.01		47	51	
$3d^2(^3F)4d$	^2P	1/2	66 521.01		93		
		3/2	66 794.01		91		
$3d^2(^3F)4d$	$e\ ^2G$	7/2	67 606.04		91		
		9/2	67 822.49		91		
$3d^2(^3F)4d$	$e\ ^2H$	9/2	68 331.02		95		
		11/2	68 584.28		95		
$3d^2(^3F)4d$	^2D	3/2	68 364.39		86	11	$3d^2(^1D)4d\ ^2D$
		5/2	68 482.41		85	12	
$3d^2(^3F)4d$	$f\ ^4F$	3/2	68 769.19		96		
		5/2	68 846.52		96		
		7/2	68 951.98		96		
		9/2	69 084.44		96		
$3d(^2D)4s4p(^1P^\circ)$	$v\ ^2D^\circ$	3/2	*69 327.52*		65	31	$3d^2(^3F)5p\ ^2D^\circ$
		5/2	*69 622.63*		65	31	
$3d(^3F)5p$	$v\ ^2F^\circ$	5/2	*70 607.53*		54	41	$3d(^2D)4s4p(^1P^\circ)\ ^2F^\circ$
		7/2	*70 892.79*		55	41	
$3d^2(^3F)5p$	$^4G^\circ$	5/2	*71 461.59*		98		
		7/2	*71 586.06*		99		
		9/2	*71 747.46*		100		
		11/2	*71 945.90*		100		
$3d^2(^3F)5p$	$^4F^\circ$	3/2	*71 728.62*		100		
		5/2	*71 825.81*		99		
		7/2	*71 960.29*		99		
		9/2	*72 126.70*		99		
$3d^2(^3F)5p$	$^4D^\circ$	1/2	*72 270.31*		100		
		3/2	*72 337.97*		99		
		5/2	*72 451.52*		99		
		7/2	*72 608.85*		99		
$3d^2(^3F)5p$	$^2G^\circ$	7/2	*72 884.04*		99		
		9/2	*73 133.35*		99		

Ti II—Continued

Configuration	Term	J	Level (cm^{-1})	g	Leading percentages		
$3d(^2D)4s4p(^1P^\circ)$	$^2F^\circ$	5/2	73 521.67		51	45	$3d^2(^3F)5p\ ^2F^\circ$
		7/2	73 800.67		52	44	
$3d(^2D)4s4p(^1P^\circ)$	$^2P^\circ$	1/2	73 627.82		86		
		3/2	73 950.01		86		
$3d^2(^3F)5p$	$^2D^\circ$	3/2	74 378.67		67	27	$3d(^2D)4s4p(^1P^\circ)\ ^2D^\circ$
		5/2	74 645.08		67	27	
$3d^2(^3F)4f$	$^4H^\circ$	7/2	81 627.64				
		9/2	81 676.30				
		11/2	81 753.98				
		13/2	82 072.84				
$3d^2(^3F)4f$	$^2G^\circ$	7/2	81 685.81				
		9/2	81 842.09				
$3d^2(^3F)4f$	$^4G^\circ$	5/2	81 724.17				
		7/2	81 860.84				
		9/2	82 078.43				
		11/2	82 103.06				
$3d^2(^3F)4f$	$^4I^\circ$	9/2	81 738.13				
		11/2	81 889.46				
		13/2	81 919.58				
		15/2	82 216.91				
$3d^2(^3F)4f$	$^4F^\circ$	5/2	81 773.98				
		3/2	81 806.88				
		7/2	81 912.92				
		9/2	82 147.54				
$3d^2(^3F)4f$	$^4P^\circ$	3/2	81 867.70				
		5/2	81 996.83				
		1/2	82 043.85				
$3d^2(^3F)4f$	$^2H^\circ$	9/2	81 923.99				
		11/2	82 183.31				
$3d^2(^3F)4f$	$^2F^\circ$	5/2	81 943.25				
		7/2	82 151.31				
$3d^2(^3F)4f$	$^2I^\circ$	11/2	82 001.01				
		13/2	82 284.22				
$3d^2(^3F)4f$	$^4D^\circ$	1/2	82 008.55				
		3/2	82 020.94				
		7/2	82 133.99				
		5/2	82 246.37				
$3d^2(^3F)4f$	$^2D^\circ$	3/2	82 065.47				
		5/2	82 318.91				
$3d^2(^3F)4f$	$^4S^\circ$	3/2	82 304.25				
$3d^2(^3F)4f$	$^2P^\circ$	3/2	82 369.97				

Ti II—Continued

Configuration	Term	J	Level (cm^{-1})	g	Leading percentages
$3d^2(^3F)6s$	^4F	3/2	82 839.08		
		5/2	82 914.09		
		7/2	83 058.33		
		9/2	83 257.04		
$3d^2(^3F)6s$	^2F	5/2	83 244.91		
		7/2	83 519.16		
$3d^2(^3F)5d$	^4H	7/2	84 165.71		
		9/2	84 334.14		
		11/2	84 490.76		
		13/2	84 722.08		
$3d^2(^3F)5d$	^4G	5/2	84 268.77		
		7/2	84 369.70		
		9/2	84 512.57		
		11/2	84 632.03		
Ti III ($^3F_2$)	***Limit***		**109 494**		

Ti III

$Z=22$

Ca I isoelectronic sequence

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

Ionization energy = 221 735.6±2.0 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. The levels have an estimated uncertainty of ±0.1 cm^{-1} except for those of $3d6h$ whose uncertainty is ±0.5 cm^{-1}. 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 interaction of $4s4p$ with each of $3d(4p, 5p, 4f, 5f)$ plus the mixture of $3d5p$ and $3d4f$. The levels of $3d4s$ were calculated by Shadmi, Caspi, and Oreg (1969) but no percentages were given. Goldschmidt (1982) has provided the percentage compositions in J_1l-coupling for the $3d5g$ and $3d6g$ configurations.

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

References

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Ti III

Configuration	Term	J	Level (cm^{-1})	Leading percentages		
$3d^2$	^{3}F	2	0.0	100		
		3	184.9	100		
		4	420.4	100		
$3d^2$	^{1}D	2	8 473.5	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 percentages		
$3d\,4p$	$^3P^\circ$	1	*80 939.19*	99		
		0	*80 944.87*	100		
		2	*81 024.47*	100		
$3d\,4p$	$^1F^\circ$	3	*83 116.93*	100		
$3d\,4p$	$^1P^\circ$	1	*83 796.86*	98		
$4s^2$	^1S	0	102 665.15			
$3d\,4d$	^1F	3	127 790.57	98		
$3d\,4d$	^3D	1	128 433.40	96	4	^1P
		2	128 546.38	100		
		3	128 689.67	98		
$3d\,4d$	^3G	3	129 093.28	99		
		4	129 252.74	100		
		5	129 469.37	100		
$3d\,4d$	^1P	1	129 253.41	96	4	^3D
$3d\,4d$	^3S	1	130 739.82	99		
$3d\,4d$	^3F	2	133 065.24	100		
		3	133 207.10	100		
		4	133 371.07	100		
$3d\,5s$	^3D	1	133 898.50	100		
		2	133 999.79	91	8	^1D
		3	134 275.12	100		
$3d\,5s$	^1D	2	134 557.84	60	32	$3d4d\ ^1D$
$3d\,4d$	^1D	2	135 405.27	57	31	$3d5s\ ^1D$
$3d\,4d$	^3P	0	135 541.46	100		
		1	135 601.47	100		
		2	135 721.51	88	9	^1D
$3d\,4d$	^1G	4	136 339.74	100		
$4s4p$	$^3P^\circ$	0	*137 258.9*	100		
		1	*137 487.8*	100		
		2	*137 961.2*	100		
$3d\,4d$	^1S	0	140 019.24	100		
$3d\,5p$	$^1D^\circ$	2	*147 212.77*	90	5	$^3D^\circ$
$3d\,5p$	$^3D^\circ$	1	*147 562.14*	99		
		2	*147 749.89*	92	5	$^3F^\circ$
		3	*147 939.47*	99		
$3d\,5p$	$^3F^\circ$	2	*147 931.47*	92	5	$^1D^\circ$
		3	*148 111.10*	99		
		4	*148 410.24*	100		

Ti III—Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages		
$3d\,5p$	$^3P^\circ$	1	*148 978.72*	71	26	$^1P^\circ$
		0	*149 019.75*	100		
		2	*149 267.99*	99		
$3d\,5p$	$^1P^\circ$	1	*149 403.52*	64	28	$^3P^\circ$
$3d\,5p$	$^1F^\circ$	3	*149 655.77*	99		
$4s4p$	$^1P^\circ$	1	*157 204.16*	60	32	$3d4f\,^1P^\circ$
$3d4f$	$^1G^\circ$	4	*158 285.34*	81	10	$^3F^\circ$
$3d4f$	$^3F^\circ$	2	*158 536.63*	93	6	$^1D^\circ$
		3	*158 557.76*	67	31	$^3G^\circ$
		4	*158 690.85*	46	28	$^3G^\circ$
$3d4f$	$^3G^\circ$	3	*158 740.92*	60	25	$^3F^\circ$
		4	*158 865.03*	29	40	$^3F^\circ$
		5	*158 903.55*	70	28	$^3H^\circ$
$3d4f$	$^3H^\circ$	4	*159 022.93*	58	35	$^3G^\circ$
		5	*159 128.94*	69	30	$^3G^\circ$
		6	*159 269.53*	100		
$3d4f$	$^1D^\circ$	2	*159 123.78*	89	4	$^3F^\circ$
$3d4f$	$^1F^\circ$	3	*159 180.24*	75	6	$^3D^\circ$
$3d4f$	$^3D^\circ$	1	*159 394.89*	97		
		2	*159 403.91*	89	4	$^3P^\circ$
		3	*159 481.95*	86	12	$^1F^\circ$
$3d4f$	$^3P^\circ$	2	*159 991.54*	92	6	$^3D^\circ$
		1	*160 104.61*	97		
		0	*160 167.06*	100		
$3d4f$	$^1H^\circ$	5	*160 054.90*	97		
$3d4f$	$^1P^\circ$	1	*161 854.24*	67	28	$4s4p\,^1P^\circ$
$3d\,5d$	^1F	3	167 724.09	92	5	^3D
$3d\,5d$	^3D	1	167 905.19	86	14	^1P
		2	168 030.15	99		
		3	168 206.79	56	37	^3G
$3d\,5d$	^3G	3	168 152.20	60	39	^3D
		4	168 307.06	99		
		5	168 520.52	100		
$3d\,5d$	^1P	1	168 343.62	82	14	^3D
$3d\,5d$	^3S	1	168 932.83	96	4	^1P
$3d\,5d$	^3F	2	169 615.12	97		
		3	169 769.13	99		
		4	169 912.11	99		

Ti III—Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages		
$3d\,6s$	^{3}D	1	169 875.52	100		
		2	169 930.80	72	25	^{1}D
		3	170 254.75	100		
$3d\,6s$	^{1}D	2	170 270.02	47	26	^{3}D
$3d\,5d$	^{3}P	0	170 579.96	99		
		1	170 659.72	99		
		2	170 666.94	56	25	^{1}D
$3d\,5d$	^{1}D	2	170 840.80	46	43	^{3}P
$3d\,5d$	^{1}G	4	171 141.93	99		
$3d\,5d$	^{1}S	0	172 373.52	99		
$3d5f$	^{1}G$^{\circ}$	4	*181 219.06*	68	17	^{3}F$^{\circ}$
$3d5f$	^{3}F$^{\circ}$	2	*181 339.27*	84	12	^{1}D$^{\circ}$
		3	*181 368.45*	65	30	^{3}G$^{\circ}$
		4	*181 611.79*	58	25	^{1}G$^{\circ}$
$3d5f$	^{3}H$^{\circ}$	4	*181 439.64*	69	20	^{3}G$^{\circ}$
		5	*181 558.44*	73	21	^{3}G$^{\circ}$
		6	*181 837.98*	100		
$3d5f$	^{3}G$^{\circ}$	3	*181 507.92*	53	22	^{1}F$^{\circ}$
		4	*181 758.34*	68	16	^{3}F$^{\circ}$
		5	*181 821.83*	78	22	^{3}H$^{\circ}$
$3d5f$	^{1}D$^{\circ}$	2	*181 700.72*	61	19	^{3}D$^{\circ}$
$3d5f$	^{1}F$^{\circ}$	3	*181 860.55*	46	22	^{3}D$^{\circ}$
$3d5f$	^{3}D$^{\circ}$	2	*181 908.15*	58	23	^{1}D$^{\circ}$
		3	*182 025.86*	66	32	^{1}F$^{\circ}$
$3d(^{2}D_{3/2})5g$	$^{2}[9/2]$	5	182 013.32	100		
		4	182 014.92	100		
$3d(^{2}D_{3/2})5g$	$^{2}[7/2]$	3	182 067.49	98	2	$(^{2}D_{5/2})\ ^{2}[7/2]$
		4	182 068.87	98	2	
$3d(^{2}D_{3/2})5g$	$^{2}[11/2]$	5	182 166.91	93	7	$(^{2}D_{5/2})\ ^{2}[11/2]$
		6	182 170.72	92	8	
$3d5f$	^{3}P$^{\circ}$	2	*182 207.39*	76	19	^{3}D$^{\circ}$
		1	*182 276.75*	84	12	^{3}D$^{\circ}$
		0	*182 333.95*	100		
$3d(^{2}D_{3/2})5g$	$^{2}[5/2]$	3	182 224.72	95	5	$(^{2}D_{5/2})\ [5/2]$
		2	182 225.09	95	5	
$3d5f$	^{1}H$^{\circ}$	5	*182 353.45*	94	5	^{3}H$^{\circ}$
$3d(^{2}D_{5/2})5g$	$^{2}[9/2]$	5	182 403.64	100		
		4	182 405.25	100		

Ti III—Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages		
$3d(^2D_{5/2})5g$	$^2[^{11}/_2]$	5	182 436.46	93	7	$(^2D_{3/2})\ ^2[^{11}/_2]$
		6	182 439.62	92	8	
$3d(^2D_{5/2})5g$	$^2[^7/_2]$	3	182 473.21	98	2	$(^2D_{3/2})\ ^2[^7/_2]$
		4	182 474.38	98	2	
$3d5f$	$^1P^\circ$	1	*182 561.61*	89	8	$^3P^\circ$
$3d(^2D_{5/2})5g$	$^2[^5/_2]$	3	182 587.12	95	5	$(^2D_{3/2})\ ^2[^5/_2]$
		2	182 587.62	95	5	
$3d(^2D_{5/2})5g$	$^2[^{13}/_2]$	7	182 596.87	100		
		6	182 601.96	100		
$3d(^2D_{5/2})5g$	$^2[^3/_2]$	1	182 680.27	100		
		2	182 680.53	100		
$3d(^2D_{3/2})6g$	$^2[^9/_2]$	5	194 168.25	100		
		4	194 169.81	100		
$3d(^2D_{3/2})6g$	$^2[^7/_2]$	3	194 200.46	99	1	$(^2D_{5/2})\ ^2[^7/_2]$
		4	194 201.57	99	1	
$3d(^2D_{3/2})6g$	$^2[^{11}/_2]$	5	194 261.00	98	2	$(^2D_{5/2})\ ^2[^{11}/_2]$
		6	194 264.82	98	2	
$3d(^2D_{5/2})6g$	$^2[^9/_2]$	4	194 556.67	100		
$3d(^2D_{5/2})6g$	$^2[^{11}/_2]$	5	194 567.08	97	2	$(^2D_{3/2})\ [^{11}/_2]$
		6	194 569.80	98	2	
$3d(^2D_{5/2})6g$	$^2[^7/_2]$	3	194 592.07	99	1	$(^2D_{3/2})\ ^2[^7/_2]$
		4	194 592.98	99	1	
$3d(^2D_{5/2})6g$	$^2[^5/_2]$	3	194 656.18	98	2	$(^2D_{3/2})\ ^2[^5/_2]$
$3d(^2D_{5/2})6g$	$^2[^{13}/_2]$	7	194 664.08	100		
		6	194 669.10	100		
$3d(^2D_{3/2})6h$	$^2[^{11}/_2]^\circ$	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*			

Ti III—Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages
$3d(^2D_{3/2})7h$	$^2[11/2]°$	5,6	[*201 543.5*]	
$3d(^2D_{3/2})7h$	$^2[9/2]°$	4,5	[*201 553.5*]	
$3d(^2D_{3/2})7h$	$^2[13/2]°$	6,7	[*201 578.7*]	
$3d(^2D_{3/2})7h$	$^2[7/2]°$	3,4	[*201 588.7*]	
$3d(^2D_{5/2})7h$	$^2[11/2]°$	5,6	[*201 926.0*]	
$3d(^2D_{5/2})7h$	$^2[13/2]°$	6,7	[*201 932.7*]	
$3d(^2D_{5/2})7h$	$^2[9/2]°$	4,5	[*201 937.4*]	
$3d(^2D_{5/2})7h$	$^2[7/2]°$	3,4	[*201 958.3*]	
$3d(^2D_{5/2})7h$	$^2[15/2]°$	7,8	[*201 967.5*]	
$3d(^2D_{5/2})7h$	$^2[5/2]°$	2,3	[*201 981.7*]	
Ti IV ($^2D_{3/2}$)	***Limit***		**221 735.6**	

Ti IV

$Z = 22$

K I isoelectronic sequence

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

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 (1929) who identified the low one-electron configurations $3d$, $4s$, and $4p$. The work was extended by Russell and Lang (1927) who recognized the higher configura tions $4d$, $5d$, $5s$, $6s$, $5p$, $4f$, 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 $3p^5 3d^2$. The level uncertainty is estimated to be ±0.2 cm^{-1}. By application of the polarization formula to the hydrogen-like terms ng, nh, and ni they determined the ionization energy.

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Ti IV

Configuration	Term	J	Level (cm^{-1})	Configuration	Term	J	Level (cm^{-1})
$3p^6 3d$	^2D	3/2	0.0	$3p^6 5g$	^2G	7/2	278 510.63
		5/2	382.1			9/2	278 511.23
$3p^6 4s$	^2S	1/2	80 388.93	$3p^6 6d$	^2D	3/2	289 185.99
						5/2	289 206.93
$3p^6 4p$	$^2P°$	1/2	*127 921.36*				
		3/2	*128 739.59*	$3p^6 7s$	^2S	1/2	292 999.54
$3p^6 4d$	^2D	3/2	196 804.27	$3p^6 6g$	^2G	7/2	300 045.9
		5/2	196 889.96			9/2	300 046.2
$3p^6 5s$	^2S	1/2	212 407.34	$3p^6 6h$	$^2H°$	9/2, 11/2	*300 158.76*
$3p^6 5p$	$^2P°$	1/2	*230 608.89*	$3p^6 7d$	^2D	3/2	306 395.69
		3/2	*230 924.38*			5/2	306 408.30
$3p^6 4f$	$^2F°$	5/2	*236 135.29*	$3p^6 7g$	^2G	7/2	313 033.9
		7/2	*236 142.30*			9/2	313 034.1
$3p^6 5d$	^2D	3/2	258 838.48	$3p^6 7h$	$^2H°$	9/2, 11/2	*313 110.72*
		5/2	258 877.08				
				$3p^6 7i$	^2I	11/2, 13/2	313 130.66
$3p^6 6s$	^2S	1/2	265 847.42				
				$3p^6 8i$	^2I	11/2, 13/2	321 531.3
$3p^6 6p$	$^2P°$	1/2	*274 726.29*				
		3/2	*274 881.21*	Ti V ($^1S_0$)	*Limit*		**348 973.3**
$3p^5 3d^2$	$^2F°$	5/2	*274 839.82*				
$3p^6 5f$	$^2F°$	5/2	*275 847.01*				
		7/2	*275 861.94*				

Ti v

$Z=22$

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

Ionization energy = 800 900±100 cm^{-1} (99.30±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. The uncertainty in these level values is ±2 cm^{-1}. He calculated the percentage compositions of the levels.

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}. The uncertainty in these level values is ±50 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 percentages		
$3s^2 3p^6$	^1S	0	0			
$3s^2 3p^5 3d$	$^3P°$	0	*274 439.7*	100		
		1	*275 371.9*	100		
		2	*277 310.6*	99		
$3s^2 3p^5 3d$	$^3F°$	4	*287 276.5*	100		
		3	*289 050.2*	98		
		2	*290 778.7*	98		
$3s^2 3p^5 3d$	$^1D°$	2	*306 874.5*	84	14	$^3D°$
$3s^2 3p^5 3d$	$^3D°$	3	*307 429.2*	80	20	$^1F°$
		1	*309 252.1*	100		
		2	*309 433.1*	85	14	$^1D°$
$3s^2 3p^5 3d$	$^1F°$	3	*311 433.8*	79	20	$^3D°$
$3s^2 3p^5 3d$	$^1P°$	1	*395 320.9*	100		
$3s^2 3p^5 4s$	$^3P°$	2	*434 339.4*	100		
		1	*436 849.8*	81	19	$^1P°$
		0	*440 065.2*	100		
$3s^2 3p^5 4s$	$^1P°$	1	*443 752.7*	81	19	$^3P°$
$3s^2 3p^5 4p$	^3S	1	481 987.7	97		
$3s^2 3p^5 4p$	^3D	3	487 974.6	65	35	$3s3p^6 3d\ ^3D$
		2	488 225.7	47	41	
		1	493 300.5	47	22	

Ti v—Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages			
$3s3p^6\,3d$	^3D	1	488 928.7	75		23	$3s^23p^54p\ ^3D$
		2	491 558.7	51		31	$3s^23p^54p\ ^1D$
		3	492 567.1	65		35	$3s^23p^54p\ ^3D$
$3s^2\,3p^5\,4p$		2	494 035.7	42	^3P	33	^1D
$3s^2\,3p^5\,4p$	^1P	1	496 890.7	50		29	^1D
$3s^2\,3p^5\,4p$	^3P	2	498 057.2	55		22	^3D
		0	498 176.4	98			
		1	499 336.2	66		31	^1P
$3s3p^6\,3d$	^1D	2	506 224.7	89		10	$3s^23p^54p\ ^1D$
$3s^2\,3p^5\,4p$	^1S	0	514 608.7	98			
$3s^2\,3p^5(^2P^\circ_{3/2})4d$	$^2[1/2]^\circ$	0	*568 698.5*	100			
		1	*569 304.5*	72		22	$(^2P^\circ_{3/2})\ ^2[3/2]^\circ$
$3s^2\,3p^5(^2P^\circ_{3/2})4d$	$^2[3/2]^\circ$	2	*570 597.8*	82		18	$(^2P^\circ_{1/2})\ ^2[3/2]^\circ$
		1	*577 249.8*	74		14	$(^2P^\circ_{3/2})\ ^2[1/2]^\circ$
$3s^2\,3p^5(^2P^\circ_{3/2})4d$	$^2[7/2]^\circ$	4	*571 401.1*	100			
		3	*572 093.9*	90			
$3s^2\,3p^5(^2P^\circ_{3/2})4d$	$^2[5/2]^\circ$	2	*573 838.3*	84		16	$(^2P^\circ_{1/2})\ ^2[5/2]^\circ$
		3	*574 683.8*	84			
$3s^2\,3p^5(^2P^\circ_{1/2})4d$	$^2[5/2]^\circ$	2	*578 698.5*	84		16	$(^2P^\circ_{3/2})\ ^2[5/2]^\circ$
		3	*579 334.6*	90			
$3s^2\,3p^5(^2P^\circ_{1/2})4d$	$^2[3/2]^\circ$	2	*579 584.2*	82		18	$(^2P^\circ_{3/2})\ ^2[3/2]^\circ$
		1	*582 836.5*	82		14	$(^2P^\circ_{3/2})\ ^2[1/2]^\circ$
$3s^2\,3p^5(^2P^\circ_{3/2})5s$	$^2[3/2]^\circ$	2	*607 033.0*	100			
		1	*608 100.7*	97			
$3s^2\,3p^5(^2P^\circ_{1/2})5s$	$^2[1/2]^\circ$	0	*612 793.2*	100			
		1	*613 558.2*	97			
$3s^2\,3p^5(^2P^\circ_{3/2})6s$	$^2[3/2]^\circ$	1	*680 748*				
$3s^2\,3p^5(^2P^\circ_{1/2})6s$	$^2[1/2]^\circ$	1	*685 940*				
$3s3p^6\,4p$	$^3P^\circ$	1	*687 980*				
$3s3p^6\,4p$	$^1P^\circ$	1	*691 797*				
Ti VI ($^2P^\circ_{3/2}$)	***Limit***		**800 900**				
$3s3p^6\,5p$	$^3P^\circ$	1	*825 500*				
$3s3p^6\,5p$	$^1P^\circ$	1	*827 650*				
$3s3p^6\,6p$	$^3P^\circ$	1	*885 770*				
$3s3p^6\,6p$	$^1P^\circ$	1	*888 930*				

Ti V—Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages
$3s3p^6\,7p$	$^3P°$	1	*920 720*	
$3s3p^6\,7p$	$^1P°$	1	*922 140*	
$3s3p^6\,8p$	$^3P°$	1	*940 660*	
$3s3p^6\,8p$	$^1P°$	1	*942 030*	
$3s3p^6\,9p$	$^3P°$	1	*954 820*	
$3s3p^6\,9p$	$^1P°$	1	*955 010*	
$3s3p^6\,10p$	$^3P°$	1	*963 820*	
$3s3p^6\,10p$	$^1P°$	1	*964 010*	
$3s3p^6\,11p$	$^1P°$	1	*970 320*	
Ti VI ($^2S°_{1/2}$)	***Limit***		**997 500**	

Ti VI

$Z = 22$

Cl I isoelectronic sequence

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

Ionization energy = 964 100±200 cm^{-1} (119.53±0.02 eV)

The first observation of Ti VI was made by Weissberg and Kruger (1936), who identified the resonance lines $3s^2 3p^5\ {}^2P^\circ - 3s3p^6\ {}^2S$ at 508 and 524 Å. These have been remeasured by Svensson (1971). In 1937 Edlén reported the $3p^4 4s$ configuration. Gabriel, Fawcett, and Jordan (1966) and Fawcett and Gabriel (1966) reported terms in $3p^4 3d$. Fawcett, Peacock, and Cowan (1968) identified $3p^4 4d$, $5d$, and $5s$. Fawcett, Cowan, and Hayes (1972) observed $3p^4 3d - 3p^4 4f$ 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. The uncertainty in their level values is ±10 cm^{-1}. They determined the ionization energy from an extrapolation formula.

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Ti VI

Configuration	Term	J	Level (cm^{-1})	Configuration	Term	J	Level (cm^{-1})
$3s^2 3p^5$	$^2P^\circ$	3/2	*0*	$3s^2 3p^4(^3P)4s$	^2P	3/2	502 571
		1/2	*5 829*			1/2	506 432
$3s3p^6$	^2S	1/2	196 628	$3s^2 3p^4(^1D)4s$	^2D	5/2	518 797
						3/2	518 914
$3s^2 3p^4(^3P)3d$	^2P	1/2	288 412				
		3/2	291 890	$3s^2 3p^4(^1S)4s$	^2S	1/2	548 995
$3s^2 3p^4(^3P)3d$	^2D	3/2	298 991	$3s^2 3p^4(^3P)4d$	^2D	5/2	651 255
		5/2	302 386			3/2	651 960
$3s^2 3p^4(^3P)3d$	^4P	1/2	301 417	$3s^2 3p^4(^3P)4d$	^4F	5/2	653 766
						3/2	654 503
$3s^2 3p^4(^1D)3d$	^2F	5/2	331 221				
				$3s^2 3p^4(^3P)4d$	^2F	5/2	656 437
$3s^2 3p^4(^1S)3d$	^2D	3/2	352 625				
		5/2	354 340	$3s^2 3p^4(^3P)4d$	^2P	3/2	658 339
$3s^2 3p^4(^1D)3d$	^2S	1/2	379 874	$3s^2 3p^4(^1D)4d$	^2S	1/2	668 630
$3s^2 3p^4(^1D)3d$	^2P	3/2	391 583	$3s^2 3p^4(^1D)4d$	^2P	3/2	671 096
		1/2	393 644			1/2	671 549
$3s^2 3p^4(^1D)3d$	^2D	5/2	399 231	$3s^2 3p^4(^1D)4d$	^2D	5/2	674 297
		3/2	404 123			3/2	675 207
$3s^2 3p^4(^3P)4s$	^4P	5/2	492 126	$3s^2 3p^4(^1S)4d$	^2D	3/2	704 270
		3/2	495 380			5/2	704 283
		1/2	497 389				

Ti VI—Continued

Configuration	Term	J	Level (cm^{-1})	Configuration	Term	J	Level (cm^{-1})
$3s^2\,3p^4(^3P)5s$	^4P	$3/2$	708 652	$3s^2\,3p^4(^3P)5d$	^4F	$5/2$	778 513
$3s^2\,3p^4(^3P)5s$	^2P	$3/2$	712 034	$3s^2\,3p^4(^1D)5d$	^2P	$3/2$	795 615
		$1/2$	714 742				
				$3s^2\,3p^4(^1D)5d$	^2D	$5/2$	797 092
$3s^2\,3p^4(^1D)5s$	^2D	$3/2$	731 453			$3/2$	797 406
		$5/2$	731 455				
$3s^2\,3p^4(^3P)5d$	^2D	$5/2$	773 702	Ti VII ($^3P_2$)	***Limit***		**964 100**
		$3/2$	774 306				

Ti VII

Z=22

S I isoelectronic sequence

Ground state: $1s^2 2s^2 2p^6 3s^2 3p^4\ ^3P_2$

Ionization energy = 1 136 000±2000 cm^{-1} (140.8±0.2 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 $3p^3 4s$ configuration. He also determined the limit quoted here from an isoelectronic extrapolation. Kruger and Pattin (1937) observed the $3s^2 3p^4\ ^3P - 3s3p^5\ ^3P^\circ$ multiplet. This has been remeasured by Svensson (1971), who has also observed the singlet transitions of the $3s^2 3p^4 - 3s3p^5$ array.

The $3p^3 3d$ configuration was first identified by Fawcett and Gabriel (1966) and Gabriel, Fawcett, and Jordon (1966). The higher configuration, $3p^3 4d$, 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 $3p^3 3d - 3p^3 4f$ array but these are not connected to the known system.

Level-values for the triplet system of $3s^2 3p^4$ and $3s3p^5$ are from Svensson (1971). The position of the $^1D_2$ of $3s^2 3p^4$ is established by the intersystem transitions of the $3s^2 3p^4 - 3s^2 3p^3 3d$ array measured by Svensson and Ekberg (1968). The singlet transitions given by Svensson (1971) are then used to establish the $^1S_0$ of $3s^2 3p^4$ 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).

The uncertainty in the level values is estimated to be ±10 cm^{-1}.

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Ti VII

Configuration	Term	J	Level (cm^{-1})	Configuration	Term	J	Level (cm^{-1})
$3s^2 3p^4$	^3P	2	0	$3s^2 3p^3(^2P^\circ)3d$	$^3D^\circ$	3	*393 667*
		1	4 534			2	*396 572*
		0	5 888			1	*398 527*
$3s^2 3p^4$	^1D	2	24 130	$3s^2 3p^3(^2P^\circ)3d$	$^1D^\circ$	2	*407 703*
$3s^2 3p^4$	^1S	0	54 801	$3s^2 3p^3(^2P^\circ)3d$	$^1F^\circ$	3	*420 522*
$3s3p^5$	$^3P^\circ$	2	*196 266*	$3s^2 3p^3(^2P^\circ)3d$	$^1P^\circ$	1	*450 729*
		1	*200 059*				
		0	*202 202*	$3s^2 3p^3(^4S^\circ)4s$	$^3S^\circ$	1	*564 217*
$3s3p^5$	$^1P^\circ$	1	*251 214*	$3s^2 3p^3(^2D^\circ)4s$	$^3D^\circ$	1	*586 092*
						2	*586 308*
$3s^2 3p^3(^2D^\circ)3d$	$^1D^\circ$	2	*325 261*			3	*586 998*
$3s^2 3p^3(^2D^\circ)3d$	$^1F^\circ$	3	*361 904*	$3s^2 3p^3(^2D^\circ)4s$	$^1D^\circ$	2	*592 918*
$3s^2 3p^3(^2D^\circ)3d$	$^3S^\circ$	1	*375 235*	$3s^2 3p^3(^2P^\circ)4s$	$^3P^\circ$	0	*607 538*
						1	*607 982*
$3s^2 3p^3(^2P^\circ)3d$	$^3P^\circ$	2	*377 614*			2	*609 116*
		1	*378 872*				
		0	*381 808*	$3s^2 3p^3(^2P^\circ)4s$	$^1P^\circ$	1	*614 794*
$3s^2 3p^3(^2D^\circ)3d$	$^1P^\circ$	1	*381 894*				

Ti VII—Continued

Configuration	Term	J	Level (cm^{-1})	Configuration	Term	J	Level (cm^{-1})
$3s^2\,3p^3(^4S^\circ)4d$	$^3D^\circ$	1	*726 277*	$3s^2\,3p^3(^2P^\circ)4d$	$^3D^\circ$	2	*775 416*
		2	*726 303*			1	*776 122*
		3	*726 424*			3	*779 699*
$3s^2\,3p^3(^2D^\circ)4d$	$^3P^\circ$	2	*752 850*	$3s^2\,3p^3(^2P^\circ)4d$	$^1D^\circ$	2	*780 853*
		1	*755 732*	$3s^2\,3p^3(^2P^\circ)4d$	$^1F^\circ$	3	*781 170*
$3s^2\,3p^3(^2D^\circ)4d$	$^3D^\circ$	3	*753 393*				
		2	*754 591*	$3s^2\,3p^3(^2P^\circ)4d$	$^1P^\circ$	1	*785 716*
$3s^2\,3p^3(^2D^\circ)4d$	$^3S^\circ$	1	*756 518*				
				Ti VIII ($^4S^\circ_{3/2}$)	***Limit***		**1 136 000**
$3s^2\,3p^3(^2D^\circ)4d$	$^1D^\circ$	2	*757 984*				
$3s^2\,3p^3(^2D^\circ)4d$	$^1F^\circ$	3	*760 504*				

Ti VIII

$Z=22$

P I isoelectronic sequence

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

Ionization energy = 1 374 000±3000 cm^{-1} (170.4±0.4 eV)

This spectrum was initially studied by Kruger and Pattin (1937), who observed five multiplets of the $3s^2 3p^3 - 3s^2 3p^2 4s$ 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 $3s^2 3p^3 - 3s3p^4$ array in the range 423-514 Å. Fawcett, Cowan, and Hayes (1972) reported four lines of the $3p^2 3d - 3p^2 4f$ 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 $3s^2 3p^3$ 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 $3p^2 3d$ 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 ±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})	Configuration	Term	J	Level (cm^{-1})
$3s^2 3p^3$	$^4S^\circ$	3/2	*0.0*	$3s^2 3p^2(^1D)3d$	^2P	1/2	412 858+x
						3/2	415 589+x
$3s^2 3p^3$	$^2D^\circ$	3/2	*32 190.5*+x				
		5/2	*33 256.4*+x	$3s^2 3p^2(^1D)3d$	^2F	5/2	418 873+x
						7/2	419 939+x
$3s^2 3p^3$	$^2P^\circ$	1/2	*54 189.2*+x				
		3/2	*55 633.6*+x	$3s^2 3p^2(^1D)3d$	^2S	1/2	423 834+x
$3s3p^4$	^4P	5/2	194 474.6	$3s^2 3p^2(^1S)3d$	^2D	5/2	435 049+x
		3/2	198 097.9			3/2	436 270+x
		1/2	199 953.6				
				$3s^2 3p^2(^3P)4s$	^4P	1/2	660 135
$3s3p^4$	^2D	3/2	240 971.6+x			3/2	662 835
		5/2	241 426.0+x			5/2	666 493
$3s3p^4$	^2P	3/2	278 037.7+x	$3s^2 3p^2(^3P)4s$	^2P	1/2	671 405+x
		1/2	281 108.1+x			3/2	675 631+x
$3s3p^4$	^2S	1/2	290 233.6+x	$3s^2 3p^2(^1D)4s$	^2D	5/2	690 446+x
						3/2	690 672+x
$3s^2 3p^2(^3P)3d$	^2P	3/2	364 082+x				
		1/2	368 663+x	$3s^2 3p^2(^1S)4s$	^2S	1/2	722 394+x
$3s^2 3p^2(^3P)3d$	^4P	5/2	371 012				
		3/2	372 887	Ti IX ($^3P_0$)	*Limit*		**1 374 000**
		1/2	373 971				
$3s^2 3p^2(^1D)3d$	^2D	5/2	399 323+x				
		3/2	399 772+x				

Ti IX

$Z=22$

Si I isoelectronic sequence

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

Ionization energy $= 1\ 549\ 000 \pm 3000\ \mathrm{cm}^{-1}$ (192.1 ± 0.4 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 $3s3p^3\ {}^3S^\circ$ and $3s^2 3p3d\ {}^3P^\circ$. Fawcett, Gabriel, and Saunders (1967) extended the $3p^2 - 3p3d$ array; Fawcett and Peacock (1967) and Fawcett (1970) added to the $3s^2 3p^2 - 3s3p^3$ 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 $3s^2 3p^2$ and $3s3p^3$ configurations are taken from the more accurate data of Smitt et al. and the values for $3s^2 3p3d$ and $3s^2 3p4s$ 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 $\pm 10\ \mathrm{cm}^{-1}$. Six intersystem transitions have been observed.

The ionization energy was obtained by extrapolation by Ekberg and Svensson.

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Ti IX

Configuration	Term	J	Level (cm^{-1})	Configuration	Term	J	Level (cm^{-1})
$3s^2 3p^2$	^3P	0	0	$3s^2 3p3d$	$^3D^\circ$	1	*364 414*
		1	3 119			2	*365 611*
		2	7 282			3	*366 074*
$3s^2 3p^2$	^1D	2	28 555	$3s^2 3p3d$	$^1F^\circ$	3	*401 771*
$3s^2 3p^2$	^1S	0	61 100	$3s^2 3p3d$	$^1P^\circ$	1	*411 820*
$3s3p^3$	$^3D^\circ$	1	*200 209*	$3s^2 3p4s$	$^3P^\circ$	0	*727 806*
		2	*200 293*			1	*729 111*
		3	*201 000*			2	*735 208*
$3s3p^3$	$^3P^\circ$	0	*230 524*	$3s^2 3p4s$	$^1P^\circ$	1	*740 648*
		1	*230 645*				
		2	*230 754*	$3s^2 3p4d$	$^1F^\circ$	3	*926 660*
$3s3p^3$	$^1D^\circ$	2	*254 028*	$3s^2 3p4d$	$^3D^\circ$	3	*914 040*
$3s3p^3$	$^3S^\circ$	1	*299 944*	Ti X ($^2P^\circ_{1/2}$)	*Limit*		**1 549 000**
$3s3p^3$	$^1P^\circ$	1	*311 087*				
$3s^2 3p3d$	$^3P^\circ$	2	*352 632*				
		1	*356 962*				
		0	*358 427*				

Ti x

$Z = 22$

Al I isoelectronic sequence

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

Ionization energy = 1 741 500±1000 cm^{-1} (215.92±0.12 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 to the ground level. The error is indicated by x.

Smitt, Svensson, and Outred (1976) remeasured the $3s^2 3p - 3s3p^2$ 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 term values with an uncertainty of ±10 cm^{-1}.

The ionization energy was obtained by Ekberg and Svensson from the $3s^2nf\ ^2F^{\circ}$ series.

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Ti x

Configuration	Term	J	Level (cm^{-1})	Configuration	Term	J	Level (cm^{-1})
$3s^2 3p$	$^2P^{\circ}$	1/2	*0*	$3s3p4s$	$^4P^{\circ}$	1/2	*966 176+x*
		3/2	*7 543*			3/2	*968 680+x*
						5/2	*973 441+x*
$3s3p^2$	^4P	1/2	157 850+x				
		3/2	160 655+x	$3s^2 4d$	^2D	3/2	986 655
		5/2	164 764+x			5/2	986 919
$3s3p^2$	^2D	3/2	212 055	$3s^2 4f$	$^2F^{\circ}$	5/2	*1 046 622*
		5/2	212 606			7/2	*1 046 694*
$3s3p^2$	^2S	1/2	264 456	$3s^2 5s$	^2S	1/2	1 180 390
$3s3p^2$	^2P	1/2	281 045	$3s^2 5d$	^2D	3/2	1 271 460
		3/2	285 218			5/2	1 271 680
$3s^2 3d$	^2D	3/2	345 329	$3s^2 5f$	$^2F^{\circ}$	5/2	*1 302 120*
		5/2	345 857			7/2	*1 302 170*
$3p^3$	$^4S^{\circ}$	3/2	*421 188+x*	$3s^2 6d$	^2D	3/2	1 423 180
						5/2	1 423 470
$3s3p3d$	$^4D^{\circ}$	3/2	*504 516+x*				
		5/2	*505 134+x*	$3s^2 6f$	$^2F^{\circ}$	5/2,7/2	*1 434 560*
		7/2	*505 266+x*				
$3s^2 4s$	^2S	1/2	797 113	Ti XI ($^1S_0$)	***Limit***		**1 741 500**

Ti XI

$Z=22$

Mg I isoelectronic sequence

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

Ionization energy = 2 137 900±500 cm^{-1} (265.07±0.06 eV)

Edlén (1936) reported three unconnected systems of levels for this ion: the resonance line $3s^2\ ^1S_0-3s4p\ ^1P_1^\circ$; the triplet system of $3s3p-3s4s$, $3s4d$, $3s5d$ and the triplets of $3s3d-3s4f$, $3s5f$. Fawcett and Peacock (1967) identified the terms $3p^2\ ^3P$, ^1D, and $3s3p\ ^1P^\circ$. Fawcett (1970) identified $3p^2\ ^1S$ and several terms in $3p3d$.

Svensson and Ekberg (1969) made extensive observations of titanium spark spectra in the region 50–425 Å. With these data and longer wavelength lines from Fawcett and Peacock, Ekberg (1971) determined all the levels given in this compilation with an uncertainty of ±40 cm^{-1}, except the $3p^2\ ^1S$ and the $3p3d$ levels taken from Fawcett (1970) and the $3p4f$ levels from Fawcett (1976) whose level uncertainty is ±50 cm^{-1}. Some tentative classifications of $3p^2-3p4d$ and $3s3d-3p4d$ are given by Kastner et al. (1978). The singlets and triplets have been connected by the observation of the $3s^2\ ^1S_0-3s3p\ ^3P_1^\circ$ line at 569.3±0.2 Å in a tokamak plasma by Finkenthal, Bell, and Moos (1982). An improved value of 568.98±0.04 Å was measured by Peacock, Stamp, and Silver (1984).

We calculated the ionization energy from the $3snf\ ^3F^\circ$ series.

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Ti XI

Configuration	Term	J	Level (cm^{-1})	Configuration	Term	J	Level (cm^{-1})
$3s^2$	^{1}S	0	0	$3p3d$	^{3}D°	3	*730 560*
$3s3p$	^{3}P°	0	*173 200*	$3p3d$	^{1}P°	1	*750 220*
		1	*175 753*				
		2	*181 400*	$3s4s$	^{3}S	1	1 050 850
$3s3p$	^{1}P°	1	*258 973*	$3s4s$	^{1}S	0	1 065 780
$3p^2$	^{3}P	0	410 640	$3s4p$	^{1}P°	1	*1 139 920*
		1	415 150				
		2	420 700	$3s4d$	^{3}D	1	1 243 920
						2	1 244 260
$3p^2$	^{1}D	2	408 820			3	1 244 630
$3p^2$	^{1}S	0	482 840	$3s4d$	^{1}D	2	1 253 100
$3s3d$	^{3}D	1	499 840	$3p4s$	^{3}P°	0	*1 267 600*
		2	500 160			1	*1 269 840*
		3	500 650			2	*1 276 040*
$3s3d$	^{1}D	2	564 604	$3s4f$	^{3}F°	2	*1 293 870*
						3	*1 293 940*
$3p3d$	^{3}F°	2	*683 920*			4	*1 294 040*
		3	*687 580*				
		4	*691 980*	$3s4f$	^{1}F°	3	*1 304 360*
$3p3d$	^{1}D°	2	*694 610*	$3p4p$	^{3}D	3	1 353 860

Ti XI—Continued

Configuration	Term	J	Level (cm^{-1})	Configuration	Term	J	Level (cm^{-1})
$3p4p$	^3P	0	1 353 940	$3s5d$	^1D	2	1 584 970
		1	1 356 280				
		2	1 360 140	$3s5f$	$^3F^\circ$	2	*1 599 850*
						3	*1 599 940*
$3p4p$	^3S	1	1 361 780			4	*1 599 960*
$3s5s$	^3S	1	1 484 620	$3s5f$	$^1F^\circ$	3	*1 603 140*
$3s5s$	^1S	0	1 491 740	$3s6p$	$^1P^\circ$	1	*1 727 380*
$3p4f$	^3G	4	1 500 130	$3s6f$	$^3F^\circ$	4	*1 765 260*
		5	1 505 620				
				$3s7p$	$^1P^\circ$	1	*1 840 880*
$3p4f$	^3F	3	1 502 090				
		4	1 505 420	Ti XII ($^2S_{1/2}$)	***Limit***		**2 137 900**
$3s5p$	$^1P^\circ$	1	*1 528 980*				
$3s5d$	^3D	1	1 577 670				
		2	1 577 820				
		3	1 577 980				

Ti XII

$Z=22$

Na I isoelectronic sequence

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

Ionization energy = 2 351 080±100 cm^{-1} (291.502±0.012 eV)

The first observations were made in the range of 60–117 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 52–960 Å enabled them to redetermine to known level values and extend the known series through $6s$, $6p$, $8d$, and $8f$ with an uncertainty of ±20 cm^{-1}. Further extensions were made by Cohen and Behring (1976) through $7s$, $11p$, and $10d$. The level uncertainty is estimated to be ±500 cm^{-1}.

Transitions $2p^6 3s-2p^5 3s^2$, $2p^6 3p-2p^5 3s3p$, and $2p^6 3d-2p^5 3s3d$ were observed in the range of 26–28 Å with an accuracy of ±0.01 Å by Burkhalter, Cohen, Cowan, and Feldman (1979). Classifications are made on the basis of calculated wavelength and intensities. The uncertainty in the values of the core-excited levels is ±2000 cm^{-1}. Percentage compositions are given in two alternate coupling schemes.

The value for the ionization energy was derived by Edlén (1978) from core polarization theory applied to the nf series.

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Ti XII

Configuration	Term	J	Level (cm^{-1})	Leading percentages
$2p^6(^1S)3s$	^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})	Leading percentages			
$2p^6(^1S)6s$	^2S	1/2	1 848 640				
$2p^6(^1S)6p$	$^2P°$	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				
$2p^6(^1S)6f$	$^2F°$	5/2	*1 910 630*				
		7/2	*1 910 680*				
$2p^6(^1S)7s$	^2S	1/2	1 989 000				
$2p^6(^1S)7p$	$^2P°$	1/2,3/2	*2 003 500*				
$2p^6(^1S)7d$	^2D	3/2	2 020 620				
		5/2	2 020 690				
$2p^6(^1S)7f$	$^2F°$	5/2	*2 027 700*				
		7/2	*2 027 730*				
$2p^6(^1S)8p$	$^2P°$	1/2,3/2	*2 087 400*				
$2p^6(^1S)8d$	^2D	3/2,5/2	2 098 880				
$2p^6(^1S)8f$	$^2F°$	5/2	*2 103 590*				
		7/2	*2 103 610*				
$2p^6(^1S)9p$	$^2P°$	1/2,3/2	*2 144 000*				
$2p^6(^1S)9d$	^2D	3/2,5/2	2 152 300				
$2p^6(^1S)10p$	$^2P°$	1/2,3/2	*2 184 200*				
$2p^6(^1S)10d$	^2D	3/2,5/2	2 190 500				
$2p^6(^1S)11p$	$^2P°$	1/2,3/2	*2 214 000*				
Ti XIII ($^1S_0$)	***Limit***		**2 351 080**				
$2p^5(^2P^\circ_{1/2})3s^2(^1S_0)$	$(1/2,0)°$	1/2	*3 687 000*	100	or	100	$2p^5(^2P°)3s^2\ ^2P°$
$2p^5(^2P^\circ_{3/2})3s3p(^3P^\circ_1)$	$(3/2,1)$	5/2	3 792 000	97	or	74	$2p^53s(^3P°)3p\ ^4D$
		1/2	3 805 000	84	or	43	$2p^53s(^3P°)3p\ ^4D$
$2p^5(^2P^\circ_{3/2})3s3p(^3P^\circ_0)$	$(3/2,0)$	3/2	3 797 000	71	or	57	$2p^53s(^3P°)3p\ ^4D$
$2p^5(^2P^\circ_{3/2})3s3p(^3P^\circ_2)$	$(3/2,2)$	5/2	3 812 000	98	or	69	$2p^53s(^3P°)3p\ ^4P$
		3/2	3 813 000	56	or	37	$2p^53s(^1P°)3p\ ^2D$
		1/2	3 826 000	58	or	58	$2p^53s(^3P°)3p\ ^4P$
$2p^5(^2P^\circ_{1/2})3s3p(^3P^\circ_2)$	$(1/2,2)$	5/2	3 854 000	96	or	42	$2p^53s(^1P°)3p\ ^2D$
$2p^5(^2P^\circ_{1/2})3s3p(^3P^\circ_1)$	$(1/2,1)$	1/2	3 862 000	42	or	62	$2p^53s(^1P°)3p\ ^2S$
$2p^5(^2P^\circ_{3/2})3s3p(^1P^\circ_1)$	$(3/2,1)$	5/2	3 890 000	99	or	69	$2p^53s(^3P°)3p\ ^2D$
$2p^5(^2P^\circ_{1/2})3s3p(^1P^\circ_1)$	$(1/2,1)$	3/2	3 942 000	98	or	54	$2p^53s(^3P°)3p\ ^2D$

Ti XII—Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages			
$2p^5(^2P^\circ_{3/2})3s3d(^3D_2)$	$(\frac{3}{2},2)^\circ$	$\frac{7}{2}$	*4 105 000*	96	or	82	$2p^53s(^3P^\circ)3d\ ^4F^\circ$
		$\frac{5}{2}$	*4 124 000*	69	or	40	$2p^53s(^1P^\circ)3d\ ^2F^\circ$
		$\frac{1}{2}$	*4 127 000*	48	or	53	$2p^53s(^1P^\circ)3d\ ^2P^\circ$
$2p^5(^2P^\circ_{1/2})3s3d(^3D_2)$	$(\frac{1}{2},\frac{5}{2})^\circ$	$\frac{7}{2}$	*4 120 000*	99	or	68	$2p^53s(^3P^\circ)3d\ ^4D^\circ$
		$\frac{5}{2}$	*4 165 000*	41	or	61	$2p^53s(^1P^\circ)3d\ ^2D^\circ$
$2p^5(^2P^\circ_{3/2})3s3d(^3D_3)$	$(\frac{3}{2},3)^\circ$	$\frac{3}{2}$	*4 134 000*	51	or	51	$2p^53s(^1P^\circ)3d\ ^2P^\circ$
$2p^5(^2P^\circ_{3/2})3s3d(^1D_2)$	$(\frac{3}{2},2)^\circ$	$\frac{7}{2}$	*4 145 000*	99	or	76	$2p^53s(^3P^\circ)3d\ ^2F^\circ$
$2p^5(^2P^\circ_{1/2})3s3d(^3D_3)$	$(\frac{1}{2},3)^\circ$	$\frac{5}{2}$	*4 159 000*	55	or	45	$2p^53s(^3P^\circ)3d\ ^4D^\circ$
$2p^5(^2P^\circ_{1/2})3s3d(^1D_2)$	$(\frac{1}{2},2)^\circ$	$\frac{3}{2}$	*4 186 000*	36	or	44	$2p^53s(^3P^\circ)3d\ ^2D^\circ$
$2p^5(^2P^\circ_{1/2})3s3d(^1D_2)$	$(\frac{1}{2},2)^\circ$	$\frac{5}{2}$	*4 199 000*	94	or	43	$2p^53s(^3P^\circ)3d\ ^2F^\circ$
$2p^5(^2P^\circ_{1/2})3s3d(^1D_2)$	$(\frac{1}{2},2)^\circ$	$\frac{3}{2}$	*4 224 000*	58	or	73	$2p^53s(^3P^\circ)3d\ ^2P^\circ$

Ti XIII

$Z=22$

Ne I isoelectronic sequence

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

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

Resonance lines between 17 and 27 Å are classified by this system of energy levels. Edlén and Tyrén (1936) identified transitions from $2p^5 3s$ and $3d$. Fawcett (1965) observed three transitions arising from $2p^5 4d$ and from $2s2p^6 3p\ ^1P_1^\circ$. Feldman and Cohen (1967) observed nine transitions, including those reported by Fawcett. We have adopted the more accurate values of Feldman and Cohen, whose level uncertainty is ±2000 cm^{-1}.

The percentage compositions were given by Bogdanovich et al. (1980).

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. Three levels of the $2p^5 4p$ configuration were obtained from the classified lines of the $2p^5 3s - 2p^5 4p$ array by Fawcett, Bromage, and Hayes (1979). They have also observed lines of $2p^5 3d - 2p^5 4f$, $5f$, and $2p^5 3p - 2p^5 4s$, $4d$ but they are not connected with known levels.

We derived the ionization energy from the $2p^5 nd\ ^3D_1^\circ$ series for $n=3$, 4, and 5.

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Ti XIII

Configuration	Term	J	Level (cm^{-1})	Leading percentages		
$2s^2 2p^6$	^1S	0	0	100		
$2s^2 2p^5 3s$	$^3P^\circ$	1	*3 709 200*	55	45	$^1P^\circ$
$2s^2 2p^5 3s$	$^1P^\circ$	1	*3 753 600*	55	45	$^3P^\circ$
$2s^2 2p^5 3d$	$^3P^\circ$	1	*4 168 200*	94		
$2s^2 2p^5 3d$	$^3D^\circ$	1	*4 219 800*	86		
$2s^2 2p^5 3d$	$^1P^\circ$	1	*4 281 600*	90		
$2s2p^6 3p$	$^3P^\circ$	1	*4 733 300*	96	4	$^1P^\circ$
$2s2p^6 3p$	$^1P^\circ$	1	*4 754 000*	96	4	$^3P^\circ$
$2s^2 2p^5 4s$	$^3P^\circ$	1	*4 966 500*	59	41	$^1P^\circ$
$2s^2 2p^5 4s$	$^1P^\circ$	1	*5 014 300*	59	41	$^3P^\circ$
$2s^2 2p^5(^2P^\circ_{3/2})4p$	$^2[5/2]$	2	5 047 200			
$2s^2 2p^5(^2P^\circ_{3/2})4p$	$^2[3/2]$	1	5 049 900			
$2s^2 2p^5(^2P^\circ_{1/2})4p$	$^2[3/2]$	2	5 097 300			
$2s^2 2p^5 4d$	$^3D^\circ$	1	*5 163 700*	61	34	$^1P^\circ$
$2s^2 2p^5 4d$	$^1P^\circ$	1	*5 207 200*	66	28	$^3D^\circ$

Ti XIII—Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages
$2s^2\,2p^5\,5d$	$^3D°$	1	*5 596 300*	
$2s^2\,2p^5\,5d$	$^1P°$	1	*5 641 100*	
Ti XIV ($^2P°_{3/2}$)	***Limit***		**6 354 300**	

Ti XIV

$Z = 22$

F I isoelectronic sequence

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

Ionization energy = 6 961 000 ± 14 000 cm^{-1} (863.1 ± 1.7 eV)

The first work on this spectrum was done by Fawcett (1965), who classified many lines of the $2s^2 2p^5 - 2s^2 2p^4 3s$ 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 with an uncertainty of ±4000 cm^{-1}. The ground term $2s^2 2p^5\ ^2P^\circ$ interval was confirmed by Fawcett (1971) from his identification of the $2s^2 2p^5 - 2s 2p^6$ doublet at ~125 Å. A more accurate value for the ground term splitting was determined by the observation of the magnetic dipole transition $2s^2 2p^5\ ^2P^\circ_{3/2} - ^2P^\circ_{1/2}$ in tokamak plasmas by Suckewer, Fonck, and Hinnov (1980) and by Lawson, Peacock, and Stamp (1981). The value given here is from these observations, with an uncertainty of ±4 cm^{-1}. The $2s 2p^6\ ^2S$ term is derived from the improved measurements of Kaufman, Sugar, and Cooper (1982) with an uncertainty of ±50 cm^{-1}.

The $2s 2p^5 3s\ ^2P^\circ_{1/2}$ term is from Feldman et al. (1973).

Bogdanovich et al. (1980) calculated the percentage compositions of the levels.

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

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Ti XIV

Configuration	Term	J	Level (cm^{-1})	Leading percentages		
$2s^2 2p^5$	$^2P^\circ$	3/2	*0*			
		1/2	*47 219*			
$2s2p^6$	^2S	1/2	819 772			
$2s^2 2p^4(^3P)3s$	^4P	5/2	3 996 000	96		
		3/2	4 014 700	59	37	$(^3P)\ ^2P$
		1/2	4 035 900	96		
$2s^2 2p^4(^3P)3s$	^2P	3/2	4 043 600	56	41	$(^3P)\ ^4P$
		1/2	4 065 500	96		
$2s^2 2p^4(^1D)3s$	^2D	5/2	4 112 700	96		
		3/2	4 113 600	94		
$2s^2 2p^4(^1S)3s$	^2S	1/2	4 221 000	94		
$2s^2 2p^4(^3P)3d$	^4P	1/2	4 478 700	83		
		3/2	4 488 300	74	10	$(^3P)\ ^2D$
		5/2	4 501 500	55	24	$(^3P)\ ^4F$
$2s^2 2p^4(^3P)3d$	^4F	5/2	4 488 500	66	16	$(^3P)\ ^2F$
$2s^2 2p^4(^3P)3d$	^2P	1/2	4 494 600	55	24	$(^1D)\ ^2P$
		3/2	4 525 500	50	23	
$2s^2 2p^4(^3P)3d$	^2D	3/2	4 506 400	38	19	$(^1D)\ ^2D$
		5/2	4 531 900	55	18	

Ti XIV—Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages		
$2s^2\,2p^4(^3P)3d$	^2F	$5/2$	4 512 200	56	27	$(^3P)\ ^4P$
$2s^2\,2p^4(^1D)3d$	^2S	$1/2$	4 583 000	92		
$2s^2\,2p^4(^1D)3d$	^2D	$5/2$	4 601 500	64	24	$(^3P)\ ^2D$
		$3/2$	4 617 200	69	28	
$2s^2\,2p^4(^1D)3d$	^2P	$3/2$	4 601 400	71	25	$(^3P)\ ^2P$
$2s^2\,2p^4(^1S)3d$	^2D	$5/2$	4 685 800	94		
		$3/2$	4 693 800	88		
$2s2p^5(^3P^\circ)3s$	$^2P^\circ$	$3/2$	*4 778 600*	88		
		$1/2$	*4 806 100*	94		
Ti XV ($^3P_2$)	***Limit***		**6 961 000**			

Ti XV

$Z = 22$

O I isoelectronic sequence

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

Ionization energy $= 7\,597\,000 \pm 15\,000\ cm^{-1}$ (941.9 ± 1.9 eV)

The transition array $2s^2 2p^4 - 2s 2p^5$ was analyzed by Fawcett (1971) and with improved resolution by Doschek, Feldman, Cowan, and Cohen (1974). The $2p^6\ ^1S_0$ level was identified by Kasyanov et al. (1974). More accurate measurements of this spectral region (102–165 Å) were given by Kaufman, Sugar, and Cooper (1982) who also observed intersystem lines. These measurements are used to determine the energy levels with an uncertainty of $\pm 50\ cm^{-1}$. Kaufman and Sugar (1982) provided the percentage compositions for these levels. Their calculation includes configuration interaction between $2s^2 2p^4$ and $2p^6$. The $2s^2 2p^4\ ^3P_2 - ^3P_1$ magnetic dipole transition was observed in a Tokamak plasma by Lawson, Peacock, and Stamp (1981) and by Suckewer, Fonck, and Hinnov (1980). They obtained the wavenumber intervals 39291 $\pm 1\ cm^{-1}$ and $39\,284 \pm 2\ cm^{-1}$, respectively. Peacock, Stamp, and Silver (1984) measured the transition $^3P_2 - ^1D_2$ at 919.73 ± 0.08 Å in a tokamak plasma. These magnetic dipole lines are used to determine the positions of the $^3P_1$ and $^1D_2$ levels.

The $2s^2 2p^4 - 2s^2 2p^3 3s$ array in the range of 22.4–23.2 Å was measured by Doschek, Feldman, and Cohen (1973) with an accuracy of ± 0.01 Å. Their analysis is used to obtain the levels of the $2s^2 2p^3 3s$ configuration with an uncertainty of $\pm 2000\ cm^{-1}$. Fawcett and Hayes (1975) give measurements of the $2s^2 2p^4 - 2s^2 2p^3 3d$ array in the range of 20.0–21.1 Å. The uncertainty of wavelength appears to be ± 0.02–0.03 Å. We obtained the $2s^2 2p^3 3d$ levels from their classifications with an uncertainty of $\pm 7000\ cm^{-1}$. Subsequent revisions by Bromage and Fawcett (1977) based on new calculations are included.

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

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Ti XV

Configuration	Term	J	Level (cm^{-1})	Leading percentages		
$2s^2\,2p^4$	^3P	2	0	95	5	^1D
		1	39 288	100		
		0	42 345	92	8	^1S
$2s^2\,2p^4$	^1D	2	108 730	95	5	^3P
$2s^2\,2p^4$	^1S	0	215 528	90	8	^3P
$2s2p^5$	$^3P°$	2	*712 278*	100		
		1	*742 877*	99	1	$^1P°$
		0	*762 056*	100		
$2s2p^5$	$^1P°$	1	*978 037*	99	1	$^3P°$
$2p^6$	^1S	0	1 656 300	98	2	$2s^2 2p^4\ ^1S$
$2s^2\,2p^3(^4S°)3s$	$^3S°$	1	*4 354 100*			

Ti XV—Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages
$2s^2 2p^3(^2D^\circ)3s$	$^3D^\circ$	1	*4 440 200*	
		2	*4 440 400*	
		3	*4 451 600*	
$2s^2 2p^3(^2D^\circ)3s$	$^1D^\circ$	2	*4 469 100*	
$2s^2 2p^3(^2P^\circ)3s$	$^3P^\circ$	2	*4 523 000*	
$2s^2 2p^3(^2P^\circ)3s$	$^1P^\circ$	1	*4 557 300*	
$2s^2 2p^3(^4S^\circ)3d$	$^3D^\circ$	2	*4 780 000*	
		3	*4 785 000*	
$2s^2 2p^3(^2D^\circ)3d$	$^3D^\circ$	1	*4 873 000*	
		2	*4 891 000*	
		3	*4 898 000*	
$2s^2 2p^3(^2D^\circ)3d$	$^3P^\circ$	2	*4 905 000*	
		1	*4 965 000*	
$2s^2 2p^3(^2D^\circ)3d$	$^1D^\circ$	2	*4 911 000*	
$2s^2 2p^3(^2D^\circ)3d$	$^1F^\circ$	3	*4 940 000*	
$2s^2 2p^3(^2P^\circ)3d$	$^3P^\circ$	2	*4 950 000*	
$2s^2 2p^3(^2P^\circ)3d$	$^1D^\circ$	2	*4 962 000*	
$2s^2 2p^3(^2P^\circ)3d$	$^3D^\circ$	1	*4 984 000*	
		3	*4 987 000*	
		2	*5 006 000*	
$2s^2 2p^3(^2P^\circ)3d$	$^1F^\circ$	3	*5 006 000*	
$2s^2 2p^3(^2P^\circ)3d$	$^1F^\circ$	3	*5 014 000*	
$2s^2 2p^3(^2P^\circ)3d$	$^1P^\circ$	1	*5 046 000*	
Ti XVI ($^4S^\circ_{3/2}$)	***Limit***		**7 597 000**	

Ti XVI

$Z = 22$

N I isoelectronic sequence

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

Ionization energy = 8 420 000 ± 17 000 cm^{-1} (1044 ± 2 eV)

The transition arrays $2s^2 2p^3 - 2s2p^4$ and $2s2p^4 - 2p^5$ were identified by Fawcett (1971). The intersystem line $2s^2 2p^3\ ^4S^\circ_{3/2} - 2s2p^4\ ^2P_{3/2}$ at 102.393 Å was identified by Kaufman, Sugar, and Cooper (1982) who remeasured the spectrum in the range of 102–178 Å with an uncertainty of ±0.01 Å. This provided a level uncertainty of ±50 cm^{-1}. Kaufman and Sugar (1982) provided the percentage compositions for these levels. Their calculation includes configuration interaction between $2s^2 2p^3$ and $2p^5$.

Fawcett and Hayes (1975) classified the lines of the $2s^2 2p^3 - 2s^2 2p^2 3d$ array at 19 Å. Two additional classifications were made by Bromage and Fawcett (1977). The level uncertainty for the $2s^2 2p^2 3d$ configuration is ±2000 cm^{-1}.

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

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Ti XVI

Configuration	Term	J	Level (cm^{-1})	Leading percentages		
$2s^2 2p^3$	$^4S^\circ$	3/2	*0*	97	3	$^2P^\circ$
$2s^2 2p^3$	$^2D^\circ$	3/2	*116 030*	84	14	$^2P^\circ$
		5/2	*130 720*	100		
$2s^2 2p^3$	$^2P^\circ$	1/2	*197 700*	98	2	$2p^5\ ^2P^\circ$
		3/2	*219 250*	81	15	$2p^3\ ^2D^\circ$
$2s(^2S)2p^4(^3P)$	^4P	5/2	589 140	99	1	$2s(^2S)2p^4(^1D)\ ^2D$
		3/2	620 470	100		
		1/2	633 660	98	2	$2s(^2S)2p^4(^3P)\ ^2S$
$2s(^2S)2p^4(^1S)$	^2D	3/2	813 080	98	2	$2s(^2S)2p^4(^3P)\ ^2P$
		5/2	817 210	99	1	$2s(^2S)2p^4(^3P)\ ^4P$
$2s(^2S)2p^4(^1S)$	^2S	1/2	939 920	83	16	$2s(^2S)2p^4(^1S)\ ^2P$
$2s(^2S)2p^4(^3P)$	^2P	3/2	976 650	98	2	$2s(^2S)2p^4(^1D)\ ^2D$
		1/2	1 020 500	84	15	$2s(^2S)2p^4(^1S)\ ^2S$
$2p^5$	$^2P^\circ$	3/2	*1 537 660*	98	2	$2s^2 2p^3\ ^2P^\circ$
		1/2	*1 587 830*	92	2	
$2s^2 2p^2(^3P)3d$	^2P	3/2	5 194 100			
$2s^2 2p^2(^3P)3d$	^4P	5/2	5 232 300			
		3/2	5 238 600			
$2s^2 2p^2(^3P)3d$	^2F	7/2	5 245 500			
$2s^2 2p^2(^3P)3d$	^2D	3/2	5 287 000			
		5/2	5 293 300			

Ti XVI—Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages
$2s^2\,2p^2(^1D)3d$	^2F	$^7/_2$	5 336 300	
		$^5/_2$	5 348 100	
$2s^2\,2p^2(^1D)3d$	^2P	$^3/_2$	5 361 000	
Ti XVII ($^3P_0$)	***Limit***		**8 420 000**	

Ti XVII

$Z = 22$

C I isoelectronic sequence

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

Ionization energy = 9 120 000±18 000 cm^{-1} (1131±2 eV)

The ground term splitting $2s^2 2p^2\ ^3P_0 - ^3P_1$ was obtained from a magnetic dipole transition observed in a tokamak plasma at 3370.8±0.2 Å (in air) by Suckewer, Fonck, and Hinnov (1980). They also reported the $2s^2 2p^2\ ^3P_1 - ^3P_2$ line at 3834.4±0.2 Å (in air). These results are used here to determine the ^3P levels with an uncertainty of ±2 cm^{-1}.

The $2s^2 2p^2 - 2s 2p^3$ 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 $2s 2p^3 - 2p^4$ lines. These arrays were re-observed by Sugar, Kaufman, and Cooper (1982) in the range of 109-188 Å with an accuracy of ±0.01 Å, including several intersystem lines. The levels of $2s^2 2p^2$, $2s 2p^3$, and $2p^4$ are derived from these data with a level value uncertainty of ±50 cm^{-1}. None of the above investigations revealed the position of the $2s 2p^3\ ^5S_2^\circ$ term. Denne and Hinnov (1984) have observed a faint line in a tokamak plasma that they classified as $2s^2 2p^2\ ^3P_2 - 2s 2p^3\ ^5S_2^\circ$. We adopted their result. Kaufman and Sugar (1982) provided the percentage compositions of these levels. Their calculation includes configuration interaction between $2s^2 2p^2$ and $2p^4$.

The levels of $2s^2 2p 3d$ are from the classifications by Fawcett and Hayes (1972) with additions by Bromage and Fawcett (1977). The levels of $2s^2 2p 3s$, $2s 2p^2 3s$ and $2s 2p^2 3d$ are due to Goldsmith et al. (1972). They identified two quintet transitions which are not connected to the known levels. The uncertainty in the level values is ±2000 cm^{-1}.

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

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Ti XVII

Configuration	Term	J	Level (cm^{-1})	Leading percentages		
$2s^2\,2p^2$	^3P	0	0	94	4	$2s^22p^2\ ^1S$
		1	29 658	99	1	$2p^4\ ^3P$
		2	55 730	89	10	$2s^22p^2\ ^1D$
$2s^2\,2p^2$	^1D	2	140 660	89	10	^3P
$2s^2\,2p^2$	^1S	0	242 180	91	4	$2p^4\ ^1S$
$2s(^2S)2p^3(^4S^\circ)$	$^5S^\circ$	2	*333 660*	99	1	$2s(^2S)2p^3(^2P^\circ)\ ^3P^\circ$
$2s(^2S)2p^3(^2D^\circ)$	$^3D^\circ$	2	*578 890*	93	7	$2s(^2S)2p^3(^2P^\circ)\ ^3P^\circ$
		1	*580 110*	95	5	$2s(^2S)2p^3(^2P^\circ)\ ^3P^\circ$
		3	*586 760*	100		
$2s(^2S)2p^3(^2P^\circ)$	$^3P^\circ$	0	*678 450*	100		
		1	*680 910*	94	5	$2s(^2S)2p^3(^2D^\circ)\ ^3D^\circ$
		2	*686 780*	90	7	$2s(^2S)2p^3(^2D^\circ)\ ^3D^\circ$
$2s(^2S)2p^3(^4S^\circ)$	$^3S^\circ$	1	*832 340*	92	7	$2s(^2S)2p^3(^2P^\circ)\ ^1D^\circ$

Ti XVII—Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages		
$2s(^2S)2p^3(^2D^\circ)$	$^1D^\circ$	2	*845 140*	98	2	$2s(^2S)2p^3(^2P^\circ)\ ^3P^\circ$
$2s(^2S)2p^3(^2P^\circ)$	$^1P^\circ$	1	*943 500*	92	7	$2s(^2S)2p^3(^4S^\circ)\ ^3S^\circ$
$2p^4$	^3P	2	1 271 380	93	6	$2p^4\ ^1D$
		1	1 313 280	99	1	$2s^22p^2\ ^3P$
		0	1 319 740	94	5	$2p^4\ ^1S$
$2p^4$	^1D	2	1 380 290	93	6	^3P
$2p^4$	^1S	0	1 556 810	91	4	$2s^22p^2\ ^1S$
$2s^2\,2p3s$	$^3P^\circ$	1	*5 144 000*			
		2	*5 193 000*			
$2s^2\,2p3s$	$^1P^\circ$	1	*5 200 000*			
$2s^2\,2p3d$	$^3F^\circ$	2	*5 472 000*			
$2s^2\,2p3d$	$^1D^\circ$	2	*5 502 000*			
$2s^2\,2p3d$	$^3D^\circ$	1	*5 519 000*			
		2	*5 542 000*			
		3	*5 557 000*			
$2s^2\,2p3d$	$^3P^\circ$	2	*5 568 000*			
$2s^2\,2p3d$	$^1P^\circ$	1	*5 612 000*			
$2s^2\,2p3d$	$^1F^\circ$	3	*5 614 000*			
$2s2p^2(^2D)3s$	^3D	2	5 707 000			
$2s2p^2(^4P)3d$	^3F	3	5 859 000			
$2s2p^2(^2D)3d$	^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: $1s^2 2s^2 2p\ ^2P^\circ_{1/2}$

Ionization energy $= 9\,850\,000 \pm 20\,000$ cm^{-1} (1221 ± 2 eV)

The $^2P^\circ$ ground term splitting was obtained from a magnetic dipole transition at 1778.1±0.1 Å in a tokamak discharge by Suckewer, Fonck, and Hinnov (1980).

Kasyanov et al. (1974) and Fawcett and Hayes (1975) analyzed the transition arrays $2s^2 2p - 2s2p^2$ and $2s2p^2\,^4P - 2p^3\,^4S^\circ$ found between 130 Å and 200 Å. They were remeasured by Sugar, Kaufman, and Cooper (1982) with a wavelength uncertainty of ±0.01 Å, providing a level value uncertainty of ±50 cm^{-1}. Denne and Hinnov (1984) have tentatively classified a line at 322.6 Å observed in a tokamak plasma as the $2s^2 2p\ ^2P_{1/2} - 2s2p^2\,^4P_{1/2}$ transition. We use this wavelength to determine the position of the quartet system. They also tentatively classify a fainter line at 361.1 Å as $2s^2 2p\ ^2P_{3/2} - 2s2p^2\,^4P_{3/2}$, which we use. The $^2P^\circ$ and $^2D^\circ$ terms of $2p^3$ were found by Fawcett, Ridgeley, and Hatter (1980). The percentage composition for these levels was provided by Kaufman and Sugar (1982). Their calculation includes configuration interaction between $2s^2 2p$ and $2p^3$.

The higher lying levels are from the classifications of the spectrum at 16–17 Å by Fawcett and Hayes, who obtained a level value uncertainty of ±3000 cm^{-1}.

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

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Ti XVIII

Configuration	Term	J	Level (cm^{-1})	Leading percentages		
$2s^2\,2p$	$^2P^\circ$	1/2	*0*	97	3	$2p^3\ ^2P^\circ$
		3/2	*56 240*	97	3	
$2s2p^2$	^4P	1/2	309 980	99	1	^2S
		3/2	333 170	100		
		5/2	360 960	98	2	^2D
$2s2p^2$	^2D	3/2	555 860	98	2	^2P
		5/2	561 700	98	2	^4P
$2s2p^2$	^2S	1/2	673 680	52	47	^2P
$2s2p^2$	^2P	1/2	733 750	53	47	^2S
		3/2	747 070	98	2	^2D
$2p^3$	$^4S^\circ$	3/2	*962 100*	98	2	$^2P^\circ$
$2p^3$	$^2D^\circ$	3/2	*1 078 800*	92	7	$^2P^\circ$
		5/2	*1 088 900*	100		
$2p^3$	$^2P^\circ$	1/2	*1 208 800*	97	3	$2s^2 2p\ ^2P^\circ$
		3/2	*1 227 700*	88	8	$2p^3\ ^2D^\circ$
$2s^2\,3d$	^2D	3/2	5 807 000			
		5/2	5 815 000			

Ti XVIII—Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages
$2s2p(^3P°)3p$	^2P	$1/2$	5 917 000	
		$3/2$	5 960 000	
$2s2p(^3P°)3p$	^2D	$3/2$	6 038 000	
		$5/2$	6 072 000	
$2s2p(^3P°)3d$	$^2D°$	$5/2$	*6 142 000*	
$2s2p(^3P°)3d$	$^4D°$	$7/2$	*6 143 000*	
$2s2p(^3P°)3d$	$^4P°$	$5/2$	*6 148 000*	
$2s2p(^3P°)3d$	$^2F°$	$5/2$	*6 201 000*	
		$7/2$	*6 234 000*	
$2s2p(^1P°)3d$	$^2F°$	$7/2$	*6 393 000*	
$2s2p(^1P°)3d$	$^2D°$	$5/2$	*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 $= 10\ 860\ 000 \pm 22\ 000\ cm^{-1}$ (1346 ± 3 eV)

The resonance line $2s^2\ ^1S_0 - 2s2p\ ^1P_1^\circ$ was identified at 169.59 Å by Kasyanov et al. (1974). They also give the $2s2p\ ^3P^\circ - 2p^2\ ^3P$ multiplet. A more complete array was identified by Fawcett, Ridgeley, and Hatter (1980), including the intersystem line $2s2p\ ^3P_2^\circ - 2p^2\ ^1D_2$. Their wavelength uncertainty is ± 0.05 Å giving a level value uncertainty of $\pm 200\ cm^{-1}$. A new measurement of the $2s^2\ ^1S_0 - 2s2p\ ^1P_1^\circ$ transition was given by Stamp and Peacock (1982) at 169.580 ± 0.002 Å. They also give a value for the $^1S_0 - ^3P_1^\circ$ line which, however, is shown to be incompatible with related data by Edlén (1983). Denne and Hinnov (1984) observed this line in a tokamak plasma at 328.3 Å, in close agreement with Edlén's prediction. We have used this value for the intersystem interval.

The $2s2p\ ^3P_1 - ^3P_2$ interval is obtained from the magnetic dipole transition observed by Lawson, Peacock, and Stamp (1981) at 2344.6 ± 0.2 Å (in air) in a tokamak plasma.

The higher-lying configurations are from the classifications of Fawcett and Hayes (1975) and Boiko et al. (1977).

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

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Ti XIX

Configuration	Term	J	Level (cm^{-1})	Configuration	Term	J	Level (cm^{-1})
$2s^2$	^1S	0	0	$2s3d$	^1D	2	6 445 900
$2s2p$	$^3P^\circ$	0	*288 190*	$2p3p$	^3P	0	6 685 800
		1	*304 600*				
		2	*347 240*	$2p3p$	^3D	3	6 699 700
$2s2p$	$^1P^\circ$	1	*589 692*	$2p3p$	^3S	1	6 701 300
$2p^2$	^3P	0	775 810	$2p3d$	$^1D^\circ$	2	*6 738 000*
		1	804 890				
		2	832 410	$2p3d$	$^3D^\circ$	2	*6 789 100*
						3	*6 807 600*
$2p^2$	^1D	2	917 580				
				$2p3p$	^1D	2	6 770 900
$2p^2$	^1S	0	1 104 170				
				$2p3d$	$^3P^\circ$	1,2	*6 813 700*
$2s3s$	^3S	1	6 160 800				
				$2p3d$	$^1P^\circ$	1	*6 866 000*
$2s3p$	$^1P^\circ$	1	*6 303 200*				
				$2p3d$	$^1F^\circ$	3	*6 871 700*
$2s3d$	^3D	1	6 380 600				
		2	6 389 200	Ti XX ($^2S_{1/2}$)	***Limit***		**10 860 000**
		3	6 402 700				

Ti xx

$Z=22$

Li I isoelectronic sequence

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

Ionization energy = 11 497 000±4000 cm^{-1} (1425.4±0.4 eV)

The $2s-2p$ doublet was observed in a tokamak plasma at 259.272±0.004 Å and 309.072±0.010 Å by Stamp and Peacock (1982).

The $2s-3p$, $2p-3s$, and $2p-3d$ transitions near 16 Å were reported by Goldsmith, Feldman, Oren and Cohen (1972) with an uncertainty of ±0.005 Å. 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. The $3d4f$ transition was reported by Fawcett and Ridgeley (1981). These levels have an uncertainty of ±2000 cm^{-1}.

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. The uncertainty in these level values is ±7000 cm^{-1}.

We derived the ionization energy from the first three members of the nd series.

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Ti xx

Configuration	Term	J	Level (cm^{-1})	Configuration	Term	J	Level (cm^{-1})
$1s^2 2s$	^2S	$1/2$	0	$1s^2 8d$	^2D	$3/2, 5/2$	10 812 000
$1s^2 2p$	$^2P^\circ$	$1/2$	*323 549*	$1s^2 8p$	$^2P^\circ$	$1/2, 3/2$	*10 815 000*
		$3/2$	*385 695*				
				$1s^2 9p$	$^2P^\circ$	$1/2, 3/2$	*10 955 000*
$1s^2 3s$	^2S	$1/2$	6 466 000				
$1s^2 3p$	$^2P^\circ$	$1/2$	*6 556 000*	Ti XXI ($^1S_0$)	*Limit*		**11 497 000**
		$3/2$	*6 574 000*				
				$1s(^2S)2s2p(^3P^\circ)$	$^4P^\circ$		*37 764 000*
$1s^2 3d$	^2D	$3/2$	6 610 000				
		$5/2$	6 616 000	$1s(^2S)2s2p(^3P^\circ)$	$^2P^\circ$	$1/2, 3/2$	*38 030 000*
$1s^2 4p$	$^2P^\circ$	$1/2, 3/2$	*8 732 000*	$1s2p^2$	^4P		38 117 000
$1s^2 4d$	^2D	$3/2$	8 747 000	$1s(^2S)2s2p(^1P^\circ)$	$^2P^\circ$	$1/2, 3/2$	*38 162 000*
		$5/2$	8 748 000				
				$1s2p^2$	^2D	$3/2$	38 319 000
$1s^2 4f$	$^2F^\circ$	$5/2, 7/2$	*8 753 000*			$5/2$	38 329 000
$1s^2 5p$	$^2P^\circ$	$1/2, 3/2$	*9 730 000*	$1s2p^2$	^2P	$3/2$	38 416 000
$1s^2 5d$	^2D	$3/2, 5/2$	9 740 000	$1s2p^2$	^2S	$1/2$	38 550 000
$1s^2 6p$	$^2P^\circ$	$1/2, 3/2$	*10 274 000*	$1s2p3p$			44 820 000
$1s^2 6d$	^2D	$3/2, 5/2$	10 278 000				
$1s^2 7p$	$^2P^\circ$	$1/2, 3/2$	*10 600 000*				
$1s^2 7d$	^2D	$3/2, 5/2$	10 601 000				

Ti XXI

$Z = 22$

He I isoelectronic sequence

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

Ionization energy = 50 401 000±10 000 cm^{-1} (6249.0±1.0 eV)

Because of the excellent agreement of the calculated energies of the $n = 2$ shell by Safronova (1981) with the few well-measured spectra in the He I sequence, we have compiled her results for the $n = 2$ levels and for the ionization energy. Detailed comparisons are given in the Introduction. Levels of the $n = 3$–5 shells are from the calculated binding energies by Ermolaev and Jones (1974) subtracted from Safronova's value for the binding energy of the ground state. We have assumed an uncertainty of 2 parts in 10^4 for the excited levels relative to the ground state, and for the ionization energy. This is equal to the random deviation of the measurements by Aglitskii et al. (1974) from the calculations by Safronova (see Introduction). For differences between excited levels where $\Delta n = 0$, we assumed an uncertainty of 2 parts in 10^3.

Corrected measurements (see Introduction) by Aglitskii et al. (1974) place the $1s2p\ {}^3P^\circ_1$ level at 38 123 000 cm^{-1} and the $1s2p\ {}^1P^\circ_1$ at 38 310 000 cm^{-1} with an estimated uncertainty of ±7000 cm^{-1}.

Percentage compositions are from Ermolaev and Jones.

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Ti XXI

Configuration	Term	J	Level (cm^{-1})	Leading percentages		
$1s^2$	^1S	0	0			
$1s2s$	^3S	1	[37 923 330]			
$1s2p$	$^3P^\circ$	0	[*38 114 090*]			
		1	[*38 125 540*]	96	4	$^1P^\circ$
		2	[*38 180 210*]			
$1s2s$	^1S	0	[38 131 630]			
$1s2p$	$^1P^\circ$	1	[*38 307 120*]	96	4	$^3P^\circ$
$1s3s$	^3S	1	[44 911 530]			
$1s3p$	$^3P^\circ$	0	[*44 964 290*]			
		1	[*44 967 230*]	95	5	$^1P^\circ$
		2	[*44 983 570*]			
$1s3s$	^1S	0	[44 966 300]			
$1s3p$	$^1P^\circ$	1	[*45 018 280*]	95	5	$^3P^\circ$
$1s4s$	^3S	1	[47 328 420]			
$1s4p$	$^3P^\circ$	0	[*47 350 340*]			
		1	[*47 351 570*]	94	6	$^1P^\circ$
		2	[*47 358 480*]			
$1s4s$	^1S	0	[47 350 610]			
$1s4p$	$^1P^\circ$	1	[*47 372 630*]	94	6	$^3P^\circ$

Ti XXI—Continued

Configuration	Term	J	Level (cm^{-1})	Leading percentages		
$1s5s$	^3S	1	[48 440 550]			
$1s5p$	$^3P^\circ$	0	[*48 451 630*]			
		1	[*48 452 270*]	94	6	$^1P^\circ$
		2	[*48 455 810*]			
$1s5s$	^1S	0	[48 451 640]			
$1s5p$	$^1P^\circ$	1	[*48 462 950*]	94	6	$^3P^\circ$
Ti XXII ($^2S_{1/2}$)	***Limit***		**50 401 000**			

Ti XXII

$Z=22$

H I isoelectronic sequence

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

Ionization energy = 53 440 800±100 cm^{-1} (6625.87±0.01 eV)

The two $1s$–$2p$ transitions have been observed by Bitter et al. (1982) in a tokamak discharge, but without absolute wavelength calibration. We give calculated values by Mohr (1983) for the $n=2$ shell and by Erickson (1977) for $n=3$-5 relative to the $2p\ ^2P^\circ_{3/2}$ level. Further details are given in the Introduction. Relative to the ground state, the level uncertainty is estimated to be 5 parts in 10^7. The uncertainty in the excited states relative to $2p\ ^2P^\circ_{3/2}$ is 1 part in 10^6.

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Ti XXII

Configuration	Term	J	Level (cm^{-1})	g	Leading percentages
$1s$	^2S	1/2	0		
$2p$	$^2P^\circ$	1/2	*[40 054 190]*		
		3/2	*[40 141 335]*		
$2s$	^2S	1/2	[40 056 747]		
$3p$	$^2P^\circ$	1/2	*[47 500 870]*		
		3/2	*[47 526 701]*		
$3s$	^2S	1/2	[47 501 659]		
$3d$	^2D	3/2	[47 526 656]		
		5/2	[47 535 163]		
$4p$	$^2P^\circ$	1/2	*[50 103 648]*		
		3/2	*[50 114 539]*		
$4s$	^2S	1/2	[50 103 982]		
$4d$	^2D	3/2	[50 114 519]		
		5/2	[50 118 110]		
$4f$	$^2F^\circ$	5/2	*[50 118 104]*		
		7/2	*[50 119 890]*		
$5p$	$^2P^\circ$	1/2	*[51 306 846]*		
		3/2	*[51 312 419]*		
$5s$	^2S	1/2	[51 307 017]		
$5d$	^2D	3/2	[51 312 409]		
		5/2	[51 314 247]		
$5f$	$^2F^\circ$	5/2	*[51 314 244]*		
		7/2	*[51 315 161]*		
$5g$	^2G	7/2	[51 315 159]		
		9/2	[51 315 709]		
Limit			**53 440 800**		

F. Atomic Transition Probabilities of Titanium, Ti I through Ti XXII

F. Atomic Transition Probabilities of Titanium

[Exerpted from: G. A. Martin, J. R. Fuhr, and W. L. Wiese, J. Phys. Chem. Ref. Data **17**, Supplement 3 (1988)]

1. Introduction

The following tables, including the introductory comments, are excerpted from the above cited compilation of atomic transition probabilities by G. A. Martin, J. R. Fuhr, and W. L. Wiese of the Data Center on Atomic Transition Probabilities at the National Institute of Standards and Technology (formerly the National Bureau of Standards).

This is part of the third major critical compilation by the NBS Data Center on Atomic Transition Probabilities. A first tabulation[1] containing transition probabilities for about 4,000 spectral lines of the elements hydrogen through neon, atomic numbers $Z=1$ through 10, including the neutral atoms as well as their various ions, was published in 1966. A second data volume[2] was issued in 1969, containing data for about 5,000 lines of the elements sodium ($Z=11$) through calcium ($Z=20$), again for all stages of ionization for which data were available. The data compilation work then continued with a series of smaller tables for the atoms and ions of the elements of the iron group, i.e., Sc and Ti[3]; V, Cr, and Mn[4]; Fe, Co, and Ni[5]; and the forbidden lines of all these elements.[6] From the beginning, it has been the intention to integrate these smaller tabulations into a single volume for the iron-group elements, in updated and expanded form. Unexpectedly, a great deal of new data were generated for these elements during the past few years, often with much improved accuracy, so that the revisions and additions became very extensive. Thus it took a much longer time than anticipated to complete these largely new data tables, and the greatly expanded tabulations had to be split into two separate volumes. Titanium is included in a volume that contains the material on the elements Sc ($Z=21$) through Mn ($Z=25$), and a companion volume[7] contains the material on Fe ($Z=26$) through Ni ($Z=28$).

In the present compilation, the scope and format of the earlier tabulations is maintained, i.e., critically evaluated atomic transition probabilities of allowed and forbidden discrete transitions of all stages of ionization are presented for which reliable data are available. Data are listed for at least the more prominent lines of each spectrum, even if some of these data are of low accuracy. Furthermore, transition-probability data are also presented for weaker transitions if the accuracy of these data has been estimated to be better than ± 50%.

The original literature is continually monitored by this NBS Data Center, and a master reference list is maintained from which all literature sources for this compilation have been taken.

2. Method of Evaluation

For the compilation of data on a critical basis, the central task is the evaluation of the data accuracy and the subsequent choice of the most accurate material. In order to accomplish this task in a consistent manner, general guideposts were established for each experimental and theoretical approach in earlier compilation work, and these criteria were maintained in this work. Specifically, each original literature source was judged by the following principal criteria:

(1) A general evaluation of the capabilities and reliability of the applied experimental or theoretical method.
(2) The author's consideration of the major critical factors in his approach that enter into the results.
(3) The degree of agreement and general consistency between the author's results and other reliable data.
(4) The degree of fit of the data into established systematic trends and, if deviations exist, the reasons for such disagreements.
(5) The author's estimate of his uncertainties.

The general evaluations of each experimental and theoretical method have been discussed in considerable detail in the introductions to previous tabulations.[1–6] Thus, these publications are to be consulted for further details. However, it should be pointed out that in this tabulation, particularly interesting situations are illustrated by providing comparison tables or graphs in the introductions to individual spectra. For example, in the introduction to the forbidden lines of Ti XXI, a table is presented comparing theoretical and the few available experimental data on M1 and M2 lines of He-like ions.

With respect to error estimates, one should note that the theoretical literature sources, which provide a large part of the data, generally contain no error estimates, since no reliable assessment of the uncertainties introduced by the various approximations is possible. But even for the experimental papers, where error estimates may often readily be made, the statements by some authors are too imprecise and also incomplete, so that they are not particularly useful as presented. Sometimes only statistical measurement errors have been given, without allowance for systematic errors. It therefore became essential to judge each paper by the principal factors 1–4 listed above, in addition to utilizing the author's error estimate (point (5)) whenever appropriate.

3. General Arrangement of the Tables

The same general arrangement of the tables is used as in earlier volumes,[1,2] i.e., data are included which serve to identify the spectral lines, as well as the actual transition probabilities (and related quantities), accuracy estimates, and references to the sources of the compiled material. However, for most of the spectra of neutral and singly-ionized atoms of the iron-group elements, the transition array column was dropped. Instead, in order to identify the lower and upper levels of a transition, the level designation scheme of C. E. Moore[8] was adopted, who affixed lower-case letters ($a,b,c,...,x,y,z$) to the term designations. This convention is also retained in the very recent tables of "Atomic Energy Levels" by J. Sugar and C. Corliss.[9] In other special cases, the notation was adapted to the special coupling situations encountered in those spectra, as, for example, the J_1j coupling encountered in Ne-like ions and J_1j and $J_1\ell$ coupling for Ar-like ions.

Material pertaining to spectral-line identifications has been taken from the comprehensive wavelength tabulations of Reader and Corliss,[10] Kelly,[11,12] and Kelly and Palumbo,[13] the multiplet tables of C. E. Moore,[14,15] and the recent energy-level compilation of Sugar and Corliss[9] (this last reference supersedes earlier compilations by Sugar and others[16,17]). The wavelength and energy-level data from these sources have been supplemented by original literature data when needed in the course of preparing the transition-probability tables.

Wavelengths and energy levels which are the results of theoretical calculations, or which were either calculated from experimentally determined data or interpolated or extrapolated from data on similar (e.g., isoelectronic) species, are placed in square brackets in order to distinguish them from the usually more accurate experimental material.

For each transition-probability table which contains a minimum of twenty distinct wavelength values, a "list of tabulated lines," has been provided, in ascending order of wavelength, of the spectral lines contained therein, along with an index to the multiplet number (or numbers) in which each is to be found. Wavelengths that are printed in italics in the transition-probability tables are not included in these line lists.

The uncertainties in the atomic transition-probability data are denoted by letters as follows:

A . . for uncertainties within 3 percent,
B . . for uncertainties within 10 percent,
C . . for uncertainties within 25 percent,
D . . for uncertainties within 50 percent,
E . . for uncertainties greater than 50 percent.

The word *uncertainty* is used here with the connotation "estimated extent of the deviation from the true value." The estimation procedure is based on the evaluation of random errors *as well as estimates of the maximum effect of possible systematic errors*. Often, further distinctions were made in the uncertainty labels by assigning plus or minus signs to some transitions to indicate that these lines are estimated to be somewhat better or worse than similar lines. These should, therefore, be the first or last choice among similar transitions.

A summary of the abbreviations and special symbols used in the tables is given in Section 4. Included there for convenience are formulas which relate various properties of individual spectral lines to those for entire multiplets. In Table 1, the conversion factors are provided which have been used throughout this compilation to convert from transition probabilities to oscillator strengths and line strengths, and vice versa.

TABLE 1. Conversion factors

The factor in each box converts by multiplication the quantity above it into the one at its left.

	A_{ki}	f_{ik}	S
A_{ki}	1	$\frac{6.670_3 \times 10^{15} g_i}{g_k \lambda^2}$	E1 $\frac{2.026_1 \times 10^{18}}{g_k \lambda^3}$ E2 $\frac{1.679_9 \times 10^{18}}{g_k \lambda^5}$ M1 $\frac{2.697_4 \times 10^{13}}{g_k \lambda^3}$ M2 $\frac{6.626_5 \times 10^{12}}{g_k \lambda^5}$
f_{ik}	$\frac{1.499_2 \times 10^{-16} \lambda^2 g_k}{g_i}$	1	E1 $\frac{303.7_6}{g_i \lambda}$
S	E1 $4.935_5 \times 10^{-19}\, g_k \lambda^3$ E2 $5.952_6 \times 10^{-19}\, g_k \lambda^5$ M1 $3.707_3 \times 10^{-14}\, g_k \lambda^3$ M2 $1.509_1 \times 10^{-13}\, g_k \lambda^5$	E1 $3.292_1 \times 10^{-3}\, g_i \lambda$	1

The line strength (S) is given in atomic units; formulas and values for these quantities in SI units are as follows:

For E1 transitions, $a_0^2 e^2 = 7.188_3 \times 10^{-59}\ \mathrm{m^2\ C^2}$

For E2 transitions, $a_0^4 e^2 = 2.012_9 \times 10^{-79}\ \mathrm{m^4\ C^2}$

For M1 transitions, $\mu_B^2 = (eh/4\pi m_e)^2 = 8.600_7 \times 10^{-47}\ \mathrm{J^2\ T^{-2}}$

For M2 transitions, $\mu_B^2 a_0^2 = 2.408_5 \times 10^{-67}\ \mathrm{J^2\ m^2\ T^{-2}}$.

where a_0, e, m_e, and h are the Bohr radius, electron charge, electron mass, and Planck constant, respectively, and μ_B is the Bohr magneton.

The transition probability (A_{ki}) is in units of s^{-1}, and the f-value is dimensionless. The wavelength (λ) is given in Ångström units, and g_i and g_k are the statistical weights of the lower and upper level, respectively.

[Note: the definition of the line strength for E2 transitions, which is used by some authors, yields an S-value that is 50% higher than that employed here and in earlier NBS transition-probability compilations. Such line strengths have been multiplied by $\frac{2}{3}$ before tabulating them here, and this fact is indicated in the short introductions to the pertinent data tables.]

For the atomic constants entering into the relations given in this table, the recommendations of the CODATA Task Group on Fundamental Constants (E. R. Cohen and B. N. Taylor, Rev. Mod. Phys. 59, 1121 (1987)) have been used. The 1987 values were not available at the time that most of the data was compiled for this publication; however, differences between these and the earlier (CODATA Task Group, 1973) values of the fundamental constants were utilized, which amount to only 0.002% or less for the E1 transitions and 0.05% or less for the M1, E2, and M2 (forbidden) transitions and have therefore not affected the tabulated data.

4. Key to Abbreviations and Symbols Used in the Tables

1. Symbols for indication of accuracy:

A...... uncertainties within 3 percent,
B...... uncertainties within 10 percent,
C...... uncertainties within 25 percent,
D...... uncertainties within 50 percent,
E...... uncertainties greater than 50 percent.

2. Abbreviations appearing in the source column of allowed transitions:

ls = *LS* coupling rules applied
n = normalized to a scale different from that of the author (as explained in the introductory remarks to the pertinent spectrum).
interp. = derived by an interpolation technique, rather than taken directly from the literature.

3. Special symbols used in the wavelength and energy level columns:

The number in parentheses under the multiplet designation refers to the sequence number of Ref. 14 (Revised Multiplet Table). If letters "uv" are added, they refer to the sequence number of Ref. 15 (Ultraviolet Multiplet Table).

Numbers in italics indicate multiplet values, i.e., weighted averages of *line* values.

Numbers in square brackets indicate approximate calculated or extrapolated values.

Useful Relations

(A) Statistical weights:

The statistical weights are related to the inner quantum number J_L (for one-electron spectra: j_l) of a level (i.e., initial or final state of a *line*) by

$$g_L = 2J_L + 1,$$

and to the quantum numbers of a term (initial or final state of a *multiplet*) by

$$g_M = (2L + 1)(2S + 1).$$

(The "multiplet" values g_M may also be obtained by summing over all possible "line" values g_L. S is the resultant spin.)

(B) Relations between the strengths of allowed lines and the total multiplet strength:

1. Line strength S:

$$S(i,k) = \sum_{J_i, J_k} S(J_i, J_k)$$

or

$$S\ (\text{Multiplet}) = \Sigma\, S\ (\text{line})$$

(k denotes the upper and i the lower term).

2. Absorption oscillator strength f_{ik}:

$$f_{ik}^{\text{multiplet}} = \frac{1}{\bar{\lambda}_{ik} \sum_{J_i} (2J+1)} \sum_{J_i, J_k} (2J_i+1) \times \lambda(J_i, J_k) \times f(J_i, J_k).$$

The mean wavelength for the multiplet, $\bar{\lambda}_{ik}$, may be obtained from the *weighted* energy levels. Often the wavelength differences for the lines within a multiplet are small, in which case the wavelength factors may be neglected.

3. Transition probability A_{ki}:

$$A_{ki}^{\text{multiplet}} = \frac{1}{(\bar{\lambda}_{ik})^3 \sum_{J_k} (2J_k+1)} \sum_{J_i, J_k} (2J_k+1) \times \lambda(J_i, J_k)^3 \times A(J_i, J_k).$$

Relative strengths $S(J_i, J_k)$ of the components of a multiplet are listed for the case of LS coupling in C. W. Allen, *Astrophysical Quantities,* 3rd ed. (The Athlone Press, London, 1973); H. E. White and A. Y. Eliason, Phys. Rev. **44**, 753 (1933); B. W. Shore and D. H. Menzel, *Principles of Atomic Structure*, p. 447 (John Wiley & Sons, Inc., New York, 1968); L. Goldberg, Astrophys. J. **82**, 1 (1935) and **84**, 11 (1936).

5. References

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Titanium

Ti I

Ground State: $1s^2 2s^2 2p^6 3s^2 3p^6 3d^2 4s^2\ {}^3F_2$

Ionization Energy: $6.820\ \mathrm{eV} = 55010\ \mathrm{cm}^{-1}$

Allowed Transitions

List of tabulated lines

Wavelength (Å)	No.	Wavelength (Å)	No.	Wavelength (Å)	No.	Wavelength (Å)	No.
2276.75	37	3214.24	24	3956.34	11	4562.64	5
2280.00	37	3341.88	22	3958.21	14	4563.43	122
2299.86	36	3348.54	21	3962.85	9	4617.27	95
2302.75	36	3352.94	21	3964.27	9	4623.10	95
2305.69	36	3354.63	22	3981.76	9	4639.94	95
2384.52	35	3358.27	20	3982.48	8	4640.43	121
2418.37	34	3370.44	20	3989.76	9	4645.19	95
2421.31	34	3371.45	22	3998.64	9	4650.02	95
2424.26	34	3377.58	20	4008.93	9	4656.05	95
2428.24	33	3379.22	22	4009.65	8	4656.47	4
2440.98	33	3385.66	22	4013.24	107	4667.59	4
2519.01	32	3385.94	23	4024.57	9	4675.12	67
2520.54	32	3493.28	19	4055.01	68	4681.91	4
2527.99	32	3506.64	19	4060.26	68	4690.83	66
2529.87	32	3511.63	19	4064.20	68	4693.67	4
2541.92	32	3635.46	18	4065.09	68	4715.30	4
2590.27	31	3637.97	17	4112.71	7	4722.60	65
2593.65	30	3642.68	18	4186.12	92	4742.32	86
2596.60	30	3646.20	17	4266.23	119	4742.79	114
2599.91	30	3653.50	18	4281.37	48	4758.12	114
2605.16	30	3654.59	17	4284.99	97	4758.91	46
2611.29	30	3658.10	18	4287.41	48	4759.27	114
2611.47	30	3660.63	17	4289.07	48	4771.10	46
2619.94	30	3668.97	17	4290.93	48	4778.26	113
2631.55	29	3671.67	18	4295.75	48	4781.72	46
2632.42	29	3687.35	18	4393.93	117	4783.31	46
2641.12	29	3689.92	17	4417.27	104	4789.80	46
2644.28	29	3717.39	16	4441.27	103	4805.42	120
2646.65	29	3722.57	16	4449.14	103	4812.91	46
2657.19	28	3724.57	93	4450.90	103	4820.41	91
2661.97	27	3725.16	69	4453.31	88	4840.87	54
2669.61	27	3729.81	16	4453.71	103	4856.01	112
2679.95	27	3741.06	16	4455.32	88	4885.08	102
2733.27	70	3752.86	16	4457.43	88	4913.62	102
2735.30	70	3753.62	16	4462.10	6	4915.24	102
2912.07	56	3771.65	16	4465.81	96	4926.15	45
2933.53	26	3774.33	15	4481.26	96	4928.34	109
2937.30	26	3786.04	55	4496.15	96	4941.56	109
2942.00	26	3788.80	15	4496.25	6	4964.71	105
2948.26	26	3881.40	13	4512.73	47	4981.73	44
2956.13	26	3889.95	13	4518.02	47	4989.14	105
2956.80	26	3898.49	14	4518.70	87	4991.07	44
2967.22	26	3900.96	13	4522.80	47	4997.10	3
2970.38	25	3914.33	13	4527.31	47	4999.50	44
2981.45	25	3914.75	12	4533.24	47	5000.99	105
2983.31	25	3921.42	12	4534.78	47	5007.21	44
3000.87	25	3924.53	14	4544.69	47	5009.65	3
3186.45	24	3929.88	11	4548.09	124	5014.19	3
3191.99	24	3934.23	13	4548.76	47	5014.28	44
3199.92	24	3947.77	12	4552.45	47	5016.16	44
3203.83	24	3948.67	10	4555.49	47	5020.03	44

List of tabulated lines — Continued

Wavelength (Å)	No.	Wavelength (Å)	No.	Wavelength (Å)	No.	Wavelength (Å)	No.
5022.87	44	5328.72	40	5880.31	60	7084.25	75
5024.84	44	5338.33	39	5899.30	62	7138.91	75
5036.47	85	5340.68	40	5903.32	60	7188.55	74
5038.40	85	5351.07	129	5906.50	80	7209.44	75
5039.96	3	5361.72	39	5918.55	60	7216.20	72
5040.64	44	5366.65	39	5922.11	61	7244.86	74
5043.58	44	5384.63	39	5937.81	62	7251.74	73
5045.40	44	5389.18	39	5941.76	61	7266.29	94
5062.11	108	5401.32	39	5953.16	101	7271.41	71
5064.07	127	5408.94	1	5965.83	101	7299.67	71
5064.65	3	5426.26	1	5978.54	101	7344.72	71
5071.48	85	5436.70	53	6013.42	59	7357.74	71
5087.06	84	5446.59	1	6017.00	59	7364.11	71
5113.45	84	5453.65	83	6064.63	58	7423.17	71
5145.47	84	5460.50	1	6091.18	116	7432.69	71
5147.48	2	5471.20	81	6092.81	100	7440.60	110
5152.19	2	5474.23	83	6098.66	130	7938.53	99
5173.74	2	5490.15	82	6126.22	58	7949.17	89
5192.97	2	5490.84	1	6220.46	126	8024.84	99
5194.04	106	5497.92	52	6258.10	79	8066.05	99
5201.10	106	5503.90	125	6258.71	79	8068.24	99
5210.39	2	5562.74	51	6261.10	79	8100.10	99
5211.22	42	5600.05	51	6303.75	79	8353.15	38
5219.70	2	5648.57	123	6312.24	79	8412.36	38
5222.69	106	5662.15	118	6336.10	78	8426.50	38
5223.62	106	5679.91	123	6358.66	79	8435.68	38
5224.30	106	5689.47	118	6395.47	90	8675.38	57
5247.29	106	5702.67	118	6499.92	90	8682.99	57
5252.11	2	5716.45	118	6554.23	77	8692.34	57
5259.98	128	5720.45	118	6556.07	77	8734.70	57
5266.49	43	5739.46	111	6599.11	50	9832.15	98
5282.38	64	5739.98	111	6650.38	76	9927.35	98
5289.28	43	5774.04	131	6657.03	76	9997.94	98
5295.78	64	5785.98	131	6666.55	76		
5300.01	64	5804.27	131	6743.12	49		
5323.96	41	5866.45	63	6861.47	115		

A number of experiments have recently been performed which feature a variety of techniques and provide reliable oscillator strengths for Ti I. These data sources, utilized for this compilation, include experiments by Smith and Kühne[1] and Bachor and Kock,[14] who employed the anomalous dispersion (hook) method in a furnace; Blackwell *et al.*,[2,3,16,17] who measured very accurate relative oscillator strengths by using the absorption technique; Kühne *et al.*,[4] who used the hook method plus emission measurements with a wall-stabilized arc; Whaling *et al.*,[6] who measured branching ratios in a hollow cathode discharge; Holys and Fuhr,[7] Lotrian *et al.*,[8] and Roberts *et al.*,[9] who measured relative oscillator strengths in emission with stabilized arcs; Kostyk,[18] who derived log *gf*-values from solar spectra; and Bell *et al.*,[10] who determined absolute oscillator strengths by the atomic beam method. We have also included a paper by Cardon *et al.*,[5] who applied the "bowtie" method to interrelate the data of Refs. 1 and 6, in order to generate a set of *f*-values with high internal consistency.

This compilation significantly revises some of our previously published critically evaluated data (tabulated in Ref. 11). These earlier compiled oscillator strengths were based largely on those measured by Klemt,[12] who used a wall-stabilized arc and recorded the intensities photographically. His data apparently suffer from an intensity-dependent systematic error.[1–4,6,7] In particular, comparisons between Klemt and the more recent experiments indicate that Klemt's *f*-values for weak lines are probably too high by factors ranging from two to four. Strong support for this revised compilation is indicated by good agreement—generally within 25 percent—among Refs. 1–7 and 10.

The most reliable source of absolute oscillator strengths for this spectrum is probably the work of Bell *et al.*[10] These authors conducted an advanced absorption experiment in which a diffuse titanium atomic beam emanates from a specially constructed oven, and a number of titanium atoms are measured by weighings and chemical analysis of the titanium deposits. These measurements have yielded especially accurate f-values for the two lines at 3998.64 Å and 3653.50 Å, with claimed uncertainties of ±10 percent. The uncertainties of the remaining f-values measured by Bell *et al.* are estimated to be approximately ±15 percent, primarily since fewer runs were made.

Another reference providing a reliable absolute scale is that of Roberts *et al.*,[13] who measured lifetimes by using the beam-foil technique. These lifetimes are generally accurate to within ±15 percent. The authors of all data sources that we selected for the compilation (excluding Refs. 8 and 18) normalized their own relative oscillator strengths to either Ref. 10 or Ref. 13, or to a combination of the two.

The most reliable sources of relative data for this spectrum are those by Blackwell *et al.*[2,3,16,17] and by Cardon *et al.*[5] The consistency between these two sets of data is quite impressive: on the same absolute scale (which both authors have adopted), the agreement is within ±12 percent for all sixteen overlapping lines (for 12 of 16 lines, the agreement is within ±5 percent). In this compilation, we have averaged the data of Refs. 2, 3, 16, 17, and 5 whenever possible, assigning "B" accuracies to lines having the best agreement (i.e., the twelve lines mentioned above). For lines not tabulated in Refs. 2, 3, 16, 17, and 5, we have chosen the renormalized data of Ref. 1.

In evaluating data for this spectrum, we made numerous graphical comparisons between various data sources. These graphs entailed comparing an individual data source to the accurate log gf-values of Blackwell *et al.*[2,3,16,17] After plotting these graphs, we were able to detect intensity-dependent or energy-level-dependent trends in the references in question. Subsequently, we were able to correct for differences in absolute scale by normalizing (whenever necessary) the data of a particular reference to the data of Blackwell *et al.* These comparisons indicated good agreement (no renormalization required) among Refs. 2–7 and 10. Nevertheless, when compared to Blackwell *et al.*, the data of Refs. 1, 4, 7, and 10 exhibit very similar intensity-dependent trends, indicating weak lines to be too strong. Lacking detailed information, one may only speculate on some of the reasons for this dependency: the f-values for strong lines measured by Bell *et al.* may be more uncertain than claimed, because of corrections for some of these lines which are on the "knee" of the curve of growth.[15] Also, there may be a small amount of self-absorption present in the Holys-Fuhr experiment; and short distances become increasingly difficult to measure in "hook" experiments.

To obtain better agreement with the above-cited reference data, the log gf-values of Ref. 8 were lowered by 0.04 dex and those of Ref. 9 by 0.07 dex. Because of larger scatter in these data, we have lowered the accuracy ratings for the f-values of Ref. 8 and have omitted all lines of Ref. 9 having log gf-values less than -0.5.

The two most comprehensive sources of oscillator strengths are those by Smith and Kühne[1] and by Whaling *et al.*[6] Each of these references contains data for more than one hundred lines, of which there are eighteen lines in common. Whaling *et al.* normalized their branching ratios to the lifetimes of Roberts *et al.*[13] Smith and Kühne, however, normalized their relative scale to that of Bell *et al.*[10] Although Refs. 1 and 6 generally agree within 20 percent, a comparison of these two references indicates a small difference in scale. On the average, the log gf-values of Smith and Kühne are about 0.03 dex smaller than those of Bell *et al.* The reason for this discrepancy is that Smith and Kühne omitted the 3956.34 Å line (the case of largest disagreement between Refs. 1 and 10) in normalizing their data. However, for this same line, the data of Refs. 2, 5, 6, and 10 are in good agreement with each other, but all disagree similarly with the f-value tabulated in Ref. 1. Consequently, we have increased all log gf-values of Smith and Kühne by 0.03 dex.

When comparing some of their data to those of Whaling *et al.*, Kühne *et al.* noticed that for lines originating from the $y\ ^3F^\circ$ level, the log gf-values of Whaling *et al.* are about 0.10 dex lower than their own. There appears to be no obvious reason for this discrepancy; therefore, in these cases we have lowered the accuracies and averaged the two sources whenever the data overlapped.

Another reference providing reliable f-values is the work of Kostyk.[18] His oscillator strengths are derived from solar data of Ti I lines, taken from the Liege solar atlas.[19] The data of Kostyk[18] and Blackwell *et al.*[2,3,16,17] overlap for 70 lines. For these common lines, the f-values for 48 lines agreed within 25 percent. For each spectral line, Kostyk provided two log gf-values, one derived from line depth and the other from equivalent widths of Ti I lines. In this compilation, we have tabulated the *average* of these two values, since we could not establish which method was better.

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Ti I: Allowed transitions

No.	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} (10^8 s^{-1})	f_{ik}	S (at. u.)	log gf	Accuracy	Source
1.	$a\ ^3F - z\ ^5D^\circ$ (3)											
		5460.50	386.9	18695	9	9	3.90(−4)[a]	1.74(−4)	0.0282	−2.804	C+	16
		5426.26	170.1	18594	7	7	3.19(−4)	1.41(−4)	0.0176	−3.006	C+	2
		5490.84	386.9	18594	9	7	1.4(−4)	5.0(−5)	0.0081	−3.35	C	1*n*
		5446.59	170.1	18525	7	5	2.5(−4)	7.9(−5)	0.0099	−3.26	C	1*n*
		5408.94	0.0	18483	5	3	1.11(−4)	2.92(−5)	0.00260	−3.836	C+	2
2.	$a\ ^3F - z\ ^3F^\circ$ (4)	*5195.7*	*222.5*	*19464*	21	21	0.0392	0.0159	5.70	−0.477	C+	2
		5210.39	386.9	19574	9	9	0.0357	0.0145	2.24	−0.884	C+	2
		5192.97	170.1	19422	7	7	0.0349	0.0141	1.69	−1.006	C+	2
		5173.74	0.0	19323	5	5	0.0380	0.0152	1.30	−1.118	C+	2
		5252.11	386.9	19422	9	7	0.00123	3.96(−4)	0.0616	−2.448	C+	2
		5219.70	170.1	19323	7	5	0.00250	7.29(−4)	0.0877	−2.292	C+	2
		5152.19	170.1	19574	7	9	0.00264	0.00135	0.160	−2.024	C+	2
		5147.48	0.0	19422	5	7	0.00350	0.00195	0.165	−2.012	C+	2
3.	$a\ ^3F - z\ ^3D^\circ$ (5)											
		5064.65	386.9	20126	9	7	0.0379	0.0113	1.70	−0.991	C+	2
		5039.96	170.1	20006	7	5	0.0389	0.0106	1.23	−1.130	C+	16
		5014.19	0.0	19938	5	3	0.053	0.012	0.99	−1.22	C	1*n*
		5009.65	170.1	20126	7	7	0.00209	7.87(−4)	0.0908	−2.259	C+	2
		4997.10	0.0	20006	5	5	0.00407	0.00152	0.125	−2.118	C+	2
4.	$a\ ^3F - z\ ^3G^\circ$ (6)											
		4681.91	386.9	21740	9	11	0.0235	0.00944	1.31	−1.071	C+	2
		4667.59	170.1	21588	7	9	0.0218	0.00914	0.983	−1.194	C+	2
		4656.47	0.0	21469	5	7	0.0199	0.00904	0.693	−1.345	C+	2
		4715.30	386.9	21588	9	9	6.9(−4)	2.3(−4)	0.032	−2.68	C	1*n*,4
		4693.67	170.1	21469	7	7	8.5(−4)	2.8(−4)	0.030	−2.71	C	1*n*,4
5.	$a\ ^3F - z\ ^1D^\circ$ (7)											
		4562.64	170.1	22081	7	5	0.00141	3.15(−4)	0.0332	−2.656	C+	2
6.	$a\ ^3F - z\ ^1F^\circ$ (8)											
		4496.25	170.1	22405	7	7	0.0011	3.4(−4)	0.036	−2.62	C	1*n*
		4462.10	0.0	22405	5	7	3.72(−4)	1.55(−4)	0.0114	−3.110	C+	2
7.	$a\ ^3F - z\ ^1G^\circ$ (9)											
		4112.71	386.9	24695	9	9	0.00765	0.00194	0.236	−1.758	C+	2

Ti I: Allowed transitions — Continued

No.	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} (10^8 s^{-1})	f_{ik}	S (at. u.)	log gf	Accuracy	Source
8.	$a\,^3F - z\,^5S^\circ$ (11)											
		4009.65	170.1	25103	7	5	0.0121	0.00208	0.192	−1.837	C+	2
		3982.48	0.0	25103	5	5	0.045	0.011	0.70	−1.27	C	1*n*
9.	$a\,^3F - y\,^3F^\circ$ (12)	*3991.8*	*222.5*	*25267*	21	21	0.455	0.109	30.0	0.358	B	2,5
		3998.64	386.9	25388	9	9	0.408	0.0977	11.6	−0.056	B	2,5
		3989.76	170.1	25227	7	7	0.379	0.0905	8.32	−0.198	B	2,5
		3981.76	0.0	25107	5	5	0.376	0.0893	5.85	−0.350	B	2,5
		4024.57	386.9	25227	9	7	0.0614	0.0116	1.38	−0.981	B	2,5
		4008.93	170.1	25107	7	5	0.0703	0.0121	1.12	−1.072	B	2,5
		3964.27	170.1	25388	7	9	0.0309	0.00935	0.854	−1.184	B	2,5
		3962.85	0.0	25227	5	7	0.0413	0.0136	0.887	−1.167	B	2,5
10.	$a\,^3F - y\,^3D^\circ$ (13)											
		3948.67	0.0	25318	5	3	0.485	0.0681	4.43	−0.468	C+	2
11.	$a\,^3F - (\ ^\circ)^b$											
		3956.34	170.1	25439	7	5	0.300	0.0503	4.59	−0.453	B	2,5
		3929.88	0.0	25439	5	5	0.0752	0.0174	1.13	−1.060	B	2,5
12.	$a\,^3F - z\,^3P^\circ$ (14)											
		3947.77	170.1	25494	7	5	0.096	0.016	1.5	−0.95	C	1*n*,4
		3914.75	0.0	25537	5	3	0.0083	0.0012	0.074	−2.24	C	1*n*
		3921.42	0.0	25494	5	5	0.0215	0.00497	0.321	−1.605	C+	2
13.	$a\,^3F - y\,^5D^\circ$ (15)											
		3914.33	386.9	25927	9	9	0.023	0.0052	0.60	−1.33	C	1*n*
		3900.96	170.1	25798	7	7	0.0128	0.00291	0.262	−1.691	C+	2
		3889.95	0.0	25700	5	5	0.0051	0.0012	0.074	−2.24	C	1*n*
		3934.23	386.9	25798	9	7	0.0045	8.0(−4)	0.094	−2.14	C	1*n*
		3881.40	170.1	25927	7	9	0.0030	8.6(−4)	0.077	−2.22	C	1*n*
14.	$a\,^3F - (\ ^\circ)^b$											
		3958.21	386.9	25644	9	7	0.405	0.0739	8.67	−0.177	C+	2,5
		3924.53	170.1	25644	7	7	0.0715	0.0165	1.49	−0.937	B	2,5
		3898.49	0.0	25644	5	7	0.00348	0.00111	0.0712	−2.256	C+	2,5
15.	$a\,^3F - y\,^5G^\circ$ (16)											
		3788.80	386.9	26773	9	11	2.7(−4)	7.2(−5)	0.0081	−3.19	C	6
		3774.33	170.1	26657	7	9	3.22(−4)	8.85(−5)	0.00770	−3.208	C+	2

Ti I: Allowed transitions — Continued

No.	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} (10^8 s^{-1})	f_{ik}	S (at. u.)	log gf	Accuracy	Source
16.	$a\ ^3F - x\ ^3F°$ (17)	*3743.3*	*222.5*	*26929*	21	21	0.526	0.111	28.6	0.366	C+	1*n*,2
		3752.86	386.9	27026	9	9	0.504	0.106	11.8	−0.019	C+	2
		3741.06	170.1	26893	7	7	0.417	0.0875	7.54	−0.213	C+	2
		3729.81	0.0	26803	5	5	0.427	0.0891	5.47	−0.351	C+	2
		3771.65	386.9	26893	9	7	0.0603	0.00999	1.12	−1.046	C+	2
		3753.62	170.1	26803	7	5	0.082	0.012	1.1	−1.06	C	1*n*
		3722.57	170.1	27026	7	9	0.034	0.0090	0.77	−1.20	C	1*n*
		3717.39	0.0	26893	5	7	0.043	0.012	0.75	−1.21	C	1*n*
17.	$a\ ^3F - x\ ^3D°$ (18)	*3673.9*	*222.5*	*27434*	21	15	0.078	0.0113	2.88	−0.62	C	1*n*,2
		3689.92	386.9	27480	9	7	0.0353	0.00561	0.613	−1.297	C+	2
		3668.97	170.1	27418	7	5	0.054	0.0079	0.66	−1.26	C	1*n*
		3654.59	0.0	27355	5	3	0.087	0.010	0.63	−1.28	C	1*n*
		3660.63	170.1	27480	7	7	0.030	0.0061	0.51	−1.37	C	1*n*
		3646.20	0.0	27418	5	5	0.026	0.0053	0.32	−1.58	C	1*n*
		3637.97	0.0	27480	5	7	0.0093	0.0026	0.15	−1.89	C	1*n*
18.	$a\ ^3F - y\ ^3G°$ (19)	*3646.3*	*222.5*	*27640*	21	27	0.805	0.206	52.0	0.637	C+	2,5,6
		3653.50	386.9	27750	9	11	0.754	0.184	20.0	0.220	C+	2
		3642.68	170.1	27615	7	9	0.774	0.198	16.6	0.142	B	2,5
		3635.46	0.0	27499	5	7	0.804	0.223	13.3	0.047	B	2,5
		3671.67	386.9	27615	9	9	0.0459	0.00928	1.01	−1.078	C+	2,5
		3658.10	170.1	27499	7	7	0.0583	0.0117	0.986	−1.087	C+	2,5
		3687.35	386.9	27499	9	7	0.0035	5.6(−4)	0.061	−2.30	C	6
19.	$a\ ^3F - y\ ^5F°$ (22)											
		3506.64	386.9	28896	9	11	0.0068	0.0015	0.16	−1.86	C	1*n*
		3493.28	170.1	28788	7	9	0.0036	8.4(−4)	0.068	−2.23	C	1*n*
		3511.63	170.1	28639	7	5	0.0042	5.6(−4)	0.045	−2.41	C	1*n*
20.	$a\ ^3F - w\ ^3D°$ (23)											
		3377.58	170.1	29769	7	5	0.69	0.084	6.5	−0.23	C	1*n*
		3370.44	0.0	29661	5	3	0.76	0.078	4.3	−0.41	C	1*n*
		3358.27	0.0	29769	5	5	0.076	0.013	0.71	−1.19	C	1*n*
21.	$a\ ^3F - x\ ^5D°$ (25)											
		3352.94	170.1	29986	7	7	0.0097	0.0016	0.13	−1.94	C	1*n*
		3348.54	0.0	29855	5	3	0.0091	9.1(−4)	0.050	−2.34	C	1*n*
22.	$a\ ^3F - x\ ^3G°$ (24)											
		3371.45	386.9	30039	9	11	0.72	0.15	15	0.13	C	1*n*,10
		3354.63	170.1	29971	7	9	0.69	0.15	12	0.02	C	1*n*,10
		3341.88	0.0	29915	5	7	0.65	0.15	8.3	−0.12	C	1*n*
		3379.22	386.9	29971	9	9	0.062	0.011	1.1	−1.02	C	1*n*
		3385.66	386.9	29915	9	7	0.052	0.0070	0.70	−1.20	C	1*n*

Ti I: Allowed transitions — Continued

No.	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} ($10^8\ s^{-1}$)	f_{ik}	S (at. u.)	log gf	Accuracy	Source
23.	$a\ ^3F - (\ ^\circ)^b$											
		3385.94	386.9	29912	9	7	0.50	0.067	6.7	−0.22	C	1*n*
24.	$a\ ^3F - w\ ^3G^\circ$ (27)											
		3199.92	386.9	31629	9	11	0.94	0.18	17	0.20	C	1*n*
		3191.99	170.1	31489	7	9	0.85	0.17	12	0.07	C	1*n*
		3186.45	0.0	31374	5	7	0.80	0.17	8.9	−0.07	C	1*n*
		3214.24	386.9	31489	9	9	0.065	0.010	0.97	−1.04	C	1*n*
		3203.83	170.1	31374	7	7	0.072	0.011	0.82	−1.11	C	1*n*
25.	$a\ ^3F - w\ ^3F^\circ$ (29)											
		3000.87	386.9	33701	9	9	0.12	0.016	1.5	−0.83	C	1*n*
		2983.31	170.1	33680	7	7	0.11	0.014	0.98	−1.00	C	1*n*
		2970.38	0.0	33656	5	5	0.074	0.0098	0.48	−1.31	C	1*n*
		2981.45	170.1	33701	7	9	0.0073	0.0012	0.085	−2.06	C	1*n*
26.	$a\ ^3F - v\ ^3F^\circ$ (uv 1)	*2950.1*	*222.5*	*34110*	21	21	1.1	0.15	30	0.49	C	1*n*
		2956.13	386.9	34205	9	9	0.97	0.13	11	0.06	C	1*n*
		2948.26	170.1	34079	7	7	0.93	0.12	8.3	−0.07	C	1*n*
		2942.00	0.0	33981	5	5	1.0	0.14	6.5	−0.17	C	1*n*
		2967.22	386.9	34079	9	7	0.11	0.011	0.95	−1.01	C	1*n*
		2956.80	170.1	33981	7	5	0.18	0.017	1.1	−0.93	C	1*n*
		2937.30	170.1	34205	7	9	0.077	0.013	0.86	−1.05	C	1*n*
		2933.53	0.0	34079	5	7	0.096	0.017	0.84	−1.06	C	1*n*
27.	$a\ ^3F - v\ ^3G^\circ$ (uv 2)											
		2679.95	386.9	37690	9	11	0.13	0.017	1.3	−0.82	C	1*n*
		2669.61	170.1	37618	7	9	0.10	0.014	0.86	−1.01	C	1*n*
		2661.97	0.0	37555	5	7	0.089	0.013	0.58	−1.18	C	1*n*
28.	$a\ ^3F - x\ ^1F^\circ$ (uv 3)											
		2657.19	0.0	37623	5	7	0.032	0.0048	0.21	−1.62	C	1*n*
29.	$a\ ^3F - u\ ^3D^\circ$ (uv 5)											
		2646.65	386.9	38160	9	7	1.5	0.12	9.6	0.04	C	1*n*
		2644.28	170.1	37977	7	5	1.4	0.11	6.5	−0.13	C	1*n*
		2641.12	0.0	37852	5	3	1.8	0.11	4.9	−0.25	C	1*n*
		2631.55	170.1	38160	7	7	0.17	0.018	1.1	−0.90	C	1*n*
		2632.42	0.0	37977	5	5	0.27	0.028	1.2	−0.86	C	1*n*

Ti I: Allowed transitions — Continued

No.	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} (10^8 s^{-1})	f_{ik}	S (at. u.)	log gf	Accuracy	Source
30.	$a\ ^3F - t\ ^3F^\circ$ (uv 6)	*2606.5*	*222.5*	*38576*	21	21	0.87	0.089	16	0.27	C	1*n*
		2611.29	386.9	38671	9	9	0.64	0.065	5.1	−0.23	C	1*n*
		2605.16	170.1	38544	7	7	0.64	0.065	3.9	−0.34	C	1*n*
		2599.91	0.0	38451	5	5	0.67	0.068	2.9	−0.47	C	1*n*
		2619.94	386.9	38544	9	7	0.21	0.016	1.3	−0.83	C	1*n*
		2611.47	170.1	38451	7	5	0.33	0.024	1.5	−0.77	C	1*n*
		2596.60	170.1	38671	7	9	0.069	0.0090	0.54	−1.20	C	1*n*
		2593.65	0.0	38544	5	7	0.069	0.0098	0.42	−1.31	C	1*n*
31.	$a\ ^3F - t\ ^3D^\circ$ (uv 7)											
		2590.27	170.1	38765	7	7	0.047	0.0047	0.28	−1.48	C	1*n*
32.	$a\ ^3F - s\ ^3D^\circ$ (uv 8)											
		2541.92	386.9	39715	9	7	0.43	0.032	2.4	−0.54	C	1*n*
		2529.87	170.1	39686	7	5	0.38	0.026	1.5	−0.74	C	1*n*
		2520.54	0.0	39662	5	3	0.38	0.022	0.91	−0.96	C	1*n*
		2527.99	170.1	39715	7	7	0.068	0.0065	0.38	−1.34	C	1*n*
		2519.01	0.0	39686	5	5	0.059	0.0056	0.23	−1.55	C	1*n*
33.	$a\ ^3F - u\ ^3G^\circ$ (uv 10)											
		2440.98	386.9	41342	9	11	0.072	0.0079	0.57	−1.15	C	1*n*
		2428.24	0.0	41170	5	7	0.077	0.0096	0.38	−1.32	C	1*n*
34.	$a\ ^3F - s\ ^3F^\circ$ (uv 11)											
		2424.26	386.9	41624	9	9	0.17	0.015	1.1	−0.88	C	1*n*
		2421.31	170.1	41458	7	7	0.13	0.011	0.63	−1.10	C	1*n*
		2418.37	0.0	41337	5	5	0.12	0.010	0.41	−1.29	C	1*n*
35.	$a\ ^3F - q\ ^3D^\circ$ (uv 12)											
		2384.52	386.9	42311	9	7	0.090	0.0060	0.42	−1.27	C	1*n*
36.	$a\ ^3F - r\ ^3F^\circ$ (uv 14)											
		2305.69	386.9	43745	9	9	0.52	0.041	2.8	−0.43	C	1*n*
		2302.75	170.1	43583	7	7	0.57	0.045	2.4	−0.50	C	1*n*
		2299.86	0.0	43468	5	5	0.69	0.055	2.1	−0.56	C	1*n*
37.	$a\ ^3F - o\ ^3D^\circ$ (uv 15)											
		2280.00	386.9	44234	9	7	0.94	0.057	3.8	−0.29	C	1*n*
		2276.75	170.1	44080	7	5	1.3	0.070	3.7	−0.31	C	1*n*

Ti I: Allowed transitions — Continued

No.	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} ($10^8\ s^{-1}$)	f_{ik}	S (at. u.)	log gf	Accuracy	Source
38.	$a\ ^5F - z\ ^3D^\circ$ (33)											
		8435.68	6743	18594	9	7	0.0127	0.0105	2.63	−1.023	C+	3
		8426.50	6661	18525	7	5	0.0105	0.00798	1.55	−1.253	C+	3
		8412.36	6599	18483	5	3	0.0103	0.00658	0.911	−1.483	C+	16
		8353.15	6557	18525	3	5	4.02(−4)	7.01(−4)	0.0579	−2.677	C+	16
39.	$a\ ^5F - y\ ^3F^\circ$ (35)											
		5361.72	6743	25388	9	9	2.3(−4)	1.0(−4)	0.016	−3.05	D	4,6
		5384.63	6661	25227	7	7	4.0(−4)	1.8(−4)	0.022	−2.91	D	6
		5401.32	6599	25107	5	5	5.9(−4)	2.6(−4)	0.023	−2.89	D	4,6
		5338.33	6661	25388	7	9	0.0035	0.0019	0.24	−1.87	D	6
		5366.65	6599	25227	5	7	8.64(−4)	5.22(−4)	0.0462	−2.583	C+	16
		5389.18	6557	25107	3	5	0.0033	0.0024	0.13	−2.14	D	4,6
40.	$a\ ^5F - y\ ^3D^\circ$ (36)											
		5340.68	6599	25318	5	3	5.2(−4)	1.3(−4)	0.012	−3.18	C	6
		5328.72	6557	25318	3	3	0.0078	0.0033	0.18	−2.00	C	6
41.	$a\ ^5F - (\ ^\circ)^b$											
		5323.96	6661	25439	7	5	3.5(−4)	1.1(−4)	0.013	−3.13	C	6
42.	$a\ ^5F - y\ ^5D^\circ$ (37)											
		5211.22	6743	25927	9	9	0.0031	0.0012	0.19	−1.95	D	18*n*
43.	$a\ ^5F - (\ ^\circ)^b$											
		5289.28	6743	25644	9	7	4.8(−4)	1.6(−4)	0.025	−2.85	C	6
		5266.49	6661	25644	7	7	2.8(−5)	1.2(−5)	0.0014	−4.09	D	6
44.	$a\ ^5F - y\ ^5G^\circ$ (38)	*4997.6*	*6722*	*26726*	35	45	0.667	0.321	185	1.051	C+	3,6,16
		4981.73	6843	26911	11	13	0.660	0.290	52.3	0.504	C+	3
		4991.07	6743	26773	9	11	0.584	0.267	39.4	0.380	C+	3
		4999.50	6661	26657	7	9	0.527	0.254	29.3	0.250	C+	3
		5007.21	6599	26564	5	7	0.492	0.259	21.3	0.112	C+	3
		5014.28	6557	26494	3	5	0.68	0.43	21	0.11	C	6
		5016.16	6843	26773	11	11	0.0643	0.0242	4.40	−0.574	C+	3
		5020.03	6743	26657	9	9	0.113	0.0428	6.37	−0.414	C+	3
		5022.87	6661	26564	7	7	0.139	0.0526	6.09	−0.434	C+	3
		5024.84	6599	26494	5	5	0.132	0.0500	4.14	−0.602	C+	3
		5045.40	6843	26657	11	9	0.00292	9.13(−4)	0.167	−1.998	C+	16
		5043.58	6743	26564	9	7	0.00693	0.00205	0.307	−1.733	C+	16
		5040.64	6661	26494	7	5	0.00857	0.00233	0.271	−1.787	C+	16
45.	$a\ ^5F - x\ ^3F^\circ$ (39)											
		4926.15	6599	26893	5	7	0.00265	0.00135	0.110	−2.170	C+	16

Ti I: Allowed transitions — Continued

No.	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} (10^8 s^{-1})	f_{ik}	S (at. u.)	log gf	Accuracy	Source
46.	$a\ ^5F - y\ ^3G^\circ$ (41)											
		4781.72	6843	27750	11	11	0.0029	0.0010	0.17	−1.96	C	6,7
		4789.80	6743	27615	9	9	4.5(−4)	1.5(−4)	0.022	−2.86	C	6
		4812.91	6843	27615	11	9	1.1(−4)	3.2(−5)	0.0056	−3.45	D	6
		4758.91	6743	27750	9	11	0.0018	7.5(−4)	0.11	−2.17	C	6
		4771.10	6661	27615	7	9	0.0014	6.0(−4)	0.066	−2.38	C	6,7
		4783.31	6599	27499	5	7	6.2(−4)	3.0(−4)	0.024	−2.82	C	6,7
47.	$a\ ^5F - y\ ^5F^\circ$ (42)											
		4533.24	6843	28896	11	11	0.883	0.272	44.7	0.476	C+	3
		4534.78	6743	28788	9	9	0.687	0.212	28.4	0.280	C+	3
		4555.49	6843	28788	11	9	0.116	0.0296	4.88	−0.488	C+	3
		4552.45	6743	28703	9	7	0.21	0.051	6.9	−0.34	D−	8n
		4548.76	6661	28639	7	5	0.285	0.0632	6.63	−0.354	C+	3
		4544.69	6599	28596	5	3	0.33	0.060	4.5	−0.52	D−	8n
		4512.73	6743	28896	9	11	0.0986	0.0368	4.92	−0.480	C+	3
		4518.02	6661	28788	7	9	0.172	0.0676	7.04	−0.325	C+	3
		4522.80	6599	28703	5	7	0.19	0.081	6.1	−0.39	D−	8n
		4527.31	6557	28639	3	5	0.22	0.11	5.1	−0.47	D−	8n
48.	$a\ ^5F - x\ ^5D^\circ$ (44)											
		4295.75	6557	29829	3	1	1.3	0.12	5.0	−0.45	D−	8n
		4287.41	6743	30060	9	9	0.146	0.0402	5.10	−0.442	C+	3
		4289.07	6599	29907	5	5	0.30	0.083	5.9	−0.38	D−	8n
		4290.93	6557	29855	3	3	0.45	0.12	5.2	−0.43	D−	8n
		4281.37	6557	29907	3	5	0.0318	0.0146	0.617	−1.359	C+	3
49.	$a\ ^1D - z\ ^1D^\circ$ (48)	6743.12	7255	22081	5	5	0.0069	0.0047	0.52	−1.63	D	18n
50.	$a\ ^1D - z\ ^1F^\circ$ (49)	6599.11	7255	22405	5	7	0.00180	0.00164	0.179	−2.085	C+	16
51.	$a\ ^1D - y\ ^3F^\circ$											
		5562.74	7255	25227	5	7	4.2(−4)	2.7(−4)	0.025	−2.87	D	6
		5600.05	7255	25107	5	5	1.9(−4)	8.9(−5)	0.0082	−3.35	D	6
52.	$a\ ^1D - (\ ^\circ)^b$	5497.92	7255	25439	5	5	6.2(−4)	2.8(−4)	0.026	−2.85	C	6
53.	$a\ ^1D - (\ ^\circ)^b$	5436.70	7255	25644	5	7	0.0010	6.3(−4)	0.056	−2.50	C	4,6
54.	$a\ ^1D - y\ ^1D^\circ$ (53)	4840.87	7255	27907	5	5	0.176	0.0619	4.94	−0.509	C+	3
55.	$a\ ^1D - z\ ^1P^\circ$ (57)	3786.04	7255	33661	5	3	1.4	0.18	11	−0.05	D−	8n
56.	$a\ ^1D - v\ ^1F^\circ$ (uv 23)	2912.07	7255	41585	5	7	1.3	0.23	11	0.06	D	9n

Ti I: Allowed transitions — Continued

No.	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} ($10^8 s^{-1}$)	f_{ik}	S (at. u.)	log gf	Accuracy	Source
57.	$a\ ^3P - z\ ^3D^\circ$ (68)											
		8675.38	8602	20126	5	7	0.00271	0.00429	0.612	−1.669	C+	16
		8682.99	8492	20006	3	5	0.00203	0.00382	0.327	−1.941	C+	16
		8692.34	8437	19938	1	3	0.00149	0.00507	0.145	−2.295	C+	16
		8734.70	8492	19938	3	3	0.00120	0.00138	0.119	−2.384	C+	16
58.	$a\ ^3P - z\ ^3S^\circ$ (69)											
		6126.22	8602	24921	5	3	0.0223	0.00752	0.758	−1.425	C+	16
		6064.63	8437	24921	1	3	0.00688	0.0114	0.227	−1.944	C+	16
59.	$a\ ^3P - y\ ^3F^\circ$											
		6013.42	8602	25227	5	7	2.1(−4)	1.6(−4)	0.016	−3.10	D	6
		6017.00	8492	25107	3	5	8.6(−5)	7.8(−5)	0.0046	−3.63	D	6
60.	$a\ ^3P - z\ ^3P^\circ$ (71)											
		5918.55	8602	25494	5	5	0.013	0.0069	0.68	−1.46	C	4
		5903.32	8602	25537	5	3	0.00457	0.00143	0.139	−2.145	C+	16
		5880.31	8492	25494	3	5	0.00348	0.00301	0.175	−2.045	C+	16
61.	$a\ ^3P - y\ ^3D^\circ$ (72)											
		5922.11	8437	25318	1	3	0.0217	0.0342	0.667	−1.466	C+	3,16
		5941.76	8492	25318	3	3	0.019	0.010	0.60	−1.51	C	6
62.	$a\ ^3P - (\ ^\circ)^b$											
		5899.30	8492	25439	3	5	0.0269	0.0234	1.36	−1.154	C+	3
		5937.81	8602	25439	5	5	0.0049	0.0026	0.25	−1.89	C	4,6
63.	$a\ ^3P - (\ ^\circ)^b$											
		5866.45	8602	25644	5	7	0.0400	0.0289	2.79	−0.840	C+	3
64.	$a\ ^3P - x\ ^3D^\circ$ (74)											
		5295.78	8602	27480	5	7	0.00791	0.00466	0.406	−1.633	C+	16
		5282.38	8492	27418	3	5	0.024	0.017	0.87	−1.30	D	18*n*
		5300.01	8492	27355	3	3	0.027	0.011	0.59	−1.47	D	18*n*
65.	$a\ ^3P - w\ ^3D^\circ$ (75)											
		4722.60	8492	29661	3	3	0.047	0.016	0.73	−1.33	D	18*n*
66.	$a\ ^3P - x\ ^3G^\circ$ (76)											
		4690.83	8602	29915	5	7	0.0044	0.0020	0.16	−1.99	D	18*n*
67.	$a\ ^3P - x\ ^5D^\circ$ (77)											
		4675.12	8602	29986	5	7	0.0185	0.00847	0.652	−1.373	C+	3

Ti I: Allowed transitions — Continued

No.	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} ($10^8 s^{-1}$)	f_{ik}	S (at. u.)	log gf	Accuracy	Source
68.	$a\,^3P - x\,^3P°$ (80)											
		4064.20	8492	33090	3	3	0.24	0.061	2.4	−0.74	D−	8*n*
		4065.09	8492	33085	3	1	0.70	0.058	2.3	−0.76	D−	8*n*
		4060.26	8492	33114	3	5	0.24	0.10	4.0	−0.52	D−	8*n*
		4055.01	8437	33090	1	3	0.28	0.21	2.8	−0.68	D−	8*n*
69.	$a\,^3P - y\,^3S°$ (83)											
		3725.16	8602	35439	5	3	0.73	0.091	5.6	−0.34	D−	8*n*
70.	$a\,^3P - t\,^3P°$ (uv 32)											
		2733.27	8602	45178	5	5	1.9	0.21	9.4	0.02	D	9*n*
		2735.30	8492	45041	3	1	4.1	0.15	4.1	−0.34	D	9*n*
71.	$b\,^3F - y\,^3F°$ (97)	*7354.2*	*11673*	*25267*	21	21	0.015	0.012	6.3	−0.58	D	4,6,17
		7344.72	11777	25388	9	9	0.014	0.011	2.4	−1.00	D	4,6
		7357.74	11640	25227	7	7	0.0133	0.0108	1.83	−1.122	C+	17
		7364.11	11532	25107	5	5	0.016	0.013	1.6	−1.19	D	4,6
		7432.69	11777	25227	9	7	6.9(−5)	4.4(−5)	0.0097	−3.40	D	6
		7423.17	11640	25107	7	5	5.5(−4)	3.3(−4)	0.056	−2.64	D	4
		7271.41	11640	25388	7	9	7.8(−4)	7.9(−4)	0.13	−2.26	D	4,6
		7299.67	11532	25227	5	7	0.0021	0.0023	0.28	−1.94	D	4,6
72.	$b\,^3F - z\,^3P°$ (98)											
		7216.20	11640	25494	7	5	0.018	0.010	1.7	−1.15	D	18*n*
73.	$b\,^3F - y\,^3D°$ (99)											
		7251.74	11532	25318	5	3	0.072	0.034	4.1	−0.77	C	6
74.	$b\,^3F - (\ °)^b$											
		7244.86	11640	25439	7	5	0.039	0.022	3.7	−0.81	C	4,6
		7188.55	11532	25439	5	5	0.0045	0.0035	0.41	−1.76	C	4,6
75.	$b\,^3F - (\ °)^b$											
		7209.44	11777	25644	9	7	0.058	0.035	7.5	−0.50	C	4.6
		7138.91	11640	25644	7	7	0.0048	0.0037	0.61	−1.59	C	4,6
		7084.25	11532	25644	5	7	1.3(−4)	1.4(−4)	0.016	−3.15	D	4,6
76.	$b\,^3F - y\,^5G°$ (101)											
		6666.55	11777	26773	9	11	0.0033	0.0027	0.54	−1.61	C	6
		6657.03	11640	26657	7	9	5.1(−4)	4.3(−4)	0.066	−2.52	C	6
		6650.38	11532	26564	5	7	3.3(−4)	3.0(−4)	0.033	−2.82	C	6

Ti I: Allowed transitions — Continued

No.	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} (10^8 s^{-1})	f_{ik}	S (at. u.)	log gf	Accuracy	Source
77.	$b\,^3$F – $x\,^3$F° (102)											
		6556.07	11777	27026	9	9	0.0145	0.00937	1.82	−1.074	C+	17
		6554.23	11640	26893	7	7	0.0134	0.00865	1.31	−1.218	C+	17
78.	$b\,^3$F – $x\,^3$D° (103)											
		6336.10	11640	27418	7	5	0.00601	0.00258	0.377	−1.743	C+	17
79.	$b\,^3$F – $y\,^3$G° (104)	*6261.2*	*11673*	*27640*	21	27	0.089	0.067	29	0.15	C+	6, 7, 17
		6258.71	11777	27750	9	11	0.089	0.064	12	−0.24	C	6,7
		6258.10	11640	27615	7	9	0.0836	0.0631	9.10	−0.355	C+	17
		6261.10	11532	27499	5	7	0.0807	0.0664	6.84	−0.479	C+	17
		6312.24	11777	27615	9	9	0.00522	0.00312	0.583	−1.552	C+	17
		6303.75	11640	27499	7	7	0.00651	0.00388	0.564	−1.566	C+	17
		6358.66	11777	27499	9	7	6.8(−4)	3.2(−4)	0.060	−2.54	C	6
80.	$b\,^3$F – $y\,^5$F° (105)											
		5906.50	11777	28703	9	7	0.0067	0.0027	0.48	−1.61	D	18*n*
81.	$b\,^3$F – (°)^b											
		5471.20	11640	29912	7	7	0.013	0.0057	0.72	−1.40	D	18*n*
82.	$b\,^3$F – $x\,^5$D° (107)											
		5490.15	11777	29986	9	7	0.0369	0.0130	2.11	−0.933	C+	17
83.	$b\,^3$F – $x\,^3$G° (108)											
		5474.23	11777	30039	9	11	0.012	0.0065	1.1	−1.23	D	18*n*
		5453.65	11640	29971	7	9	0.0061	0.0035	0.44	−1.61	D	18*n*
84.	$b\,^3$F – $v\,^3$D° (109)											
		5145.47	11777	31206	9	7	0.0960	0.0296	4.52	−0.574	C+	17
		5113.45	11640	31191	7	5	0.0841	0.0235	2.77	−0.783	C+	17
		5087.06	11532	31184	5	3	0.14	0.033	2.8	−0.78	D	18*n*
85.	$b\,^3$F – $w\,^3$G° (110)											
		5036.47	11640	31489	7	9	0.394	0.193	22.4	0.130	C+	17
		5038.40	11532	31374	5	7	0.387	0.206	17.1	0.013	C+	17
		5071.48	11777	31489	9	9	0.0249	0.00961	1.44	−1.063	C+	17
86.	$b\,^3$F – $y\,^1$F° (111)											
		4742.32	11777	32858	9	7	0.032	0.0084	1.2	−1.12	D	18*n*

Ti I: Allowed transitions — Continued

No.	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} (10^8 s^{-1})	f_{ik}	S (at. u.)	log gf	Accu-racy	Source
87.	$b\,^3F - w\,^3F°$ (112)											
		4518.70	11532	33656	5	5	0.065	0.020	1.5	−1.00	D	18*n*
88.	$b\,^3F - v\,^3F°$ (113)											
		4457.43	11777	34205	9	9	0.56	0.17	22	0.18	D−	8*n*
		4455.32	11640	34079	7	7	0.48	0.14	15	0.00	D−	8*n*
		4453.31	11532	33981	5	5	0.598	0.178	13.0	−0.051	C+	17
89.	$a\,^1G - z\,^1G°$ (125)	7949.17	12118	24695	9	9	0.0041	0.0039	0.91	−1.46	C	14
90.	$a\,^1G - y\,^3G°$											
		6395.47	12118	27750	9	11	3.3(−4)	2.5(−4)	0.047	−2.65	C	6
		6499.92	12118	27499	9	7	1.9(−5)	9.2(−6)	0.0018	−4.08	D	6
91.	$a\,^1G - y\,^1F°$ (126)	4820.41	12118	32858	9	7	0.149	0.0402	5.75	−0.441	C+	17
92.	$a\,^1G - y\,^1G°$ (129)	4186.12	12118	36000	9	9	0.210	0.0551	6.83	−0.305	C+	17
93.	$a\,^1G - x\,^1G°$ (131)	3724.57	12118	38959	9	9	0.91	0.19	21	0.23	D−	8*n*
94.	$a\,^5P - z\,^5P°$ (143)											
		7266.29	13982	27740	3	5	0.017	0.022	1.6	−1.18	D	18*n*
95.	$a\,^5P - w\,^5D°$ (145)											
		4617.27	14106	35758	7	9	0.851	0.350	37.2	0.389	C+	17
		4623.10	14028	35653	5	7	0.574	0.258	19.6	0.110	C+	17
		4639.94	13982	35528	3	3	0.664	0.214	9.82	−0.192	C+	17
		4656.05	14106	35577	7	5	0.093	0.022	2.3	−0.82	D	18*n*
		4650.02	14028	35528	5	3	0.26	0.051	3.9	−0.59	D	18*n*
		4645.19	13982	35503	3	1	0.857	0.0924	4.24	−0.557	C+	17
96.	$a\,^5P - y\,^5P°$ (146)											
		4481.26	14106	36415	7	7	0.57	0.17	18	0.08	D−	8*n*
		4496.15	14106	36341	7	5	0.44	0.094	9.8	−0.18	D−	8*n*
		4465.81	14028	36415	5	7	0.328	0.137	10.1	−0.163	C+	17
97.	$a\,^5P - y\,^5S°$ (148)											
		4284.99	14028	37359	5	5	0.32	0.089	6.3	−0.35	D−	8*n*
98.	$a\,^3G - y\,^3F°$ (149)											
		9832.15	15220	25388	11	9	0.0049	0.0059	2.1	−1.19	D	6
		9927.35	15157	25227	9	7	0.0025	0.0029	0.86	−1.58	D	6
		9997.94	15108	25107	7	5	0.0019	0.0021	0.48	−1.84	D	6

Ti I: Allowed transitions — Continued

No.	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} (10^8 s^{-1})	f_{ik}	S (at. u.)	log gf	Accuracy	Source
99.	$a\ ^3G - y\ ^3G°$ (151)											
		8024.84	15157	27615	9	9	0.0083	0.0080	1.9	−1.14	C	6
		8068.24	15108	27499	7	7	0.0077	0.0075	1.4	−1.28	C	6
		8066.05	15220	27615	11	9	3.4(−4)	2.7(−4)	0.080	−2.52	C	6
		8100.10	15157	27499	9	7	4.5(−4)	3.4(−4)	0.082	−2.51	C	6
		7938.53	15157	27750	9	11	3.8(−4)	4.4(−4)	0.10	−2.40	C	6
100.	$a\ ^3G - w\ ^3G°$ (153)											
		6092.81	15220	31629	11	11	0.00683	0.00380	0.838	−1.379	C+	17
101.	$a\ ^3G - z\ ^3H°$ (154)											
		5953.16	15220	32014	11	13	0.0679	0.0426	9.19	−0.329	C+	17
		5965.83	15157	31914	9	11	0.0664	0.0433	7.66	−0.409	C+	17
		5978.54	15108	31830	7	9	0.0662	0.0456	6.28	−0.496	C+	17
102.	$a\ ^3G - y\ ^3H°$ (157)											
		4885.08	15220	35685	11	13	0.490	0.207	36.7	0.358	C+	17
		4913.62	15108	35454	7	9	0.444	0.206	23.4	0.160	C+	17
		4915.24	15220	35560	11	11	0.0240	0.00870	1.55	−1.019	C+	17
103.	$a\ ^3G - v\ ^3G°$ (160)											
		4449.14	15220	37690	11	11	0.97	0.29	46	0.50	D−	8*n*
		4450.90	15157	37618	9	9	0.96	0.29	38	0.41	D−	8*n*
		4453.71	15108	37555	7	7	0.47	0.14	14	−0.01	D−	8*n*
		4441.27	15108	37618	7	9	0.061	0.023	2.4	−0.79	D	18*n*
104.	$a\ ^3G - u\ ^3F°$ (161)											
		4417.27	15220	37852	11	9	0.36	0.087	14	−0.02	D−	8*n*
105.	$z\ ^5G° - e\ ^5F$ (173)											
		5000.99	16106	36096	9	7	0.352	0.103	15.2	−0.034	C+	17
		4989.14	15976	36014	7	5	0.325	0.0867	9.97	−0.217	C+	17
		4964.71	15877	36014	5	5	0.0722	0.0267	2.18	−0.875	C+	17
106.	$z\ ^5F° - e\ ^5F$ (183)											
		5224.30	17215	36351	11	11	0.36	0.15	28	0.21	D	18*n*
		5223.62	16875	36014	5	5	0.135	0.0553	4.76	−0.558	C+	17
		5222.69	16817	35959	3	3	0.195	0.0798	4.11	−0.621	C+	17
		5247.29	16961	36014	7	5	0.0908	0.0268	3.24	−0.727	C+	17
		5194.04	16961	36209	7	9	0.076	0.039	4.7	−0.56	D	18*n*
		5201.10	16875	36096	5	7	0.0628	0.0356	3.05	−0.749	C+	17
107.	$z\ ^5F° - g\ ^3F$ (186)											
		4013.24	16961	41872	7	5	0.20	0.034	3.2	−0.62	D	18*n*

Ti I: Allowed transitions — Continued

No.	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} (10^8 s^{-1})	f_{ik}	S (at. u.)	log gf	Accuracy	Source
108.	$a\ ^3D - w\ ^3P°$ (199)											
		5062.11	17424	37173	5	3	0.298	0.0687	5.73	−0.464	C+	17
109.	$a\ ^3D - u\ ^3F°$ (200)											
		4928.34	17370	37655	3	5	0.62	0.37	18	0.05	D	18*n*
		4941.56	17424	37655	5	5	0.053	0.020	1.6	−1.01	D	18*n*
110.	$a\ ^3H - w\ ^3G°$ (225)											
		7440.60	18193	31629	13	11	0.022	0.015	4.9	−0.70	D	18*n*
111.	$a\ ^3H - y\ ^3H°$ (228)											
		5739.46	18141	35560	11	11	0.046	0.023	4.7	−0.60	D	18*n*
		5739.98	18037	35454	9	9	0.048	0.024	4.0	−0.67	D	18*n*
112.	$a\ ^3H - z\ ^3I°$ (231)											
		4856.01	18193	38780	13	15	0.52	0.21	44	0.44	D	18*n*
113.	$a\ ^3H - x\ ^1G°$ (232)											
		4778.26	18037	38959	9	9	0.20	0.067	9.5	−0.22	D	18*n*
114.	$a\ ^3H - x\ ^3H°$ (233)											
		4759.27	18193	39198	13	13	0.740	0.251	51.2	0.514	C+	17
		4758.12	18141	39152	11	11	0.713	0.242	41.7	0.425	C+	17
		4742.79	18037	39116	9	9	0.53	0.18	25	0.21	D	18*n*
115.	$b\ ^1G - y\ ^1F°$ (237)	6861.47	18288	32858	9	7	0.037	0.020	4.1	−0.74	D	18*n*
116.	$b\ ^1G - z\ ^1H°$ (238)	6091.18	18288	34700	9	11	0.0617	0.0420	7.57	−0.423	C+	17
117.	$b\ ^1G - y\ ^1H°$ (244)	4393.93	18288	41040	9	11	0.33	0.12	15	0.02	D−	8*n*
118.	$z\ ^5D° - e\ ^5F$ (249)											
		5662.15	18695	36351	9	11	0.147	0.0864	14.5	−0.109	C+	17
		5689.47	18525	36096	5	7	0.100	0.0679	6.36	−0.469	C+	17
		5702.67	18483	36104	3	5	0.11	0.088	4.9	−0.58	D	18*n*
		5716.45	18525	36014	5	5	0.081	0.040	3.8	−0.70	D	18*n*
		5720.45	18483	35959	3	3	0.086	0.042	2.4	−0.90	D	18*n*
119.	$z\ ^5D° - e\ ^5D$ (252)											
		4266.23	18525	41959	5	5	0.31	0.083	5.9	−0.38	D	18*n*

Ti I: Allowed transitions — Continued

No.	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} (10^8 s^{-1})	f_{ik}	S (at. u.)	log gf	Accuracy	Source
120.	$c\ ^3P - s\ ^3D^\circ$ (260)											
		4805.42	18911	39715	5	7	0.58	0.28	22	0.15	D	18*n*
121.	$c\ ^3P - v\ ^3P^\circ$ (261)											
		4640.43	18826	40370	3	1	0.50	0.054	2.5	−0.79	D	18*n*
122.	$z\ ^3F^\circ - e\ ^3G$ (266)											
		4563.43	19574	41481	9	11	0.21	0.080	11	−0.14	D	18*n*
123.	$z\ ^3D^\circ - e\ ^3F$ (269)											
		5648.57	20126	37825	7	9	0.13	0.079	10	−0.26	D	18*n*
		5679.91	19938	37539	3	5	0.11	0.090	5.0	−0.57	D	18*n*
124.	$z\ ^3D^\circ - g\ ^3F$ (270)											
		4548.09	20126	42107	7	9	0.084	0.033	3.5	−0.63	D	18*n*
125.	$a\ ^1H - x\ ^1G^\circ$ (287)	5503.90	20796	38959	11	9	0.26	0.095	19	0.02	D	18*n*
126.	$z\ ^3G^\circ - e\ ^3F$ (293)											
		6220.46	21588	37660	9	7	0.18	0.080	15	−0.14	D	18*n*
127.	$z\ ^3G^\circ - e\ ^3G$ (294)											
		5064.07	21740	41481	11	11	0.13	0.049	9.0	−0.27	D	18*n*
128.	$z\ ^1D^\circ - e\ ^1F$ (298)	5259.98	22081	41087	5	7	0.23	0.13	11	−0.18	D	18*n*
129.	$z\ ^1F^\circ - e\ ^1F$ (300)	5351.07	22405	41087	7	7	0.34	0.15	18	0.01	D	18*n*
130.	$z\ ^1G^\circ - e\ ^1F$ (304)	6098.66	24695	41087	9	7	0.25	0.11	20	−0.01	D	18*n*
131.	$y\ ^5G^\circ - f\ ^5H$ (309)											
		5804.27	26911	44135	13	15	0.68	0.39	98	0.71	D	18*n*
		5785.98	26773	44051	11	13	0.61	0.36	76	0.60	D	18*n*
		5774.04	26657	43972	9	11	0.55	0.34	57	0.48	D	18*n*

[a]The number in parentheses following the tabulated value indicates the power of ten by which this value has to be multiplied.
[b]The *LS*-coupling designation of the upper term of this multiplet was not provided in the NBS energy-level compilation (J. Sugar and C. Corliss, J. Phys. Chem. Ref. Data 14, Suppl. 2 (1985)), so we have accordingly omitted it from this work.

Ti II

Sc Isoelectronic Sequence

Ground State: $1s^2 2s^2 2p^6 3s^2 3p^6 3d^2 4s\ {}^4F_{3/2}$

Ionization Energy: $13.58\ \mathrm{eV} = 109500\ \mathrm{cm}^{-1}$

Allowed Transitions

List of tabulated lines

Wavelength (Å)	No.	Wavelength (Å)	No.	Wavelength (Å)	No.	Wavelength (Å)	No.
2440.91	80	2827.12	104	3057.40	5	3202.56	30
2443.43	80	2828.06	105	3058.08	51	3203.43	3
2448.64	80	2828.64	104	3066.23	5	3206.01	30
2451.18	80	2828.83	105	3066.34	5	3213.15	3
2474.22	7	2832.19	19	3071.25	51	3214.12	82
2477.21	7	2834.02	104	3072.12	5	3214.78	3
2478.64	7	2836.47	104	3072.99	5	3217.07	2
2482.24	22	2839.64	105	3075.23	5	3222.84	2
2499.71	22	2841.94	19	3078.65	5	3224.25	82
2510.87	12	2843.94	104	3081.52	103	3226.77	3
2517.42	12	2845.93	104	3088.04	5	3228.62	29
2519.82	12	2851.11	61	3089.44	88	3231.31	10
2524.66	12	2853.93	19	3096.42	77	3232.29	41
2525.59	12	2855.40	104	3097.20	69	3234.51	2
2529.79	12	2856.10	104	3101.54	60	3236.13	28
2531.28	12	2858.41	18	3102.98	60	3236.58	2
2534.63	12	2861.30	61	3103.81	88	3239.04	2
2535.89	12	2862.33	61	3104.60	88	3239.66	28
2555.99	21	2868.75	18	3105.10	69	3241.99	2
2571.08	21	2874.11	42	3106.26	69	3249.37	28
2573.67	21	2877.47	42	3110.10	77	3251.91	2
2635.44	109	2880.30	79	3110.69	69	3252.92	2
2638.56	109	2884.13	42	3112.07	69	3254.25	2
2642.02	109	2887.44	42	3117.67	69	3260.25	50
2645.86	109	2891.08	18	3118.83	32	3263.69	50
2713.74	34	2909.96	6	3119.83	69	3271.64	68
2716.25	34	2910.65	108	3121.62	4	3272.07	68
2717.30	43	2918.63	111	3122.07	60	3275.28	29
2719.41	34	2926.64	108	3127.86	110	3276.77	50
2725.78	43	2931.10	111	3128.50	110	3278.28	68
2746.54	112	2936.02	107	3130.82	4	3278.91	29
2751.59	112	2938.57	107	3143.77	4	3280.00	40
2752.68	115	2941.90	107	3144.74	11	3282.32	68
2757.62	115	2942.97	111	3145.42	11	3286.77	87
2758.35	115	2945.30	107	3148.06	4	3287.66	87
2758.79	115	2952.00	107	3152.27	11	3301.66	49
2761.30	33	2954.59	118	3154.22	11	3308.80	9
2762.23	33	2958.17	107	3155.68	11	3312.92	59
2762.92	115	2958.80	118	3157.40	4	3315.32	67
2763.90	20	2979.06	114	3161.23	11	3318.02	9
2764.28	115	2990.06	114	3161.80	11	3321.70	67
2764.82	33	3008.31	83	3162.59	11	3322.94	9
2780.55	20	3017.17	83	3168.55	11	3326.77	9
2784.63	20	3022.64	117	3181.73	113	3329.46	9
2804.82	105	3023.67	117	3182.54	113	3332.11	67
2806.46	62	3029.76	83	3184.12	3	3335.18	9
2810.30	105	3038.73	83	3189.49	106	3337.85	58
2817.83	105	3043.86	78	3190.91	30	3340.34	9
2819.87	105	3046.69	51	3192.26	31	3343.77	9
2820.36	19	3048.77	78	3195.71	31	3346.75	9
2821.26	104	3056.75	51	3197.53	3	3352.07	57

List of tabulated lines — Continued

Wavelength (Å)	No.	Wavelength (Å)	No.	Wavelength (Å)	No.	Wavelength (Å)	No.
3361.23	1	3593.08	76	4300.06	47	4529.48	81
3366.19	57	3596.04	16	4301.92	47	4533.97	53
3369.19	66	3624.82	55	4307.87	47	4544.02	64
3372.22	17	3641.33	55	4312.87	47	4549.61	81
3372.80	1	3659.75	75	4314.97	47	4563.77	53
3374.36	56	3662.24	75	4316.80	92	4568.31	64
3380.28	1	3679.68	75	4320.96	47	4571.96	81
3383.77	1	3706.23	73	4330.24	92	4580.45	64
3387.84	1	3721.64	15	4330.72	47	4583.41	45
3388.77	56	3741.64	73	4337.88	26	4589.92	53
3394.58	1	3748.03	99	4341.37	38	4609.26	45
3402.44	57	3757.70	74	4344.30	26	4629.29	44
3407.22	1	3759.30	15	4350.85	91	4657.20	63
3409.82	1	3761.33	15	4367.65	97	4708.65	52
3416.95	57	3761.88	99	4374.84	91	4762.78	23
3443.39	94	3770.40	99	4386.85	97	4779.98	90
3444.32	8	3774.65	14	4391.04	65	4794.83	35
3452.49	94	3776.06	74	4394.02	54	4798.53	23
3456.40	94	3786.33	14	4395.00	25	4805.09	90
3461.51	8	3796.90	14	4395.83	65	4865.62	35
3465.56	94	3799.79	15	4399.79	54	4874.01	101
3477.19	8	3813.39	14	4407.68	54	4911.18	101
3483.63	116	3814.58	14	4411.10	102	4981.35	72
3489.75	8	3882.28	39	4417.72	46	5005.17	72
3492.37	116	3900.56	39	4418.31	54	5069.08	100
3500.34	8	3913.48	39	4421.95	92	5072.27	100
3504.90	86	3932.02	39	4427.91	65	5129.16	84
3505.91	86	3987.61	13	4432.09	54	5154.06	71
3509.81	86	4012.40	13	4441.73	46	5185.90	84
3510.86	86	4025.12	13	4443.78	25	5188.69	71
3520.27	93	4028.36	85	4444.54	37	5226.53	71
3533.85	93	4053.83	85	4450.50	25	5268.61	96
3535.41	93	4161.53	27	4464.46	46	5336.78	70
3561.57	16	4163.63	98	4468.52	37	5381.01	70
3561.90	48	4171.92	98	4470.84	46	6606.97	89
3565.30	76	4174.05	98	4488.34	102	7214.74	95
3565.96	48	4287.88	26	4493.53	24		
3573.72	16	4290.22	47	4501.27	37		
3587.13	16	4294.09	26	4506.74	36		

The compiled data for this spectrum are based mainly on the experiments of Roberts, Andersen, and Sorensen[1] (RAS); Roberts, Voigt, and Czernichowski[3] (RVC); and Danzmann and Kock.[4] The data of RAS were obtained by a comprehensive experimental approach in which an emission method using a gas-flow stabilized arc for the measurement of relative oscillator strengths was combined with a lifetime experiment using the beam-foil technique to obtain an absolute scale. In the later work of RVC, emission measurements were made with a wall-stabilized arc. With this more advanced arc source, the temperature of the plasma was determined spectroscopically, and a uniform scale for all relative f-values was established. By remeasuring selected lines, the authors of Ref. 3 were able to place the log gf-values of RAS on a more reliable relative scale.

The data of Danzmann and Kock were obtained by a combination of anomalous dispersion (hook) and emission measurements. Wall-stabilized arcs and hollow-cathode discharges served as plasma light sources for these measurements. This method has proved to be quite reliable in the case of Ti I (see Ref. 5), and here too the data should generally be accurate to within ±25 percent.

The most reliable data for this spectrum are those of Blackwell *et al.*,[8] who determined oscillator strengths for eighteen lines by an advanced absorption technique. On a *relative* scale, these data are of outstanding accuracy, i.e., with uncertainties within 0.5 percent. However, because of the much larger uncertainty in the *absolute* scale obtained by utilizing the lifetime data of Ref. 1, we estimate the overall accuracy to be in the "C+" range.

Another data source which we utilized in this compilation is the work of Kostyk and Orlova.[9] These authors derived log gf-values from solar spectra, i.e., they used equivalent widths taken from the Liege solar atlas.[10] We estimate these oscillator strengths to be accurate within 50 percent. The results of shock-tube emission measurements by Wolnik and Berthel[2] were used for three lines not treated in Refs. 1, 3, 4, 8, and 9. For another eighteen lines, the data of Wolnik and Berthel overlap with those of RAS. Here, the agreement is generally within 50 percent, except for a few of the weaker lines.

In this compilation, we have given first priority to the data of Blackwell *et al.*, followed by Kostyk and Orlova, then Danzmann and Kock and/or RVC. Since RVC present a detailed error budget, which includes uncertainty estimates for the temperature and lifetime determinations, line intensity calibrations, the (partial) thermodynamic equilibrium assumption, and general statistical measurement errors, we follow their error estimates closely. For all lines originating from the highest energy levels, i.e., for states approximately 8 eV above the ground state, the uncertainties become rather large, since these lines are quite sensitive to temperature errors.

It should be noted that the normalized log *gf*-values taken from RAS and tabulated here differ slightly from those in our earlier compilation.[6] The reason for this change is that some of the data of RAS were found to contain typographical or arithmetical errors,[7] leading to inconsistencies between their relative scale and that of RVC, and the correction factors to log *gf* (RAS) had to be changed accordingly. The maximum change to the original correction factors is 0.03 in the logarithm, but most changes are smaller. For lines arising from highly excited levels, i.e., those for which $E_k > 46000\ \mathrm{cm}^{-1}$, we have tabulated additional lines from RAS. In these cases, the relative scales of RAS and RVC were generally found to agree, and the RAS data were then normalized accordingly.

Some of the normalized data of RAS disagree appreciably with those of Danzmann and Kock. For wavelengths longer than 4300 Å (or for lower energy levels $E_i > 8500\ \mathrm{cm}^{-1}$) the *f*-values of RAS are, on the average, about 36 percent lower than those of Ref. 4. Danzmann and Kock recognized this discrepancy and rechecked their measurements, obtaining the same results as before. Nevertheless, no obvious problems seem to exist with the RAS experiment. In fact, the wavelength-dependent deviations can also be considered lower-energy-level-dependent deviations, indicating possible problems with the hook measurements of Ref. 4. Because we could not determine a definite source of error in either Ref. 1 or Ref. 4, we have assigned lower accuracies ("D−") to lines above 4300 Å.

References

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Ti II: Allowed transitions

No.	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} ($10^8\ \mathrm{s}^{-1}$)	f_{ik}	S (at. u.)	log gf	Accuracy	Source
1.	$a\ ^4F - z\ ^4G^\circ$ (1)											
		3361.23	225.7	29968	8	10	1.1	0.24	21	0.28	C	4
		3372.80	94.1	29735	6	8	1.11	0.252	16.8	0.180	C+	8
		3383.77	0.0	29544	4	6	1.09	0.282	12.6	0.052	C+	8
		3380.28	393.4	29968	10	10	0.16	0.027	3.0	−0.57	C	3,4
		3387.84	225.7	29735	8	8	0.218	0.0376	3.35	−0.522	C+	8
		3394.58	94.1	29544	6	6	0.25	0.043	2.9	−0.59	C	3,4
		3407.22	393.4	29735	10	8	0.0072	0.0010	0.11	−2.00	C	3,4
		3409.82	225.7	29544	8	6	0.012	0.0016	0.14	−1.89	C	3,4

Ti II: Allowed transitions — Continued

No.	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} ($10^8 s^{-1}$)	f_{ik}	S (at. u.)	log gf	Accuracy	Source
2.	$a\,^4F - z\,^4F^{\circ}$ (2)											
		3234.51	393.4	31301	10	10	1.38	0.217	23.1	0.336	C+	8
		3236.58	225.7	31114	8	8	1.11	0.174	14.8	0.144	C+	8
		3239.04	94.1	30959	6	6	0.987	0.155	9.93	−0.031	C+	8
		3241.99	0.0	30836	4	4	1.16	0.183	7.82	−0.135	C+	8
		3254.25	393.4	31114	10	8	0.20	0.026	2.8	−0.59	C	3,4
		3252.92	225.7	30959	8	6	0.39	0.046	3.9	−0.43	C	3,4
		3251.91	94.1	30836	6	4	0.338	0.0357	2.29	−0.669	C+	8
		3217.07	225.7	31301	8	10	0.169	0.0327	2.77	−0.582	C+	8
		3222.84	94.1	31114	6	8	0.26	0.055	3.5	−0.48	C	3,4
3.	$a\,^4F - z\,^2F^{\circ}$ (3)											
		3214.78	393.4	31491	10	8	0.033	0.0041	0.43	−1.39	C	3,4
		3226.77	225.7	31207	8	6	0.016	0.0019	0.16	−1.82	C	3,4
		3197.53	225.7	31491	8	8	0.011	0.0016	0.14	−1.88	D	3
		3213.15	94.1	31207	6	6	0.0061	9.4(−4)[a]	0.059	−2.25	D−	1*n*
		3184.12	94.1	31491	6	8	0.0046	9.4(−4)	0.059	−2.25	D−	1*n*
		3203.43	0.0	31207	4	6	0.021	0.0048	0.20	−1.72	D−	1*n*
4.	$a\,^4F - z\,^2D^{\circ}$ (4)											
		3143.77	225.7	32025	8	6	0.062	0.0069	0.57	−1.26	D	1*n*
		3157.40	94.1	31757	6	4	0.012	0.0012	0.077	−2.13	D	3
		3130.82	94.1	32025	6	6	0.082	0.012	0.75	−1.14	D	1*n*
		3148.06	0.0	31757	4	4	0.11	0.016	0.65	−1.20	C	3
		3121.62	0.0	32025	4	6	0.0059	0.0013	0.053	−2.29	D−	1*n*
5.	$a\,^4F - z\,^4D^{\circ}$ (5)											
		3088.04	393.4	32767	10	8	1.25	0.143	14.6	0.156	C+	8
		3078.65	225.7	32698	8	6	1.09	0.116	9.39	−0.033	C+	8
		3075.23	94.1	32603	6	4	1.13	0.106	6.46	−0.195	C+	8
		3072.99	0.0	32532	4	2	1.6	0.11	4.5	−0.36	C	3,4
		3072.12	225.7	32767	8	8	0.20	0.028	2.3	−0.65	C	3,4
		3066.23	94.1	32698	6	6	0.253	0.0357	2.16	−0.669	C+	8
		3066.34	0.0	32603	4	4	0.33	0.047	1.9	−0.73	C	4
		3057.40	0.0	32698	4	6	0.022	0.0047	0.19	−1.73	D−	1*n*
6.	$a\,^4F - z\,^2G^{\circ}$ (uv 1)											
		2909.96	393.4	34748	10	10	0.0079	0.0010	0.096	−2.00	D	3
7.	$a\,^4F - y\,^4D^{\circ}$ (uv 2)											
		2474.22	393.4	40798	10	8	0.0057	4.2(−4)	0.034	−2.38	D−	1*n*
		2477.21	225.7	40581	8	6	0.0079	5.5(−4)	0.036	−2.36	D−	1*n*
		2478.64	94.1	40426	6	4	0.016	0.0010	0.049	−2.22	D−	1*n*

Ti II: Allowed transitions — Continued

No.	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} ($10^8 s^{-1}$)	f_{ik}	S (at. u.)	log gf	Accuracy	Source
8.	$b\,^4F - z\,^4G°$ (6)											
		3444.32	1216	30241	10	12	0.073	0.015	1.8	−0.81	D	1*n*
		3461.51	1087	29968	8	10	0.0627	0.0141	1.28	−0.948	C+	8
		3477.19	983.9	29735	6	8	0.0605	0.0146	1.00	−1.057	C+	8
		3489.75	1087	29735	8	8	0.0082	0.0015	0.14	−1.92	D	3
		3500.34	983.9	29544	6	6	0.0079	0.0015	0.10	−2.06	D	3
9.	$b\,^4F - z\,^4F°$ (7)											
		3322.94	1216	31301	10	10	0.396	0.0656	7.18	−0.183	C+	8
		3329.46	1087	31114	8	8	0.325	0.0541	4.74	−0.364	C+	8
		3335.18	983.9	30959	6	6	0.293	0.0488	3.22	−0.533	C+	8
		3340.34	908.0	30836	4	4	0.36	0.061	2.7	−0.61	C	3,4
		3343.77	1216	31114	10	8	0.040	0.0054	0.59	−1.27	C	4
		3346.75	1087	30959	8	6	0.079	0.010	0.88	−1.10	C	3,4
		3308.80	1087	31301	8	10	0.045	0.0093	0.81	−1.13	C	4
		3318.02	983.9	31114	6	8	0.060	0.013	0.87	−1.10	C	4
		3326.77	908.0	30959	4	6	0.084	0.021	0.92	−1.08	C	3,4
10.	$b\,^4F - z\,^2D°$ (9)											
		3231.31	1087	32025	8	6	0.034	0.0040	0.34	−1.50	C	3
11.	$b\,^4F - z\,^4D°$ (10)	*3163.1*	*1085*	*32690*	28	20	0.51	0.055	16	0.19	C	1*n*,3,4
		3168.55	1216	32767	10	8	0.41	0.049	5.1	−0.31	C	3
		3162.59	1087	32698	8	6	0.39	0.044	3.7	−0.45	C	3,4
		3161.80	983.9	32603	6	4	0.46	0.046	2.9	−0.56	C	3,4
		3161.23	908.0	32532	4	2	0.59	0.044	1.8	−0.75	C	3,4
		3155.68	1087	32767	8	8	0.074	0.011	0.91	−1.06	C	3,4
		3152.27	983.9	32698	6	6	0.094	0.014	0.87	−1.08	C	3,4
		3154.22	908.0	32603	4	4	0.11	0.017	0.71	−1.17	C	3,4
		3145.42	983.9	32767	6	8	0.0017	3.4(−4)	0.021	−2.69	D−	1*n*
		3144.74	908.0	32698	4	6	0.0042	9.3(−4)	0.038	−2.43	D−	1*n*
12.	$b\,^4F - y\,^4D°$ (uv 4)	2529.2	*1085*	*40612*	28	20	0.64	0.044	10	0.09	D	1*n*,3
		2525.59	1216	40798	10	8	0.56	0.043	3.5	−0.37	D	1*n*
		2531.28	1087	40581	8	6	0.49	0.035	2.3	−0.55	D	1*n*
		2534.63	983.9	40426	6	4	0.54	0.035	1.7	−0.68	D	1*n*
		2535.89	908.0	40330	4	2	0.68	0.033	1.1	−0.88	D	1*n*
		2517.42	1087	40798	8	8	0.060	0.0057	0.38	−1.34	D	3
		2524.66	983.9	40581	6	6	0.12	0.012	0.59	−1.15	D	3
		2529.79	908.0	40426	4	4	0.17	0.017	0.55	−1.18	D	3
		2510.87	983.9	40798	6	8	0.0028	3.6(−4)	0.018	−2.67	D−	1*n*
		2519.82	908.0	40581	4	6	0.0049	7.0(−4)	0.023	−2.55	D−	1*n*
13.	$a\,^2F - z\,^4G°$ (11)											
		3987.61	4898	29968	8	10	7.8(−4)	2.3(−4)	0.024	−2.73	D	4
		4025.12	4898	29735	8	8	0.0054	0.0013	0.14	−1.98	D−	1*n*
		4012.40	4629	29544	6	6	0.017	0.0041	0.32	−1.61	C	4

Ti II: Allowed transitions — Continued

No.	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} (10^8 s^{-1})	f_{ik}	S (at. u.)	log gf	Accuracy	Source
14.	$a\ ^2F - z\ ^4F^\circ$ (12)											
		3786.33	4898	31301	8	10	0.0043	0.0012	0.12	−2.03	D−	1*n*
		3774.65	4629	31114	6	8	0.0011	3.1(−4)	0.023	−2.73	D−	1*n*
		3813.39	4898	31114	8	8	0.0055	0.0012	0.12	−2.02	D−	1*n*
		3796.90	4629	30959	6	6	0.0019	4.2(−4)	0.031	−2.60	D−	1*n*
		3814.58	4629	30836	6	4	0.022	0.0032	0.24	−1.72	D−	1*n*
15.	$a\ ^2F - z\ ^2F^\circ$ (13)	*3760.3*	*4783*	*31369*	14	14	1.0	0.21	37	0.48	C	1*n*,4
		3759.30	4898	31491	8	8	0.94	0.20	20	0.20	C	4
		3761.33	4629	31207	6	6	0.99	0.21	16	0.10	C	4
		3799.79	4898	31207	8	6	9.3(−4)	1.5(−4)	0.015	−2.92	D−	1*n*
		3721.64	4629	31491	6	8	0.039	0.011	0.79	−1.19	C	4
16.	$a\ ^2F - z\ ^4D^\circ$ (15)											
		3587.13	4898	32767	8	8	0.011	0.0021	0.20	−1.77	D	1*n*
		3561.57	4629	32698	6	6	0.0044	8.4(−4)	0.059	−2.30	D	1*n*
		3596.04	4898	32698	8	6	0.052	0.0075	0.71	−1.22	C	4
		3573.72	4629	32603	6	4	0.028	0.0036	0.25	−1.67	D	1*n*
17.	$a\ ^2F - z\ ^2G^\circ$ (16)											
		3372.22	4898	34543	8	8	0.073	0.013	1.1	−1.00	D−	1*n*
18.	$a\ ^2F - y\ ^2D^\circ$ (uv 5)	*2877.4*	*4783*	*39527*	14	10	0.18	0.016	2.1	−0.65	C−	1*n*,3
		2891.08	4898	39477	8	6	0.15	0.014	1.1	−0.94	D	1*n*
		2858.41	4629	39603	6	4	0.047	0.0038	0.22	−1.64	D	3
		2868.75	4629	39477	6	6	0.11	0.014	0.79	−1.08	C	3
19.	$a\ ^2F - y\ ^2F^\circ$ (uv 7)	*2837.7*	*4783*	*40012*	14	14	0.31	0.037	4.8	−0.29	C	1*n*,3
		2841.94	4898	40075	8	8	0.29	0.035	2.6	−0.55	C	3
		2832.19	4629	39927	6	6	0.25	0.030	1.7	−0.75	C	3
		2853.93	4898	39927	8	6	0.052	0.0048	0.36	−1.42	D	3
		2820.36	4629	40075	6	8	0.019	0.0030	0.17	−1.75	D−	1*n*
20.	$a\ ^2F - y\ ^4D^\circ$ (uv 8)											
		2784.63	4898	40798	8	8	0.016	0.0019	0.14	−1.82	D	3
		2780.55	4629	40581	6	6	0.025	0.0029	0.16	−1.76	D	3
		2763.90	4629	40798	6	8	0.0017	2.6(−4)	0.014	−2.80	D−	1*n*
21.	$a\ ^2F - y\ ^2G^\circ$ (uv 9)	*2564.7*	*4783*	*43763*	14	18	0.30	0.038	4.5	−0.27	D	1*n*,3
		2571.08	4898	43781	8	10	0.27	0.033	2.2	−0.58	D	1*n*
		2555.99	4629	43741	6	8	0.32	0.042	2.1	−0.60	D	1*n*
		2573.67	4898	43741	8	8	0.027	0.0027	0.18	−1.67	C	3

Ti II: Allowed transitions — Continued

No.	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} (10^8 s^{-1})	f_{ik}	S (at. u.)	log gf	Accuracy	Source
22.	$a\ ^2F - x\ ^2D^\circ$ (uv 10)											
		2499.71	4898	44902	8	6	0.029	0.0020	0.13	−1.79	D	1*n*
		2482.24	4629	44915	6	4	0.020	0.0012	0.061	−2.13	D−	1*n*
23.	$a\ ^2D - z\ ^4G^\circ$ (17)											
		4762.78	8744	29735	6	8	7.2(−4)	3.2(−4)	0.031	−2.71	D	9
		4798.53	8710	29544	4	6	0.0018	9.3(−4)	0.059	−2.43	D	9
24.	$a\ ^2D - z\ ^4F^\circ$ (18)											
		4493.53	8710	30959	4	6	0.0010	4.7(−4)	0.028	−2.73	D	9
25.	$a\ ^2D - z\ ^2F^\circ$ (19)	*4415.9*	*8730*	*31369*	10	14	0.11	0.045	6.6	−0.34	D−	1*n*,4
		4395.00	8744	31491	6	8	0.094	0.036	3.2	−0.66	D−	1*n*
		4443.78	8710	31207	4	6	0.11	0.050	2.9	−0.70	D−	4
		4450.50	8744	31207	6	6	0.020	0.0059	0.52	−1.45	D−	4
26.	$a\ ^2D - z\ ^2D^\circ$ (20)	*4311.4*	*8730*	*31918*	10	10	0.063	0.018	2.5	−0.75	D−	1*n*
		4294.09	8744	32025	6	6	0.047	0.013	1.1	−1.11	D−	1*n*
		4337.88	8710	31757	4	4	0.066	0.019	1.1	−1.13	D−	1*n*
		4344.30	8744	31757	6	4	0.0072	0.0014	0.12	−2.09	D−	1*n*
		4287.88	8710	32026	4	6	0.0058	0.0024	0.13	−2.02	D−	1*n*
27.	$a\ ^2D - z\ ^4D^\circ$ (21)											
		4161.53	8744	32767	6	8	0.0021	7.3(−4)	0.060	−2.36	D	1*n*
28.	$a\ ^2D - y\ ^2D^\circ$ (23)											
		3236.13	8710	39603	4	4	0.70	0.11	4.7	−0.36	D	1*n*
		3239.66	8744	39603	6	4	0.94	0.098	6.3	−0.23	D	1*n*
		3249.37	8710	39477	4	6	0.045	0.011	0.46	−1.37	D	1*n*
29.	$a\ ^2D - z\ ^2P^\circ$ (24)	*3261.7*	*8730*	*39380*	10	6	1.4	0.13	14	0.12	D	1*n*,3
		3278.91	8744	39233	6	4	1.0	0.11	7.3	−0.17	D	1*n*
		3228.62	8710	39675	4	2	2.0	0.16	6.7	−0.20	C	3
		3275.28	8710	39233	4	4	0.055	0.0089	0.38	−1.45	D	3
30.	$a\ ^2D - y\ ^2F^\circ$ (26)	*3195.8*	*8730*	*40012*	10	14	1.2	0.26	27	0.41	C	1*n*,3
		3190.91	8744	40075	6	8	1.3	0.26	16	0.19	C	3
		3202.56	8710	39927	4	6	1.1	0.26	11	0.02	C	3
		3206.01	8744	39927	6	6	0.0067	0.0010	0.065	−2.21	D−	1*n*

Ti II: Allowed transitions — Continued

No.	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} (10^8 s^{-1})	f_{ik}	S (at. u.)	log gf	Accuracy	Source
31.	$a\,^2$D – $z\,^4$S° (25)											
		3195.71	8744	40027	6	4	0.080	0.0082	0.52	−1.31	C	3
		3192.26	8710	40027	4	4	0.033	0.0050	0.21	−1.70	D	1*n*
32.	$a\,^2$D – $y\,^4$D° (27)											
		3118.83	8744	40798	6	8	0.018	0.0034	0.21	−1.69	D	1*n*
33.	$a\,^2$D – $x\,^2$D° (uv 12)											
		2764.82	8744	44902	6	6	0.16	0.018	1.0	−0.96	C	3
		2761.30	8710	44915	4	4	0.13	0.015	0.54	−1.23	D	3
		2762.23	8710	44902	4	6	0.047	0.0081	0.29	−1.49	D	3
34.	$a\,^2$D – $y\,^2$P° (uv 13)	*2717.1*	*8730*	*45523*	10	6	0.11	0.0075	0.67	−1.13	D	1*n*,3
		2716.25	8744	45549	6	4	0.096	0.0071	0.38	−1.37	D	3
		2719.41	8710	45472	4	2	0.12	0.0064	0.23	−1.59	D	1*n*
		2713.74	8710	45549	4	4	0.015	0.0017	0.059	−2.18	D	1*n*
35.	$a\,^2$G – $z\,^4$G° (29)											
		4794.83	9118	29968	10	10	2.6(−5)	9.1(−6)	0.0014	−4.04	D	9
		4865.62	8998	29544	8	6	0.0012	3.1(−4)	0.039	−2.61	D	9
36.	$a\,^2$G – $z\,^4$F° (30)											
		4506.74	9118	31301	10	10	1.6(−4)	4.8(−5)	0.0071	−3.32	D	9
37.	$a\,^2$G – $z\,^2$F° (31)	*4482.2*	*9065*	*31369*	18	14	0.10	0.024	6.4	−0.36	D−	4,9
		4468.52	9118	31491	10	8	0.10	0.025	3.7	−0.60	D−	4
		4501.27	8998	31207	8	6	0.098	0.022	2.6	−0.75	D−	4
		4444.54	8998	31491	8	8	0.0039	0.0012	0.14	−2.03	D	9
38.	$a\,^2$G – $z\,^2$D° (32)											
		4341.37	8998	32025	8	6	0.0031	6.6(−4)	0.075	−2.28	D−	1*n*
39.	$a\,^2$G – $z\,^2$G° (34)	*3906.4*	*9065*	*34657*	18	18	0.17	0.038	8.9	−0.16	D	1*n*
		3900.56	9118	34748	10	10	0.16	0.035	4.6	−0.45	D	1*n*
		3913.48	8998	34543	8	8	0.16	0.037	3.8	−0.53	D	1*n*
		3932.02	9118	34543	10	8	0.0089	0.0017	0.21	−1.78	D	1*n*
		3882.28	8998	34748	8	10	0.0086	0.0024	0.25	−1.71	D	1*n*
40.	$a\,^2$G – $y\,^2$D° (35)											
		3280.00	8998	39477	8	6	0.075	0.0091	0.78	−1.14	D	3

Ti II: Allowed transitions — Continued

No.	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} (10^8 s^{-1})	f_{ik}	S (at. u.)	log gf	Accuracy	Source
41.	$a\ ^2G - y\ ^2F°$ (36)											
		3232.29	8998	39927	8	6	0.60	0.070	6.0	−0.25	C	3
42.	$a\ ^2G - y\ ^2G°$ (uv 14)	*2881.2*	*9065*	*43763*	18	18	0.56	0.070	12	0.10	D	1*n*,3
		2884.13	9118	43781	10	10	0.52	0.065	6.1	−0.19	D	3
		2877.47	8998	43741	8	8	0.57	0.070	5.3	−0.25	D	3
		2887.44	9118	43741	10	8	0.010	0.0010	0.10	−1.98	D−	1*n*
		2874.11	8998	43781	8	10	0.010	0.0016	0.12	−1.90	D−	1*n*
43.	$a\ ^2G - z\ ^2H°$ (uv 15)											
		2717.30	9118	45909	10	12	0.033	0.0044	0.39	−1.36	D	3
		2725.78	8998	45674	8	10	0.033	0.0046	0.33	−1.43	D	3
44.	$a\ ^4P - z\ ^4F°$ (38)											
		4629.29	9518	31114	6	8	0.0022	9.6(−4)	0.088	−2.24	D−	1*n*
45.	$a\ ^4P - z\ ^2F°$ (39)											
		4583.41	9396	31207	4	6	0.0010	4.8(−4)	0.029	−2.72	D	9
		4609.26	9518	31207	6	6	2.9(−4)	9.2(−5)	0.0083	−3.26	D	9
46.	$a\ ^4P - z\ ^2D°$ (40)											
		4441.73	9518	32025	6	6	0.0022	6.5(−4)	0.057	−2.41	D−	1*n*
		4470.84	9396	31757	4	4	0.0044	0.0013	0.077	−2.28	D−	1*n*
		4417.72	9396	32025	4	6	0.021	0.0093	0.54	−1.43	D−	1*n*
		4464.46	9364	31757	2	4	0.0070	0.0042	0.12	−2.08	D−	1*n*
47.	$a\ ^4P - z\ ^4D°$ (41)	*4302.1*	*9452*	*32690*	12	20	0.097	0.045	7.6	−0.27	D−	1*n*,4
		4300.06	9518	32767	6	8	0.077	0.028	2.4	−0.77	D−	1*n*
		4290.22	9396	32698	4	6	0.046	0.019	1.1	−1.12	D−	1*n*
		4301.92	9364	32603	2	4	0.062	0.035	0.98	−1.16	D−	4
		4312.87	9518	32698	6	6	0.041	0.012	0.98	−1.16	D−	4
		4307.87	9396	32603	4	4	0.046	0.013	0.73	−1.29	D−	1*n*
		4314.97	9364	32532	2	2	0.13	0.037	1.1	−1.13	D−	4
		4330.72	9518	32603	6	4	0.0081	0.0015	0.13	−2.04	D−	4
		4320.96	9396	32532	4	2	0.024	0.0034	0.19	−1.87	D−	4
48.	$a\ ^4P - z\ ^2S°$ (42)											
		3565.96	9396	37431	4	2	0.039	0.0037	0.17	−1.83	D−	1
		3561.90	9364	37431	2	2	0.013	0.0024	0.057	−2.31	E	1
49.	$a\ ^4P - z\ ^2P°$ (44)											
		3301.66	9396	39675	4	2	0.061	0.0050	0.22	−1.70	D−	1*n*

Ti II: Allowed transitions — Continued

No.	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} ($10^8 s^{-1}$)	f_{ik}	S (at. u.)	log gf	Accuracy	Source
50.	$a\ ^4P - z\ ^4S°$ (45)	*3269.7*	*9452*	40027	12	4	0.42	0.022	2.9	−0.57	C	1*n*,3
		3276.77	9518	40027	6	4	0.24	0.025	1.6	−0.82	C	3
		3263.69	9396	40027	4	4	0.12	0.019	0.83	−1.11	C	3
		3260.25	9364	40027	2	4	0.072	0.023	0.49	−1.34	D	1*n*
51.	$a\ ^4P - z\ ^4P°$ (47)											
		3058.08	9518	42209	6	6	0.50	0.069	4.2	−0.38	D	3
		3071.25	9518	42069	6	4	0.36	0.034	2.1	−0.69	D	3
		3046.69	9396	42209	4	6	0.22	0.045	1.8	−0.74	D	3
		3056.75	9364	42069	2	4	0.32	0.091	1.8	−0.74	D	3
52.	$a\ ^2P - z\ ^2F°$ (49)											
		4708.65	9976	31207	4	6	0.0031	0.0015	0.096	−2.21	D	9
53.	$a\ ^2P - z\ ^2D°$ (50)	*4547.5*	*9934*	*31918*	6	10	0.095	0.049	4.4	−0.53	D−	1*n*
		4533.97	9976	32025	4	6	0.092	0.042	2.5	−0.77	D−	1*n*
		4563.77	9851	31757	2	4	0.088	0.055	1.6	−0.96	D−	1*n*
		4589.92	9976	31757	4	4	0.013	0.0041	0.25	−1.79	D−	1*n*
54.	$a\ ^2P - z\ ^4D°$ (51)											
		4399.79	9976	32698	4	6	0.031	0.013	0.78	−1.27	D−	4
		4394.02	9851	32603	2	4	0.022	0.013	0.37	−1.59	D−	4
		4418.31	9976	32603	4	4	0.0030	8.7(−4)	0.050	−2.46	D−	1*n*
		4407.68	9851	32532	2	2	0.0058	0.0017	0.049	−2.47	D−	4
		4432.09	9976	32532	4	2	0.013	0.0020	0.12	−2.10	D−	1*n*
55.	$a\ ^2P - z\ ^2S°$ (52)	*3635.7*	*9934*	37431	6	2	0.78	0.052	3.7	−0.51	D−	1
		3641.33	9976	37431	4	2	0.49	0.049	2.3	−0.71	D−	1
		3624.82	9851	37431	2	2	0.29	0.057	1.4	−0.94	D−	1
56.	$a\ ^2P - y\ ^2D°$ (53)											
		3388.77	9976	39477	4	6	0.090	0.023	1.0	−1.03	C	3
		3374.36	9976	39603	4	4	0.16	0.028	1.2	−0.95	C	3
57.	$a\ ^2P - z\ ^2P°$ (54)	*3395.1*	*9934*	*39380*	6	6	0.25	0.043	2.9	−0.59	C−	3,1*n*
		3416.95	9976	39233	4	4	0.038	0.0067	0.30	−1.57	C	3
		3352.07	9851	39675	2	2	0.14	0.023	0.50	−1.34	D	1*n*
		3366.19	9976	39675	4	2	0.26	0.022	0.97	−1.06	D	1*n*
		3402.44	9851	39233	2	4	0.14	0.050	1.1	−1.00	C	3
58.	$a\ ^2P - y\ ^2F°$ (55)											
		3337.85	9976	39927	4	6	0.050	0.013	0.55	−1.30	D	3

Ti II: Allowed transitions — Continued

No.	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} (10^8 s^{-1})	f_{ik}	S (at. u.)	log gf	Accuracy	Source
59.	$a\ ^2P - z\ ^4S^\circ$ (56)											
		3312.92	9851	40027	2	4	0.0063	0.0021	0.045	−2.38	D−	1*n*
60.	$a\ ^2P - z\ ^4P^\circ$ (58)											
		3101.54	9976	42209	4	6	0.028	0.0060	0.24	−1.62	D	1*n*
		3102.98	9851	42069	2	4	0.027	0.0077	0.16	−1.81	D	1*n*
		3122.07	9976	41997	4	2	0.11	0.0079	0.33	−1.50	D	1*n*
61.	$a\ ^2P - x\ ^2D^\circ$ (uv 16)	*2858.5*	*9934*	*44907*	6	10	0.42	0.086	4.9	−0.29	D	1*n*,3
		2862.33	9976	44902	4	6	0.40	0.074	2.8	−0.53	D	1*n*
		2851.11	9851	44915	2	4	0.41	0.10	1.9	−0.70	C	3
		2861.30	9976	44915	4	4	0.046	0.0056	0.21	−1.65	D	1*n*
62.	$a\ ^2P - y\ ^2P^\circ$ (uv 17)											
		2806.46	9851	45472	2	2	0.19	0.022	0.41	−1.35	D	3
63.	$b\ ^4P - z\ ^2F^\circ$ (59)											
		4657.20	10025	31491	6	8	0.0027	0.0012	0.11	−2.15	D	9
64.	$b\ ^4P - z\ ^2D^\circ$ (60)											
		4544.02	10025	32025	6	6	0.0021	6.6(−4)	0.060	−2.40	D	9
		4580.45	9931	31757	4	4	0.0013	4.1(−4)	0.024	−2.79	D−	1*n*
		4568.31	9873	31757	2	4	0.0018	0.0011	0.034	−2.65	D	9
65.	$b\ ^4P - z\ ^4D^\circ$ (61)											
		4395.83	10025	32767	6	8	0.0029	0.0011	0.098	−2.17	D−	1*n*
		4391.04	9931	32698	4	6	0.0010	4.4(−4)	0.026	−2.75	D−	1*n*
		4427.91	10025	32603	6	4	6.3(−4)	1.2(−4)	0.011	−3.13	D	9
66.	$b\ ^4P - y\ ^2D^\circ$											
		3369.19	9931	39603	4	4	0.066	0.011	0.50	−1.35	D	1*n*
67.	$b\ ^4P - z\ ^4S^\circ$ (65)	*3325.8*	*9968*	40027	12	4	2.2	0.12	16	0.16	C	1*n*,3
		3332.11	10025	40027	6	4	1.1	0.12	7.8	−0.15	C	3
		3321.70	9931	40027	4	4	0.72	0.12	5.2	−0.32	D	1*n*
		3315.32	9873	40027	2	4	0.38	0.13	2.7	−0.60	C	3
68.	$b\ ^4P - y\ ^4D^\circ$ (66)											
		3272.07	9873	40426	2	4	0.32	0.10	2.2	−0.69	D	1*n*
		3271.64	10025	40581	6	6	0.24	0.039	2.5	−0.63	D	1*n*
		3278.28	9931	40426	4	4	0.96	0.15	6.7	−0.21	C	3
		3282.32	9873	40330	2	2	1.6	0.26	5.5	−0.29	C	3

Ti II: Allowed transitions — Continued

No.	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} (10^8 s^{-1})	f_{ik}	S (at. u.)	log gf	Accuracy	Source
69.	$b\,^4$P – $z\,^4$P° (67)	*3108.7*	*9968*	*42127*	12	12	1.3	0.20	24	0.37	C	1*n*,3
		3106.26	10025	42209	6	6	0.78	0.11	6.9	−0.17	C	3
		3110.69	9931	42069	4	4	0.27	0.039	1.6	−0.81	D	1*n*
		3112.07	9873	41997	2	2	0.23	0.034	0.69	−1.17	D	3
		3119.83	10025	42069	6	4	0.59	0.058	3.6	−0.46	D	1*n*
		3117.67	9931	41997	4	2	1.1	0.079	3.2	−0.50	C	3
		3097.20	9931	42209	4	6	0.44	0.095	3.9	−0.42	C	3
		3105.10	9873	42069	2	4	0.63	0.18	3.7	−0.44	D	3
70.	$b\,^2$D2 – $z\,^2$F°											
		5336.78	12758	31491	6	8	0.0058	0.0033	0.35	−1.70	D−	4
		5381.01	12629	31207	4	6	0.0032	0.0021	0.15	−2.08	D	2
71.	$b\,^2$D2 – $z\,^2$D°											
		5188.69	12758	32025	6	6	0.025	0.010	1.1	−1.21	D−	1*n*
		5226.53	12629	31757	4	4	0.031	0.013	0.86	−1.30	D−	1*n*
		5154.06	12629	32025	4	6	0.0050	0.0030	0.20	−1.92	D−	2
72.	$b\,^2$D2 – $z\,^4$D° (71)											
		4981.35	12629	32698	4	6	3.1(−4)	1.7(−4)	0.011	−3.16	D	9
		5005.17	12629	32603	4	4	0.0019	7.0(−4)	0.046	−2.55	D	9
73.	$b\,^2$D2 – $y\,^2$D°											
		3741.64	12758	39477	6	6	0.62	0.13	9.6	−0.11	D	1*n*
		3706.23	12629	39603	4	4	0.31	0.064	3.1	−0.59	D	1*n*
74.	$b\,^2$D2 – $z\,^2$P°											
		3776.06	12758	39233	6	4	0.053	0.0076	0.57	−1.34	D	1*n*
		3757.70	12629	39233	4	4	0.41	0.087	4.3	−0.46	D	1*n*
75.	$b\,^2$D2 – $y\,^2$F°	*3661.2*	*12706*	*40012*	10	14	0.13	0.037	4.5	−0.43	D	1*n*
		3659.75	12758	40075	6	8	0.11	0.030	2.2	−0.74	D	1*n*
		3662.24	12629	39927	4	6	0.14	0.041	2.0	−0.78	D	1*n*
		3679.68	12758	39927	6	6	0.017	0.0035	0.25	−1.68	D	1*n*
76.	$b\,^2$D2 – $y\,^4$D°											
		3565.30	12758	40798	6	8	0.0058	0.0015	0.10	−2.05	D−	1*n*
		3593.08	12758	40581	6	6	0.0039	7.6(−4)	0.054	−2.34	D−	1*n*
77.	$b\,^2$D2 – $x\,^2$D°											
		3110.10	12758	44902	6	6	0.071	0.010	0.63	−1.21	D	1*n*
		3096.42	12629	44915	4	4	0.060	0.0087	0.35	−1.46	D	1*n*
78.	$b\,^2$D2 – $y\,^2$P°											
		3048.77	12758	45549	6	4	0.15	0.014	0.83	−1.08	C	3
		3043.86	12629	45472	4	2	0.14	0.010	0.40	−1.40	D	3
79.	$b\,^2$D2 – $x\,^2$F°											
		2880.30	12758	47467	6	8	0.026	0.0044	0.25	−1.58	D	1*n*

Ti II: Allowed transitions — Continued

No.	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} (10^8 s^{-1})	f_{ik}	S (at. u.)	log gf	Accuracy	Source
80.	$b\ ^2$D2 – $w\ ^2$D°	*2446.3*	*12706*	*53572*	10	10	0.53	0.047	3.8	−0.33	C	1*n*,3
		2451.18	12758	53555	6	6	0.45	0.041	2.0	−0.61	C	3
		2440.91	12629	53597	4	4	0.51	0.045	1.5	−0.74	C	3
		2448.64	12758	53597	6	4	0.037	0.0022	0.11	−1.88	D	1*n*
		2443.43	12629	53555	4	6	0.040	0.0053	0.17	−1.67	D	1*n*
81.	$a\ ^2$H – $z\ ^2$G° (82)	*4559.3*	*12730*	*34657*	22	18	0.12	0.030	9.8	−0.19	D−	1*n*
		4549.61	12775	34748	12	10	0.11	0.030	5.3	−0.45	D−	1*n*
		4571.96	12677	34543	10	8	0.12	0.030	4.4	−0.53	D−	1*n*
		4529.48	12677	34748	10	10	0.0030	9.3(−4)	0.14	−2.03	D−	1*n*
82.	$a\ ^2$H – $y\ ^2$G° (84)											
		3224.25	12775	43781	12	10	0.70	0.091	12	0.04	C	3
		3214.12	12677	43781	10	10	0.085	0.013	1.4	−0.88	D	1*n*
83.	$a\ ^2$H – $z\ ^2$H° (85)	*3022.8*	*12730*	*45802*	22	22	0.39	0.053	12	0.07	C	1*n*,3
		3017.17	12775	45909	12	12	0.36	0.049	5.8	−0.23	C	3
		3029.76	12677	45674	10	10	0.35	0.048	4.8	−0.32	C	3
		3038.73	12775	45674	12	10	0.042	0.0048	0.58	−1.24	D	3
		3008.31	12677	45909	10	12	0.026	0.0043	0.42	−1.37	D−	1*n*
84.	$b\ ^2$G – $z\ ^2$G° (86)											
		5129.16	15257	34748	10	10	0.010	0.0041	0.69	−1.39	D−	1*n*
		5185.90	15266	34543	8	8	0.014	0.0056	0.76	−1.35	D	9
85.	$b\ ^2$G – $y\ ^2$F° (87)											
		4028.36	15257	40075	10	8	0.051	0.010	1.3	−1.00	D	1*n*
		4053.83	15266	39927	8	6	0.042	0.0077	0.82	−1.21	D	1*n*
86.	$b\ ^2$G – $y\ ^2$G° (88)	*3507.5*	*15261*	*43763*	18	18	0.89	0.16	34	0.47	D	1*n*
		3504.90	15257	43781	10	10	0.82	0.15	17	0.18	D	1*n*
		3510.86	15266	43741	8	8	0.93	0.17	16	0.14	D	1*n*
		3509.81	15257	43741	10	8	0.030	0.0044	0.50	−1.36	D	1*n*
		3505.91	15266	43781	8	10	0.0065	0.0015	0.14	−1.92	D−	1*n*
87.	$b\ ^2$G – $z\ ^2$H° (89)											
		3287.66	15266	45674	8	10	1.4	0.27	24	0.34	C	3
		3286.77	15257	45674	10	10	0.015	0.0025	0.27	−1.61	D	1*n*
88.	$b\ ^2$G – $x\ ^2$F° (90)	*3097.6*	*15261*	*47535*	18	14	1.3	0.14	26	0.41	C	1*n*,3
		3103.81	15257	47467	10	8	1.1	0.13	13	0.11	C	3
		3089.44	15266	47625	8	6	1.3	0.14	12	0.06	C	3
		3104.60	15266	47467	8	8	0.064	0.0093	0.76	−1.13	D	1*n*

Ti II: Allowed transitions — Continued

No.	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} (10^8 s^{-1})	f_{ik}	S (at. u.)	log gf	Accuracy	Source
89.	$b\ ^2P - z\ ^2D°$ (91)											
		6606.97	16625	31757	4	4	6.2(−4)	4.1(−4)	0.035	−2.79	D	9
90.	$b\ ^2P - z\ ^2S°$ (92)	*4796.7*	*16589*	37431	6	2	0.18	0.021	2.0	−0.90	D−	1
		4805.09	16625	37431	4	2	0.11	0.020	1.3	−1.10	D−	1
		4779.98	16516	37431	2	2	0.062	0.021	0.67	−1.37	D−	1
91.	$b\ ^2P - y\ ^2D°$ (93)											
		4374.84	16625	39477	4	6	0.030	0.013	0.74	−1.29	D	9
		4350.85	16625	39603	4	4	0.035	0.010	0.57	−1.40	D	9
92.	$b\ ^2P - z\ ^2P°$ (94)											
		4421.95	16625	39233	4	4	0.014	0.0042	0.25	−1.77	D−	1*n*
		4316.80	16516	39675	2	2	0.068	0.019	0.54	−1.42	D	9
		4330.24	16516	39233	2	4	0.027	0.015	0.44	−1.51	D	9
93.	$b\ ^2P - x\ ^2D°$ (98)	*3530.3*	*16589*	*44907*	6	10	0.53	0.17	12	−0.01	D	1*n*
		3535.41	16625	44902	4	6	0.55	0.15	7.2	−0.21	D	1*n*
		3520.27	16516	44915	2	4	0.48	0.18	4.1	−0.45	D	1*n*
		3533.85	16625	44915	4	4	0.029	0.0053	0.25	−1.67	D	1*n*
94.	$b\ ^2P - y\ ^2P°$ (99)	*3455.2*	*16589*	*45523*	6	6	0.98	0.18	12	0.02	D	1*n*,3
		3456.40	16625	45549	4	4	0.82	0.15	6.7	−0.23	D	1*n*
		3452.49	16516	45472	2	2	0.77	0.14	3.1	−0.56	C	3
		3465.56	16625	45472	4	2	0.41	0.037	1.7	−0.83	C	3
		3443.39	16516	45549	2	4	0.12	0.043	0.96	−1.07	D	1*n*
95.	$b\ ^2F - z\ ^2G°$ (101)											
		7214.74	20892	34748	8	10	0.0023	0.0023	0.43	−1.74	D	9
96.	$b\ ^2F - y\ ^2F°$ (103)											
		5268.61	20952	39927	6	6	0.0096	0.0040	0.42	−1.62	D	2
97.	$b\ ^2F - y\ ^2G°$ (104)											
		4367.65	20892	43781	8	10	0.019	0.0067	0.77	−1.27	D−	1*n*
		4386.85	20952	43741	6	8	0.024	0.0092	0.79	−1.26	D−	1*n*
98.	$b\ ^2F - x\ ^2D°$ (105)	*4167.4*	*20918*	*44907*	14	10	0.28	0.053	10	−0.13	D	1*n*
		4163.63	20892	44902	8	6	0.26	0.050	5.5	−0.40	D	1*n*
		4171.92	20952	44915	6	4	0.26	0.046	3.8	−0.56	D	1*n*
		4174.05	20952	44902	6	6	0.036	0.0094	0.77	−1.25	D	1*n*

Ti II: Allowed transitions — Continued

No.	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} ($10^8 s^{-1}$)	f_{ik}	S (at. u.)	log gf	Accuracy	Source
99.	$b\ ^2F - x\ ^2F°$ (107)											
		3761.88	20892	47467	8	8	0.14	0.031	3.0	−0.61	D	1*n*
		3748.03	20952	47625	6	6	0.15	0.031	2.3	−0.73	D	1*n*
		3770.40	20952	47467	6	8	0.0052	0.0015	0.11	−2.05	D−	1*n*
100.	$c\ ^2D - x\ ^2D°$ (113)											
		5072.27	25193	44902	6	6	0.077	0.030	3.0	−0.75	D	9
		5069.08	25193	44915	6	4	0.026	0.0068	0.68	−1.39	D	9
101.	$c\ ^2D - y\ ^2P°$ (114)											
		4911.18	25193	45549	6	4	0.32	0.076	7.4	−0.34	D	9
		4874.01	24961	45472	4	2	0.23	0.041	2.6	−0.79	D	9
102.	$c\ ^2D - x\ ^2F°$ (115)											
		4488.34	25193	47467	6	8	0.063	0.025	2.2	−0.82	D−	1*n*
		4411.10	24961	47625	4	6	0.050	0.022	1.3	−1.06	D−	1*n*
103.	$z\ ^4G° - e\ ^4F$ (119)											
		3081.52	29968	62411	10	8	1.1	0.12	12	0.08	D	3
104.	$z\ ^4G° - e\ ^4G$ (uv 24)											
		2856.10	30241	65243	12	12	1.5	0.18	20	0.33	D	3
		2845.93	29968	65096	10	10	1.2	0.15	14	0.18	D	3
		2836.47	29735	64979	8	8	1.2	0.15	11	0.08	D	3
		2828.64	29544	64886	6	6	1.2	0.15	8.3	−0.05	D	1*n*
		2855.40	29968	64979	10	8	0.14	0.014	1.3	−0.85	D	1*n*
		2843.94	29735	64886	8	6	0.15	0.014	1.1	−0.95	D	1*n*
		2834.02	29968	65243	10	12	0.79	0.11	11	0.06	D	3
		2827.12	29735	65096	8	10	1.0	0.15	11	0.08	D	3
		2821.26	29544	64979	6	8	0.79	0.13	7.0	−0.12	D	3
105.	$z\ ^4G° - e\ ^4H$ (uv 25)											
		2828.06	30241	65590	12	14	4.4	0.62	69	0.87	D	3
		2817.83	29968	65446	10	12	3.8	0.54	50	0.73	D	3
		2810.30	29735	65308	8	10	5.1	0.75	56	0.78	D	3
		2804.82	29544	65187	6	8	4.6	0.73	40	0.64	D	3
		2839.64	30241	65446	12	12	0.83	0.10	11	0.08	D	3
		2828.83	29968	65308	10	10	0.91	0.11	10	0.04	D	1*n*
		2819.87	29735	65187	8	8	0.65	0.077	5.7	−0.21	D	1*n*
106.	$z\ ^4F° - e\ ^4F$ (120)											
		3189.49	30836	62180	4	4	0.92	0.14	5.9	−0.25	D	3

Ti II: Allowed transitions — Continued

No.	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} (10^8 s^{-1})	f_{ik}	S (at. u.)	log gf	Accuracy	Source
107.	$z\,^4F^\circ - e\,^4G$ (uv 26)											
		2945.30	31301	65243	10	12	2.7	0.42	40	0.62	D	3
		2941.90	31114	65096	8	10	1.8	0.29	23	0.37	D	1*n*
		2938.57	30959	64979	6	8	2.4	0.42	24	0.40	D	3
		2936.02	30836	64886	4	6	2.7	0.52	20	0.32	D	3
		2958.17	31301	65096	10	10	0.14	0.018	1.8	−0.74	D	1*n*
		2952.00	31114	64979	8	8	0.30	0.040	3.1	−0.50	D	3
108.	$z\,^4F^\circ - f\,^2F$ (uv 27)											
		2926.64	31301	65460	10	8	0.89	0.091	8.8	−0.04	D	3
		2910.65	31114	65460	8	8	0.46	0.058	4.5	−0.33	D	1*n*
109.	$z\,^4F^\circ - f\,^4F$ (uv 29)											
		2645.86	31301	69084	10	10	2.7	0.28	25	0.45	D	3
		2642.02	31114	68952	8	8	1.9	0.19	13	0.19	D	3
		2638.56	30959	68847	6	6	1.7	0.17	9.1	0.02	D	3
		2635.44	30836	68769	4	4	1.9	0.20	6.9	−0.10	D	3
110.	$z\,^2F^\circ - e\,^2F$ (121)											
		3128.50	31491	63446	8	8	1.1	0.17	14	0.13	D	1*n*
		3127.86	31207	63169	6	6	1.6	0.23	14	0.14	D	1*n*
111.	$z\,^2F^\circ - f\,^2F$ (uv 30)											
		2942.97	31491	65460	8	8	1.1	0.15	11	0.07	D	3
		2931.10	31207	65314	6	6	3.2	0.41	24	0.39	D	3
		2918.63	31207	65460	6	8	0.041	0.0069	0.40	−1.38	D	1*n*
112.	$z\,^2F^\circ - e\,^2G$ (uv 31)											
		2751.59	31491	67822	8	10	3.7	0.52	38	0.62	D−	3
		2746.54	31207	67606	6	8	2.6	0.39	21	0.37	D−	3
113.	$z\,^2D^\circ - e\,^2F$ (122)											
		3181.73	32025	63446	6	8	0.46	0.094	5.9	−0.25	D	3
		3182.54	31757	63169	4	6	0.43	0.097	4.1	−0.41	D	3
114.	$z\,^2D^\circ - f\,^2F$ (uv 32)											
		2990.06	32025	65460	6	8	0.56	0.10	5.9	−0.22	D	1*n*
		2979.06	31757	65314	4	6	1.2	0.23	9.2	−0.03	D	3

Ti II: Allowed transitions — Continued

No.	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} (10^8 s^{-1})	f_{ik}	S (at. u.)	log gf	Accuracy	Source
115.	$z\,^4D^\circ - f\,^4F$ (uv 33)											
		2752.68	32767	69084	8	10	1.1	0.16	11	0.10	D	3
		2757.62	32698	68952	6	8	0.72	0.11	6.0	−0.18	D	1*n*
		2758.35	32603	68847	4	6	0.99	0.17	6.1	−0.17	D	1*n*
		2758.79	32532	68769	2	4	0.44	0.10	1.8	−0.70	D	1*n*
		2762.92	32767	68952	8	8	0.072	0.0083	0.60	−1.18	D	1*n*
		2764.28	32603	68769	4	4	0.74	0.085	3.1	−0.47	D	1*n*
116.	$z\,^2G^\circ - e\,^2F$ (125)											
		3483.63	34748	63446	10	8	0.97	0.14	16	0.15	D	3
		3492.37	34543	63169	8	6	0.98	0.13	12	0.03	D	3
117.	$z\,^2G^\circ - e\,^2G$ (126)											
		3022.64	34748	67822	10	10	1.2	0.17	17	0.23	D−	3
		3023.67	34543	67606	8	8	1.0	0.14	11	0.06	D−	3
118.	$z\,^2G^\circ - e\,^2H$ (uv 34)											
		2954.59	34748	68584	10	12	4.0	0.63	61	0.80	D	3
		2958.80	34543	68331	8	10	4.0	0.66	51	0.72	D	3

ªThe number in parentheses following the tabulated value indicates the power of ten by which this value has to be multiplied.

Ti III

Ca Isoelectronic Sequence

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

Ionization Energy: 27.4919 eV = 221736 cm^{-1}

Allowed Transitions

List of tabulated lines

Wavelength (Å)	No.	Wavelength (Å)	No.	Wavelength (Å)	No.	Wavelength (Å)	No.
865.79	10	1420.44	6	2103.60	17	2567.56	11
1002.37	9	1421.63	6	2104.86	17	2576.47	11
1004.67	9	1422.41	6	2105.09	17	2984.75	14
1005.80	9	1424.14	6	2199.22	20	3066.51	29
1007.16	9	1455.19	7	2237.77	19	3167.83	25
1008.12	9	1498.70	3	2331.35	13	3193.77	25
1286.37	2	1499.17	5	2331.66	13	3228.89	24
1289.30	2	1948.51	8	2334.34	13	3240.71	24
1291.62	2	2007.36	18	2339.00	13	3245.59	28
1293.23	2	2007.60	18	2346.79	13	3278.31	21
1298.97	1	2010.80	18	2374.99	16	3320.94	23
1327.59	4	2097.30	17	2413.99	15	3333.46	23
1420.04	6	2099.86	17	2516.05	12	3340.20	27

List of tabulated lines — Continued

Wavelength (Å)	No.	Wavelength (Å)	No.	Wavelength (Å)	No.	Wavelength (Å)	No.
3346.18	27	4343.25	101	4971.19	102	7379.96	54
3354.71	27	4352.28	112	5010.14	106	7397.27	131
3358.10	27	4368.56	66	5020.43	106	7408.13	120
3370.63	27	4378.94	68	5024.52	102	7417.60	125
3371.62	26	4400.57	115	5068.22	47	7432.20	131
3377.90	22	4406.20	84	5069.39	43	7441.72	124
3396.43	26	4424.40	83	5083.80	106	7450.45	54
3397.24	30	4433.91	86	5119.08	110	7460.04	136
3404.46	30	4440.66	84	5147.31	41	7484.58	132
3417.62	30	4446.56	83	5162.55	105	7491.92	136
3872.50	34	4462.56	98	5218.43	45	7495.18	124
3881.21	34	4466.08	85	5226.28	42	7506.87	130
3915.47	33	4466.69	85	5247.49	104	7507.68	55
3924.86	32	4480.36	116	5257.33	42	7508.65	89
3986.40	31	4496.51	69	5278.12	45	7511.59	124
4069.99	37	4519.42	69	5278.33	109	7515.98	131
4079.96	37	4520.38	70	5282.14	104	7531.15	136
4098.88	37	4521.15	70	5293.60	104	7540.99	54
4100.05	37	4533.26	100	5328.40	104	7544.29	130
4119.14	37	4555.46	38	5367.17	108	7552.05	131
4139.42	73	4576.53	117	5395.69	49	7566.25	89
4144.77	72	4578.52	40	5481.31	49	7704.80	135
4145.05	72	4611.04	107	5533.01	113	7742.64	129
4176.54	74	4619.78	107	5566.58	46	7775.95	56
4191.09	36	4628.07	107	6490.14	93	8164.06	142
4201.66	36	4649.45	103	6547.75	92	8235.58	143
4212.95	61	4652.86	114	6611.38	92	8252.85	143
4213.26	61	4673.40	107	6629.37	92	8338.54	141
4215.53	39	4680.58	103	6647.47	51	8394.20	141
4218.52	77	4720.90	111	6667.99	92	8406.15	141
4220.28	63	4731.11	97	6674.19	92	8439.19	141
4247.62	76	4763.58	118	6896.12	50	8505.88	139
4248.54	62	4771.46	118	6932.44	94	8516.40	141
4250.09	35	4784.09	118	7015.38	53	8527.03	139
4254.11	75	4793.50	118	7017.31	128	8544.89	139
4259.01	80	4800.27	88	7031.40	134	8563.50	145
4269.84	79	4821.80	87	7071.93	123	8566.24	140
4275.53	78	4831.33	96	7072.64	91	8584.05	140
4284.67	80	4838.25	118	7141.76	52	8605.75	145
4285.61	80	4849.66	119	7203.66	127	8618.79	139
4288.66	79	4856.22	44	7228.40	126	8731.24	138
4289.25	79	4858.13	44	7252.88	122	8887.71	144
4293.34	82	4874.00	95	7288.98	121	8916.95	146
4296.70	65	4884.32	99	7315.14	54	9017.10	60
4310.48	81	4892.84	44	7316.68	90	9024.05	57
4319.56	67	4907.61	71	7335.41	137	9081.40	58
4325.93	64	4914.32	99	7370.14	133	9271.12	59
4328.25	101	4961.36	48	7371.34	90		

The data for this ion were obtained directly from the calculations of Kurucz and Peytremann[1] and Warner and Kirkpatrick.[2] Kurucz and Peytremann used a semiempirical scaled Thomas-Fermi-Dirac approach with very limited configuration interaction. Warner and Kirkpatrick obtained radial wavefunctions via the scaled Thomas-Fermi method in a single configuration approximation and calculated individual line strengths in intermediate coupling. We have given first priority to the data of Kurucz and Peytremann because of their consideration of configuration interaction.

References 1 and (especially) 2 have provided data for more lines than we have tabulated here. However, we have often found that calculations of the above type yield uncertain results for the weaker lines. Therefore, we have included only observed lines of at least moderate strength, i.e., lines having log *gf*-values greater than -1.0. In selecting the lines, we have used the experimental line list of Edlen and Swensson.[3] Since it was pointed out by them that Warner and Kirkpatrick have erroneously interchanged the labels ^{3}F and ^{3}D for the $3d4p\ ^3D^\circ_{2,3}$ and $3d4p\ ^3F^\circ_{2,3}$ levels, we have omitted all lines from Ref. 2 originating from these four levels. In addition, we found a few other levels to be similarly misidentified by Warner and Kirkpatrick. Therefore, we have included their data only if their tabulated wavelengths and associated transition designations for each line corresponded exactly to those of Ref. 3. An exception to this rule is that we also included lines arising from the $3d5g$ configuration, labeled in jl-coupling notation by Edlen and Swensson (but in LS coupling by Warner and Kirkpatrick).

Having selected the lines for this compilation by the above-mentioned criterion, we found the data of Refs. 1 and 2 to be in excellent agreement for overlapping lines. Specifically, all log gf-values agreed within 20%, and 91% of the data for common lines agreed within 7%.

We were able to check the reliability of Kurucz and Peytremann's and Warner and Kirkpatrick's data on an absolute scale by comparing reciprocals of sums of their calculated transition probabilities, $(\sum_i A_{ki})^{-1}$, to several beam-foil lifetimes measured by Baudinet-Robinet *et al.*[4] and by Roberts *et al.*[5] These comparisons indicate agreement generally within 50% for eight different levels. However, the calculated reciprocals are always smaller than the experimental lifetimes, which seems to indicate that uncorrected cascading effects are likely to be present in the beam-foil data.

References

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[4]Y. Baudinet-Robinet, P. D. Dumont, H. P. Garnir, N. Grevesse, and E. Biemont, J. Opt. Soc. Am. **70**, 464 (1980).

[5]J. R. Roberts, T. Andersen, and G. Sorensen, Astrophys. J. **181**, 567 (1973).

Ti III: Allowed transitions

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} (10^8 s^{-1})	f_{ik}	S (at. u.)	log gf	Accuracy	Source
1.	$3d^2$–$3d4p$	^{3}F - ^{3}D°											
			1298.97	184.9	77167	7	5	4.9	0.088	2.6	−0.21	D	1
2.		^{3}F - ^{3}F°											
			1286.37	420.4	78159	9	9	2.0	0.049	1.8	−0.36	D	1
			1289.30	184.9	77746	7	7	2.2	0.054	1.6	−0.42	D	1
			1291.62	0.0	77422	5	5	2.4	0.060	1.3	−0.52	D	1
			1293.23	420.4	77746	9	7	1.0	0.020	0.76	−0.75	D	1
3.		^{1}D - ^{1}D°	1498.70	8474	75198	5	5	2.8	0.094	2.3	−0.33	D	1
4.		^{1}D - ^{1}P°	1327.59	8474	83797	5	3	3.2	0.051	1.1	−0.59	D	1
5.		^{3}P - ^{3}D°											
			1499.17	10721	77424	5	7	0.49	0.023	0.57	−0.94	D	1
6.		^{3}P - ^{3}P°											
			1422.41	10721	81024	5	5	3.0	0.091	2.1	−0.34	D	1
			1424.14	10721	80939	5	3	1.6	0.029	0.68	−0.84	D	1
			1421.63	10604	80945	3	1	4.0	0.040	0.56	−0.92	D	1
			1420.04	10604	81024	3	5	0.89	0.045	0.63	−0.87	D	1
			1420.44	10538	80939	1	3	1.2	0.11	0.52	−0.95	D	1
7.		^{1}G - ^{1}F°	1455.19	14398	83117	9	7	6.4	0.16	6.8	0.15	D	1
8.		^{1}S - ^{1}P°	1948.51	32476	83797	1	3	0.72	0.12	0.79	−0.91	D	1
9.	$3d4s$–$4s4p$	^{3}D - ^{3}P°											
			1004.67	38426	137961	7	5	43	0.46	11	0.51	D	1
			1007.16	38199	137488	5	3	38	0.35	5.8	0.24	D	1
			1008.12	38064	137259	3	1	51	0.26	2.6	−0.11	D	1
			1002.37	38199	137961	5	5	7.6	0.12	1.9	−0.24	D	1
			1005.80	38064	137488	3	3	13	0.19	1.9	−0.24	D	1

Ti III: Allowed transitions — Continued

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} ($10^8 s^{-1}$)	f_{ik}	S (at. u.)	log gf	Accuracy	Source
10.		$^1D - {}^1P°$	865.79	41704	157204	5	3	66	0.45	6.4	0.35	D	2
11.	$3d4s-3d4p$	$^3D - {}^3D°$											
			2567.56	38064	77000	3	3	2.3	0.23	5.7	−0.17	D	2
			2576.47	38199	77000	5	3	0.92	0.055	2.3	−0.56	D	2
12.		$^3D - {}^3F°$											
			2516.05	38426	78159	7	9	3.4	0.41	24	0.46	D	2
13.		$^3D - {}^3P°$											
			2346.79	38426	81024	7	5	3.3	0.20	11	0.14	D	2
			2339.00	38199	80939	5	3	3.0	0.15	5.7	−0.13	D	2
			2331.35	38064	80945	3	1	4.3	0.12	2.7	−0.46	D	2
			2334.34	38199	81024	5	5	0.77	0.063	2.4	−0.50	D	2
			2331.66	38064	80939	3	3	1.2	0.10	2.3	−0.52	D	2
14.		$^1D - {}^1D°$	2984.75	41704	75198	5	5	1.9	0.26	13	0.11	D	2
15.		$^1D - {}^1F°$	2413.99	41704	83117	5	7	3.8	0.47	19	0.37	D	2
16.		$^1D - {}^1P°$	2374.99	41704	83797	5	3	4.0	0.20	8.0	0.01	D	2
17.	$3d4p-3d4d$	$^3P° - {}^3D$											
			2097.30	81024	128690	5	7	3.3	0.30	10	0.18	D	2
			2099.86	80939	128546	3	5	2.5	0.28	5.7	−0.08	D	2
			2105.09	80945	128433	1	3	1.7	0.34	2.3	−0.47	D	2
			2103.60	81024	128546	5	5	0.56	0.037	1.3	−0.73	D	2
			2104.86	80939	128433	3	3	1.1	0.076	1.6	−0.64	D	2
18.		$^3P° - {}^3S$	*2009.3*	*80987*	130740	9	3	10	0.20	12	0.26	D	2
			2010.80	81024	130740	5	3	5.4	0.20	6.5	−0.01	D	2
			2007.36	80939	130740	3	3	3.4	0.21	4.1	−0.21	D	2
			2007.60	80945	130740	1	3	1.2	0.22	1.4	−0.66	D	2
19.		$^1F° - {}^1F$	2237.77	83117	127791	7	7	2.4	0.18	9.3	0.10	D	2
20.		$^1P° - {}^1P$	2199.22	83797	129253	3	3	5.7	0.41	8.9	0.09	D	2
21.	$3d4d-3d4f$	$^1F - {}^1G°$	3278.31	127791	158285	7	9	3.4	0.70	53	0.69	D	2
22.		$^3D - {}^1G°$											
			3377.90	128690	158285	7	9	0.075	0.016	1.3	−0.94	D	2
23.		$^3D - {}^3F°$											
			3320.94	128433	158537	3	5	2.8	0.76	25	0.36	D	2
			3333.46	128546	158537	5	5	0.20	0.033	1.8	−0.78	D	2
24.		$^3D - {}^3D°$											
			3228.89	128433	159395	3	3	1.5	0.23	7.4	−0.16	D	2
			3240.71	128546	159395	5	3	0.37	0.035	1.9	−0.76	D	2

Ti III: Allowed transitions — Continued

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} (10^8 s^{-1})	f_{ik}	S (at. u.)	log gf	Accuracy	Source
25.		$^3D - {^3P^\circ}$											
			3193.77	128690	159992	7	5	0.38	0.041	3.0	−0.54	D	2
			3167.83	128546	160105	5	3	0.34	0.030	1.6	−0.82	D	2
26.		$^3G - {^3G^\circ}$											
			3396.43	129469	158904	11	11	0.47	0.081	10	−0.05	D	2
			3371.62	129253	158904	9	11	0.48	0.099	9.9	−0.05	D	2
27.		$^3G - {^3H^\circ}$											
			3354.71	129469	159270	11	13	4.4	0.87	110	0.98	D	2
			3346.18	129253	159129	9	11	3.7	0.75	74	0.83	D	2
			3340.20	129093	159023	7	9	3.7	0.79	60	0.74	D	2
			3370.63	129469	159129	11	11	0.36	0.061	7.5	−0.17	D	2
			3358.10	129253	159023	9	9	0.40	0.067	6.7	−0.22	D	2
28.		$^3G - {^1H^\circ}$											
			3245.59	129253	160055	9	11	0.060	0.012	1.1	−0.98	D	2
29.		$^1P - {^1P^\circ}$	3066.51	129253	161854	3	3	2.5	0.36	11	0.03	D	2
30.		$^3S - {^3P^\circ}$	*3410.9*	130740	*160049*	3	9	1.8	0.95	32	0.45	D	2
			3417.62	130740	159992	3	5	1.9	0.54	18	0.21	D	2
			3404.46	130740	160105	3	3	1.8	0.31	10	−0.03	D	2
			3397.24	130740	160167	3	1	1.8	0.10	3.5	−0.51	D	2
31.		$^3F - {^1G^\circ}$											
			3986.40	133207	158285	7	9	0.21	0.064	5.9	−0.35	D	2
32.		$^3F - {^3F^\circ}$											
			3924.86	133065	158537	5	5	0.74	0.17	11	−0.07	D	2
33.		$^3F - {^3G^\circ}$											
			3915.47	133371	158904	9	11	2.1	0.58	68	0.72	D	2
34.		$^3F - {^3H^\circ}$											
			3881.21	133371	159129	9	11	0.17	0.046	5.3	−0.38	D	2
			3872.50	133207	159023	7	9	0.16	0.045	4.0	−0.50	D	2
35.		$^3P - {^1D^\circ}$											
			4250.09	135601	159124	3	5	0.95	0.43	18	0.11	D	2
36.		$^3P - {^3D^\circ}$											
			4191.09	135541	159395	1	3	0.80	0.63	8.7	−0.20	D	2
			4201.66	135601	159395	3	3	0.42	0.11	4.6	−0.48	D	2
37.		$^3P - {^3P^\circ}$											
			4119.14	135722	159992	5	5	0.99	0.25	17	0.10	D	2
			4079.96	135601	160105	3	3	0.42	0.11	4.2	−0.50	D	2
			4100.05	135722	160105	5	3	0.48	0.073	4.9	−0.44	D	2
			4098.88	135601	159992	3	5	0.085	0.036	1.4	−0.97	D	2
			4069.99	135541	160105	1	3	0.24	0.18	2.4	−0.75	D	2

Ti III: Allowed transitions — Continued

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} ($10^8 s^{-1}$)	f_{ik}	S (at. u.)	log gf	Accuracy	Source
38.		$^1G - ^1G^\circ$	4555.46	136340	158285	9	9	0.23	0.070	9.5	−0.20	D	2
39.		$^1G - ^1H^\circ$	4215.53	136340	160055	9	11	2.2	0.70	88	0.80	D	2
40.		$^1S - ^1P^\circ$	4578.52	140019	161854	1	3	0.79	0.74	11	−0.13	D	2
41.	$3d4d-3d5p$	$^1F - ^1D^\circ$	5147.31	127791	147213	7	5	0.56	0.16	19	0.05	D	2
42.		$^3D - ^3D^\circ$											
			5226.28	128433	147562	3	3	0.31	0.13	6.5	−0.42	D	2
			5257.33	128546	147562	5	3	0.082	0.020	1.8	−0.99	D	2
43.		$^3D - ^3F^\circ$											
			5069.39	128690	148410	7	9	0.033	0.016	1.9	−0.94	D	2
44.		$^3D - ^3P^\circ$											
			4858.13	128690	149268	7	5	0.42	0.11	12	−0.13	D	2
			4892.84	128546	148979	5	3	0.33	0.071	5.7	−0.45	D	2
			4856.22	128433	149020	3	1	0.47	0.055	2.7	−0.78	D	2
45.		$^3G - ^3F^\circ$											
			5278.12	129469	148410	11	9	0.79	0.27	51	0.47	D	2
			5218.43	129253	148410	9	9	0.038	0.015	2.4	−0.86	D	2
46.		$^1P - ^1D^\circ$	5566.58	129253	147213	3	5	0.057	0.044	2.4	−0.88	D	2
47.		$^1P - ^3P^\circ$											
			5068.22	129253	148979	3	3	0.11	0.041	2.1	−0.91	D	2
48.		$^1P - ^1P^\circ$	4961.36	129253	149404	3	3	0.45	0.17	8.2	−0.30	D	2
49.		$^3S - ^3P^\circ$											
			5395.69	130740	149268	3	5	0.19	0.14	7.4	−0.38	D	2
			5481.31	130740	148979	3	3	0.13	0.061	3.3	−0.74	D	2
50.		$^3F - ^3D^\circ$											
			6896.12	133065	147562	5	3	0.26	0.11	12	−0.26	D	2
51.		$^3F - ^3F^\circ$											
			6647.47	133371	148410	9	9	0.10	0.067	13	−0.22	D	2
52.		$^1D - ^1P^\circ$	7141.76	135405	149404	5	3	0.49	0.22	26	0.05	D	2
53.		$^1D - ^1F^\circ$	7015.38	135405	149656	5	7	0.58	0.60	70	0.48	D	2
54.		$^3P - ^3P^\circ$											
			7379.96	135722	149268	5	5	0.13	0.11	13	−0.26	D	2
			7540.99	135722	148979	5	3	0.041	0.021	2.6	−0.98	D	2
			7450.45	135601	149020	3	1	0.16	0.044	3.2	−0.88	D	2
			7315.14	135601	149268	3	5	0.044	0.059	4.3	−0.75	D	2
55.		$^1G - ^1F^\circ$	7507.68	136340	149656	9	7	0.28	0.18	41	0.22	D	2

Ti III: Allowed transitions — Continued

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} (10^8 s^{-1})	f_{ik}	S (at. u.)	log gf	Accu-racy	Source
56.	$3d4f$–$3d5d$	$^1G^\circ$ – ^1G	7775.95	158285	171142	9	9	0.023	0.021	4.9	−0.72	D	2
57.		$^3F^\circ$ – ^3F											
			9024.05	158537	169615	5	5	0.034	0.042	6.2	−0.68	D	2
58.		$^3G^\circ$ – ^3F											
			9081.40	158904	169912	11	9	0.11	0.11	36	0.08	D	2
59.		$^3H^\circ$ – ^3F											
			9271.12	159129	169912	11	9	0.010	0.011	3.6	−0.93	D	2
60.		$^1H^\circ$ – ^1G	9017.10	160055	171142	11	9	0.15	0.15	48	0.21	D	2
61.	$3d4f$–$3d(^2D_{3/2})5g$	$^1G^\circ$ – $^2[9/2]$											
			4213.26	158285	182013	9	11	2.2	0.70	88	0.80	D	2
			4212.95	158285	182015	9	9	0.13	0.034	4.2	−0.52	D	2
62.		$^3F^\circ$ – $^2[7/2]$											
			4248.54	158537	182067	5	7	2.3	0.87	61	0.64	D	2
63.		$^3F^\circ$ – $^2[5/2]$											
			4220.28	158537	182225	5	5	0.42	0.11	7.8	−0.25	D	2
64.		$^3G^\circ$ – $^2[9/2]$											
			4325.93	158904	182013	11	11	0.066	0.019	2.9	−0.69	D	2
65.		$^3G^\circ$ – $^2[11/2]$											
			4296.70	158904	182171	11	13	1.6	0.54	83	0.77	D	2
66.		$^3H^\circ$ – $^2[9/2]$											
			4368.56	159129	182013	11	11	0.10	0.029	4.7	−0.49	D	2
67.		$^3H^\circ$ – $^2[11/2]$											
			4319.56	159023	182167	9	11	1.1	0.39	49	0.54	D	2
68.		$^3D^\circ$ – $^2[5/2]$											
			4378.94	159395	182225	3	5	1.6	0.75	32	0.35	D	2
69.		$^3P^\circ$ – $^2[5/2]$											
			4496.51	159992	182225	5	7	0.37	0.16	12	−0.10	D	2
			4519.42	160105	182225	3	5	0.16	0.082	3.7	−0.61	D	2
70.		$^1H^\circ$ – $^2[11/2]$											
			4520.38	160055	182171	11	13	0.48	0.17	28	0.28	D	2
			4521.15	160055	182167	11	11	0.044	0.013	2.2	−0.83	D	2

Ti III: Allowed transitions — Continued

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} ($10^8 s^{-1}$)	f_{ik}	S (at. u.)	log gf	Accuracy	Source
71.		$^1P^\circ - ^2[^5/_2]$											
			4907.61	161854	182225	3	5	0.29	0.17	8.5	−0.28	D	2
72.	$3d4f-3d(^2D_{5/2})5g$	$^1G^\circ - ^2[^9/_2]$											
			4145.05	158285	182404	9	11	0.077	0.024	3.0	−0.66	D	2
			4144.77	158285	182405	9	9	0.094	0.024	3.0	−0.66	D	2
73.		$^1G^\circ - ^2[^{11}/_2]$											
			4139.42	158285	182436	9	11	0.32	0.10	12	−0.04	D	2
74.		$^3F^\circ - ^2[^7/_2]$											
			4176.54	158537	182473	5	7	0.17	0.062	4.2	−0.51	D	2
75.		$^3G^\circ - ^2[^9/_2]$											
			4254.11	158904	182404	11	11	0.43	0.12	18	0.11	D	2
76.		$^3G^\circ - ^2[^{11}/_2]$											
			4247.62	158904	182440	11	13	1.1	0.36	56	0.60	D	2
77.		$^3G^\circ - ^2[^{13}/_2]$											
			4218.52	158904	182602	11	13	0.037	0.012	1.8	−0.89	D	2
78.		$^3H^\circ - ^2[^9/_2]$											
			4275.53	159023	182405	9	9	0.23	0.062	7.9	−0.25	D	2
79.		$^3H^\circ - ^2[^{11}/_2]$											
			4288.66	159129	182440	11	13	1.1	0.37	58	0.61	D	2
			4269.84	159023	182436	9	11	1.7	0.56	70	0.70	D	2
			4289.25	159129	182436	11	11	0.21	0.059	9.1	−0.19	D	2
80.		$^3H^\circ - ^2[^{13}/_2]$											
			4285.61	159270	182597	13	15	3.0	0.95	170	1.09	D	2
			4259.01	159129	182602	11	13	0.94	0.30	46	0.52	D	2
			4284.67	159270	182602	13	13	0.038	0.010	1.9	−0.87	D	2
81.		$^3D^\circ - ^2[^5/_2]$											
			4310.48	159395	182588	3	5	0.35	0.16	7.0	−0.31	D	2
82.		$^3D^\circ - ^2[^3/_2]$											
			4293.34	159395	182680	3	3	0.31	0.086	3.6	−0.59	D	2
83.		$^3P^\circ - ^2[^5/_2]$											
			4424.40	159992	182587	5	7	0.15	0.062	4.5	−0.51	D	2
			4446.56	160105	182588	3	5	0.60	0.30	13	−0.05	D	2

Ti III: Allowed transitions — Continued

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} ($10^8 s^{-1}$)	f_{ik}	S (at. u.)	log gf	Accuracy	Source
84.		$^3P° - {}^2[^3/_2]$											
			4440.66	160167	182680	1	3	1.2	1.0	15	0.01	D	2
			4406.20	159992	182681	5	5	0.51	0.15	11	−0.13	D	2
85.		$^1H° - {}^2[^{11}/_2]$											
			4466.08	160055	182440	11	13	0.38	0.13	22	0.17	D	2
			4466.69	160055	182436	11	11	0.12	0.037	6.0	−0.39	D	2
86.		$^1H° - {}^2[^{13}/_2]$											
			4433.91	160055	182602	11	13	1.8	0.63	100	0.84	D	2
87.		$^1P° - {}^2[^5/_2]$											
			4821.80	161854	182588	3	5	0.49	0.28	14	−0.07	D	2
88.		$^1P° - {}^2[^3/_2]$											
			4800.27	161854	182681	3	5	0.84	0.48	23	0.16	D	2
89.	$3d5s-3d5p$	$^3D - {}^1D°$											
			7566.25	134000	147213	5	5	0.089	0.076	9.5	−0.42	D	2
			7508.65	133899	147213	3	5	0.044	0.062	4.6	−0.73	D	2
90.		$^3D - {}^3D°$											
			7316.68	133899	147562	3	3	0.36	0.29	21	−0.06	D	2
			7371.34	134000	147562	5	3	0.16	0.078	9.4	−0.41	D	2
91.		$^3D - {}^3F°$											
			7072.64	134275	148410	7	9	0.58	0.56	91	0.59	D	2
92.		$^3D - {}^3P°$											
			6667.99	134275	149268	7	5	0.55	0.26	40	0.26	D	2
			6674.19	134000	148979	5	3	0.40	0.16	17	−0.10	D	2
			6611.38	133899	149020	3	1	0.71	0.16	10	−0.33	D	2
			6547.75	134000	149268	5	5	0.13	0.081	8.8	−0.39	D	2
			6629.37	133899	148979	3	3	0.21	0.14	9.1	−0.38	D	2
93.		$^3D - {}^1P°$											
			6490.14	134000	149404	5	3	0.084	0.032	3.4	−0.80	D	2
94.		$^1D - {}^3P°$											
			6932.44	134558	148979	5	3	0.048	0.021	2.4	−0.98	D	2
95.	$3d5p-3d5d$	$^1D° - {}^1F$	4874.00	147213	167724	5	7	1.5	0.73	58	0.56	D	2
96.		$^1D° - {}^3D$											
			4831.33	147213	167905	5	3	0.20	0.042	3.3	−0.68	D	2
97.		$^1D° - {}^1P$	4731.11	147213	168344	5	3	0.36	0.073	5.7	−0.44	D	2

Ti III: Allowed transitions — Continued

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} (10^8 s^{-1})	f_{ik}	S (at. u.)	log gf	Accuracy	Source
98.		$^1D^\circ - {}^3F$											
			4462.56	147213	169615	5	5	0.41	0.12	9.1	−0.21	D	2
99.		$^3D^\circ - {}^3D$											
			4914.32	147562	167905	3	3	1.1	0.38	19	0.06	D	2
			4884.32	147562	168030	3	5	0.20	0.12	5.8	−0.44	D	2
100.		$^3D^\circ - {}^3F$											
			4533.26	147562	169615	3	5	1.5	0.78	35	0.37	D	2
101.		$^3D^\circ - {}^3P$											
			4343.25	147562	170580	3	1	1.0	0.094	4.0	−0.55	D	2
			4328.25	147562	170660	3	3	0.13	0.037	1.6	−0.95	D	2
102.		$^3F^\circ - {}^3G$											
			4971.19	148410	168521	9	11	2.1	0.97	140	0.94	D	2
			5024.52	148410	168307	9	9	0.10	0.039	5.7	−0.46	D	2
103.		$^3F^\circ - {}^3F$											
			4649.45	148410	169912	9	9	0.86	0.28	38	0.40	D	2
			4680.58	148410	169769	9	7	0.083	0.021	2.9	−0.72	D	2
104.		$^3P^\circ - {}^3D$											
			5247.49	148979	168030	3	5	0.50	0.34	18	0.01	D	2
			5293.60	149020	167905	1	3	0.31	0.39	6.8	−0.41	D	2
			5328.40	149268	168030	5	5	0.092	0.039	3.4	−0.71	D	2
			5282.14	148979	167905	3	3	0.25	0.11	5.5	−0.50	D	2
105.		$^3P^\circ - {}^1P$											
			5162.55	148979	168344	3	3	0.31	0.12	6.3	−0.43	D	2
106.		$^3P^\circ - {}^3S$	*5051.9*	*149144*	168933	9	3	1.7	0.21	32	0.28	D	2
			5083.80	149268	168933	5	3	0.97	0.22	19	0.05	D	2
			5010.14	148979	168933	3	3	0.43	0.16	8.1	−0.31	D	2
			5020.43	149020	168933	1	3	0.25	0.28	4.7	−0.55	D	2
107.		$^3P^\circ - {}^3P$											
			4611.04	148979	170660	3	3	0.37	0.12	5.4	−0.45	D	2
			4673.40	149268	170660	5	3	0.91	0.18	14	−0.05	D	2
			4628.07	148979	170580	3	1	1.5	0.16	7.3	−0.32	D	2
			4619.78	149020	170660	1	3	0.56	0.54	8.2	−0.27	D	2
108.		$^1P^\circ - {}^3D$											
			5367.17	149404	168030	3	5	0.064	0.046	2.4	−0.86	D	2
109.		$^1P^\circ - {}^1P$	5278.33	149404	168344	3	3	0.94	0.39	20	0.07	D	2
110.		$^1P^\circ - {}^3S$											
			5119.08	149404	168933	3	3	0.39	0.15	7.7	−0.34	D	2

Ti III: Allowed transitions — Continued

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} (10^8 s^{-1})	f_{ik}	S (at. u.)	log gf	Accuracy	Source
111.		$^1P° - {}^3P$											
			4720.90	149404	170580	3	1	0.31	0.035	1.6	−0.98	D	2
112.		$^1P° - {}^1S$	4352.28	149404	172374	3	1	0.27	0.26	11	−0.11	D	2
113.		$^1F° - {}^1F$	5533.01	149656	167724	7	7	0.41	0.19	24	0.12	D	2
114.		$^1F° - {}^1G$	4652.86	149656	171142	7	9	2.6	1.1	120	0.88	D	2
115.	$3d5p-3d6s$	$^1D° - {}^3D$											
			4400.57	147213	169931	5	5	0.34	0.098	7.1	−0.31	D	2
116.		$^3D° - {}^3D$											
			4480.36	147562	169876	3	3	0.73	0.22	9.7	−0.18	D	2
117.		$^3F° - {}^3D$											
			4576.53	148410	170255	9	7	1.3	0.31	42	0.45	D	2
118.		$^3P° - {}^3D$											
			4763.58	149268	170255	5	7	0.50	0.24	19	0.08	D	2
			4771.46	148979	169931	3	5	0.34	0.19	9.0	−0.24	D	2
			4793.50	149020	169876	1	3	0.29	0.30	4.8	−0.52	D	2
			4838.25	149268	169931	5	5	0.12	0.044	3.5	−0.66	D	2
			4784.09	148979	169876	3	3	0.26	0.090	4.2	−0.57	D	2
119.		$^1F° - {}^1D$	4849.66	149656	170270	7	5	0.11	0.028	3.1	−0.71	D	2
120.	$3d5d-3d5f$	$^1F - {}^1G°$	7408.13	167724	181219	7	9	0.87	0.92	160	0.81	D	2
121.		$^1F - {}^3H°$											
			7288.98	167724	181440	7	9	0.061	0.062	10	−0.36	D	2
122.		$^1F - {}^3G°$											
			7252.88	167724	181508	7	7	0.14	0.11	19	−0.10	D	2
123.		$^1F - {}^1F°$	7071.93	167724	181861	7	7	0.22	0.16	27	0.06	D	2
124.		$^3D - {}^3F°$											
			7495.18	168030	181368	5	7	0.57	0.68	84	0.53	D	2
			7441.72	167905	181339	3	5	0.74	1.0	76	0.49	D	2
			7511.59	168030	181339	5	5	0.039	0.033	4.1	−0.78	D	2
125.		$^3D - {}^3G°$											
			7417.60	168030	181508	5	7	0.18	0.20	25	0.01	D	2
126.		$^3D - {}^1F°$											
			7228.40	168030	181861	5	7	0.036	0.039	4.6	−0.71	D	2
127.		$^3D - {}^3D°$											
			7203.66	168030	181908	5	5	0.34	0.26	31	0.12	D	2

Ti III: Allowed transitions — Continued

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} (10^8 s^{-1})	f_{ik}	S (at. u.)	log gf	Accuracy	Source
128.		^{3}D - ^{3}P°											
			7017.31	168030	182277	5	3	0.12	0.051	5.9	−0.59	D	2
129.		^{3}G - ^{1}G°											
			7742.64	168307	181219	9	9	0.047	0.042	9.7	−0.42	D	2
130.		^{3}G - ^{3}H°											
			7506.87	168521	181838	11	13	1.1	1.1	310	1.10	D	2
			7544.29	168307	181558	9	11	0.93	0.97	220	0.94	D	2
131.		^{3}G - ^{3}G°											
			7515.98	168521	181822	11	11	0.23	0.19	53	0.33	D	2
			7432.20	168307	181758	9	9	0.15	0.12	27	0.05	D	2
			7552.05	168521	181758	11	9	0.019	0.013	3.6	−0.84	D	2
			7397.27	168307	181822	9	11	0.16	0.16	35	0.16	D	2
132.		^{1}P - ^{1}D°	7484.58	168344	181701	3	5	0.56	0.78	58	0.37	D	2
133.		^{1}P - ^{3}D°											
			7370.14	168344	181908	3	5	0.11	0.15	11	−0.34	D	2
134.		^{1}P - ^{1}P°	7031.40	168344	182562	3	3	0.50	0.37	26	0.05	D	2
135.		^{3}S - ^{3}D°											
			7704.80	168933	181908	3	5	0.087	0.13	9.9	−0.41	D	2
136.		^{3}S - ^{3}P°	*7510.5*	168933	*182244*	3	9	0.41	1.0	77	0.49	D	2
			7531.15	168933	182207	3	5	0.45	0.64	47	0.28	D	2
			7491.92	168933	182277	3	3	0.34	0.28	21	−0.07	D	2
			7460.04	168933	182334	3	1	0.44	0.12	8.9	−0.44	D	2
137.		^{3}S - ^{1}P°											
			7335.41	168933	182562	3	3	0.13	0.11	7.6	−0.50	D	2
138.		^{3}F - ^{1}G°											
			8731.24	169769	181219	7	9	0.064	0.094	19	−0.18	D	2
139.		^{3}F - ^{3}F°											
			8544.89	169912	181612	9	9	0.10	0.11	28	0.00	D	2
			8618.79	169769	181368	7	7	0.051	0.057	11	−0.40	D	2
			8527.03	169615	181339	5	5	0.22	0.24	34	0.08	D	2
			8505.88	169615	181368	5	7	0.26	0.40	56	0.30	D	2
140.		^{3}F - ^{3}H°											
			8584.05	169912	181558	9	11	0.12	0.17	43	0.18	D	2
			8566.24	169769	181440	7	9	0.12	0.17	34	0.08	D	2

Ti III: Allowed transitions — Continued

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} ($10^8 s^{-1}$)	f_{ik}	S (at. u.)	log gf	Accuracy	Source
141.		$^3F - {^3G^\circ}$											
			8394.20	169912	181822	9	11	0.56	0.72	180	0.81	D	2
			8338.54	169769	181758	7	9	0.42	0.57	110	0.60	D	2
			8406.15	169615	181508	5	7	0.34	0.50	70	0.40	D	2
			8439.19	169912	181758	9	9	0.15	0.16	40	0.16	D	2
			8516.40	169769	181508	7	7	0.13	0.14	28	0.00	D	2
142.		$^3F - {^1F^\circ}$											
			8164.06	169615	181861	5	7	0.029	0.040	5.4	−0.70	D	2
143.		$^3F - {^3D^\circ}$											
			8252.85	169912	182026	9	7	0.021	0.016	4.0	−0.83	D	2
			8235.58	169769	181908	7	5	0.043	0.031	5.9	−0.66	D	2
144.		$^3P - {^3D^\circ}$											
			8887.71	170660	181908	3	5	0.23	0.45	39	0.13	D	2
145.		$^3P - {^3P^\circ}$											
			8605.75	170660	182277	3	3	0.22	0.24	21	−0.14	D	2
			8563.50	170660	182334	3	1	0.43	0.16	13	−0.33	D	2
146.		$^1G - {^1H^\circ}$	8916.95	171142	182353	9	11	0.68	0.99	260	0.95	D	2

[a]The number in parentheses following the tabulated value indicates the power of ten by which this value has to be multiplied.

Ti III

Forbidden Transitions

List of tabulated lines

Wavelength (Å)	No.	Wavelength (Å)	No.	Wavelength (Å)	No.	Wavelength (Å)	No.
2397.1	12	3207.7	16	3661.1	18	9595.5	3
2407.8	12	3214.4	16	4160.6	17	9705.3	3
2421.5	12	3226.6	16	4165.1	8	10833	19
2601.6	11	3337.7	13	4200.3	17	11798	2
2614.2	11	3363.2	13	4570.8	10	12061	2
2617.1	11	3378.5	13	4595.5	10	12414	2
2626.3	11	3593.2	15	6943.7	4	16876	7
2629.8	11	3608.5	15	7034.0	4	44478	6
2630.4	11	3614.2	15	7152.5	4	46933	6
2639.2	11	3622.8	15	9324.8	3	424500	1
2646.2	11	3638.3	15	9428.2	3	540700	1
3008.4	14	3640.5	15	9486.5	3	850100	9
3078.4	5	3656.2	15	9488.4	3	1533000	9

For this ion, we selected the work of Warner and Kirkpatrick,[1] and that of Beck.[2] Warner and Kirkpatrick used a single-configuration approximation and calculated radial integrals with scaled Thomas-Fermi wavefunctions. They provided M1 and E2 transition probabilities for numerous lines within the $3d^2$ (ground) configuration and in the $3d^2$–$3d4s$ transition array. Beck, on the other hand, calculated electric quadrupole transition probabilities using restricted Hartree-Fock and correlated wavefunctions. He provided both length and velocity results for the following transitions: $3d^2\ ^3$F - $3d^2\ ^3$P and $3d^2$ ^{3}F -$3d4s\ ^3$D. In this compilation, we have tabulated data for the stronger lines of Ref. 1 and A-values derived from correlated wavefunctions of Ref. 2 using the dipole length transition operator.

The data of Ref. 2 should be more reliable, since the principal configuration interaction effects are included. For long-wavelength lines within the $3d^2\ ^3$F and $3d^2\ ^3$P terms, we have recalculated Warner and Kirkpatrick's A-values by using observed energy-level data instead of theoretically derived values.

References

[1]B. Warner and R. C. Kirkpatrick, Mon. Not. R. Astron. Soc. **144**, 397 (1969).

[2]D. R. Beck, Phys. Rev. A **23**, 159 (1981).

Ti III: Forbidden transitions

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	Type of transition	A_{ki} (s^{-1})	S (at. u.)	Accuracy	Source
1.	$3d^2$–$3d^2$	^{3}F - ^{3}F										
			[424500]	184.9	420.4	7	9	M1	2.5(−4)[a]	6.4	C	1*n*
			[540700]	0.0	184.9	5	7	M1	1.6(−4)	6.6	C	1*n*
2.		^{3}F - ^{1}D (1F)										
			[12414]	420.4	8473.5	9	5	E2	4.2(−5)	0.037	E	1
			[12061]	184.9	8473.5	7	5	M1	0.010	0.0033	E	1
			[11798]	0.0	8473.5	5	5	M1	0.0054	0.0016	E	1
3.		^{3}F - ^{3}P (2F)										
			[9705.3]	420.4	10721	9	5	E2	0.023	5.9	E	2
			[9595.5]	184.9	10604	7	3	E2	0.021	3.1	E	2
			[9486.5]	0.0	10538	5	1	E2	0.034	1.6	E	2
			[9488.4]	184.9	10721	7	5	M1	6.8(−5)	1.1(−5)	E	1
			"	"	"	7	5	E2	0.0068	1.6	E	2
			[9428.2]	0.0	10604	5	3	E2	0.012	1.6	E	2
			[9324.8]	0.0	10721	5	5	M1	1.2(−5)	1.8(−6)	E	1
			"	"	"	5	5	E2	0.0011	0.23	E	2
4.		^{3}F - ^{1}G (3F)										
			[7152.5]	420.4	14398	9	9	M1	0.0068	8.3(−4)	E	1
			[7034.0]	184.9	14398	7	9	M1	0.0043	5.0(−4)	E	1
			[6943.7]	0.0	14398	5	9	E2	1.6(−5)	0.0014	E	1
5.		^{3}F - ^{1}S										
			[3078.4]	0.0	32476	5	1	E2	0.0042	6.9(−4)	E	1
6.		^{1}D - ^{3}P										
			[44478]	8473.5	10721	5	5	M1	0.0025	0.041	E	1
			[46933]	8473.5	10604	5	3	M1	0.0012	0.014	E	1
7.		^{1}D - ^{1}G	[16876]	8473.5	14398	5	9	E2	3.7(−4)	2.7	E	1

Ti III: Forbidden transitions

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	Type of transition	A_{ki} (s^{-1})	S (at. u.)	Accu-racy	Source
8.		^{1}D - ^{1}S	[4165.1]	8473.5	32476	5	1	E2	4.9	3.7	E	1
9.		^{3}P - ^{3}P										
			[850100]	10604	10721	3	5	M1	1.5(−5)	1.7	C	1n
			[1533000]	10538	10604	1	3	M1	5.5(−6)	2.2	C	1n
10.		^{3}P - ^{1}S										
			[4595.5]	10721	32476	5	1	E2	0.020	0.024	E	1
			[4570.8]	10604	32476	3	1	M1	0.10	3.5(−4)	E	1
11.	$3d^2$–$3d4s$	^{3}F - ^{3}D										
			[2646.2]	420.4	38199	9	5	E2	11	4.2	E	2
			[2639.2]	184.9	38064	7	3	E2	17	3.9	E	2
			[2630.4]	420.4	38426	9	7	E2	40	21	E	2
			[2629.8]	184.9	38199	7	5	E2	26	9.7	E	2
			[2626.3]	0.0	38064	5	3	E2	35	7.8	E	2
			[2614.2]	184.9	38426	7	7	E2	12	6.1	E	2
			[2617.1]	0.0	38199	5	5	E2	15	5.5	E	2
			[2601.6]	0.0	38426	5	7	E2	1.1	0.55	E	2
12.		^{3}F - ^{1}D										
			[2421.5]	420.4	41704	9	5	E2	0.013	0.0032	E	1
			[2407.8]	184.9	41704	7	5	E2	0.092	0.022	E	1
			[2397.1]	0.0	41704	5	5	E2	0.0051	0.0012	E	1
13.		^{1}D - ^{3}D (4F)										
			[3337.7]	8473.5	38426	5	7	E2	0.025	0.043	E	1
			[3363.2]	8473.5	38199	5	5	E2	0.062	0.079	E	1
			[3378.5]	8473.5	38064	5	3	E2	0.023	0.018	E	1
14.		^{1}D - ^{1}D (5F)	[3008.4]	8473.5	41704	5	5	E2	17	12	E	1
15.		^{3}P - ^{3}D (6F)										
			[3593.2]	10604	38426	3	7	E2	1.4	3.5	E	1
			[3614.2]	10538	38199	1	5	E2	1.3	2.4	E	1
			[3608.5]	10721	38426	5	7	E2	2.7	6.9	E	1
			[3622.8]	10604	38199	3	5	E2	0.33	0.61	E	1
			[3638.3]	10721	38199	5	5	E2	2.2	4.2	E	1
			[3640.5]	10604	38064	3	3	E2	2.9	3.3	E	1
			[3656.2]	10721	38064	5	3	E2	0.94	1.1	E	1
16.		^{3}P - ^{1}D (7F)										
			[3226.6]	10721	41704	5	5	E2	0.13	0.14	E	1
			[3214.4]	10604	41704	3	5	E2	0.0015	0.0015	E	1
			[3207.7]	10538	41704	1	5	E2	0.0034	0.0034	E	1
17.		^{1}G - ^{3}D (10F)										
			[4200.3]	14398	38199	9	5	E2	0.013	0.051	E	1
			[4160.6]	14398	38426	9	7	E2	2.6(−4)	0.0014	E	1

Ti III: Forbidden transitions — Continued

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	Type of transition	A_{ki} (s^{-1})	S (at. u.)	Accuracy	Source
18.		^{1}G - ^{1}D (11F)	[3661.1]	14398	41704	9	5	E2	11	22	E	1
19.		^{1}S - ^{1}D	[10833]	32476	41704	1	5	E2	0.0055	2.4	E	1

[a]The number in parentheses following the tabulated value indicates the power of ten by which this value has to be multiplied.

Ti IV

K Isoelectronic Sequence

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

Ionization Energy: 43.2675 eV = 348973 cm^{-1}

Allowed Transitions

List of tabulated lines

Wavelength (Å)	No.	Wavelength (Å)	No.	Wavelength (Å)	No.	Wavelength (Å)	No.
423.49	2	763.84	8	1469.19	6	2957.31	11
424.16	2	768.42	8	2067.56	4	3541.36	14
424.17	2	768.65	8	2103.16	4	3576.44	14
433.04	3	776.762	1	2541.79	10	3581.39	14
433.63	3	779.074	1	2546.88	10	4395.92	12
433.76	3	781.730	1	2547.31	10	4397.33	12
664.30	5	1183.64	7	2836.97	15	4403.45	12
665.69	5	1195.21	7	2862.60	15	5398.93	13
725.03	9	1451.74	6	2929.96	11	5492.51	13
729.36	9	1467.34	6	2937.33	11		

For this relatively simple alkali-like spectrum, we have used the compilation of Kurucz and Peytremann,[1] who calculated gf-values by a semiempirical, scaled Thomas-Fermi-Dirac approach. These data are in excellent agreement with the Hartree-Fock calculations of Biemont[2] and the Coulomb approximation.[3] Since, starting with Ti IV, the $3p^53d^2$ configuration moves below the first ionization limit, increased configuration interaction is expected, especially for transitions arising from higher upper levels. Because of the likelihood of configuration mixing effects, we have omitted all lines having upper levels near or greater than 275000 cm^{-1}.

Our tabulated data can be compared to the recent beam-foil lifetimes of Baudinet-Robinet *et al.*[4] and Dumont *et al.*[5] The authors of Refs. 4 and 5 derived their published lifetimes from a complex analysis of their raw data, via various curve-fitting techniques. These data are very consistent with our adopted absolute scale.

References

[1]R. L. Kurucz and E. Peytremann, Smithsonian Astrophysical Observatory Special Report 362 (1975).

[2]E. Biemont, Physica C **81**, 158 (1976).

[3]D. R. Bates and A. Damgaard, Philos. Trans. Roy. Soc. London, Ser. A **242**, 101 (1949).

[4]Y. Baudinet-Robinet, P. D. Dumont, H. P. Garnir, N. Grevesse, and E. Biemont, J. Opt. Soc. Am. **70**, 464 (1980).

[5]P. D. Dumont, H. P. Garnir, Y. Baudinet-Robinet, and M. Kapenyak, J. Opt. Soc. Am. **71**, 502 (1981).

Ti IV: Allowed transitions — Continued

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} (10^8 s^{-1})	f_{ik}	S (at. u.)	log gf	Accuracy	Source
1.	$3d$–$4p$	^{2}D – ^{2}P°	*779.80*	*229.3*	*128467*	10	6	14	0.078	2.0	−0.11	D	1
2.	$3d$–$4f$	^{2}D – ^{2}F°	*423.89*	*229.3*	*236139*	10	14	53	0.20	2.8	0.30	D	1
			[424.16]	382.1	236142	6	8	53	0.19	1.6	0.06	D	1
			[423.49]	0.0	236135	4	6	49	0.20	1.1	−0.10	D	1
			[424.17]	382.1	236135	6	6	3.6	0.0096	0.080	−1.24	D−	1
3.	$3d$–$5p$	^{2}D – ^{2}P°	*433.67*	*229.3*	*230819*	10	6	5.4	0.0091	0.13	−1.04	D−	1
			[433.76]	382.1	230924	6	4	5.0	0.0094	0.080	−1.25	D−	1
			[433.63]	0.0	230609	4	2	5.5	0.0077	0.044	−1.51	E	1
			[433.04]	0.0	230924	4	4	0.55	0.0015	0.0088	−2.21	E	1
4.	$4s$–$4p$	^{2}S – ^{2}P° (uv 2)	*2079.3*	80389	*128467*	2	6	5.3	1.0	14	0.31	D	1
			2067.56	80389	128740	2	4	5.1	0.66	9.0	0.12	D	1
			2103.16	80389	127921	2	2	5.0	0.33	4.6	−0.18	D	1
5.	$4s$–$5p$	^{2}S – ^{2}P°	*664.76*	80389	*230819*	2	6	0.74	0.015	0.064	−1.53	E	1
			[664.30]	80389	230924	2	4	0.70	0.0093	0.041	−1.73	E	1
			[665.69]	80389	230609	2	2	0.81	0.0054	0.023	−1.97	E	1
6.	$4p$–$4d$	^{2}P° – ^{2}D (uv 3)	*1462.2*	*128467*	*196856*	6	10	21	1.1	33	0.84	D	1
			1467.34	128740	196890	4	6	21	1.0	20	0.61	D	1
			1451.74	127921	196804	2	4	18	1.1	11	0.36	D	1
			1469.19	128740	196804	4	4	3.5	0.11	2.2	−0.34	D	1
7.	$4p$–$5s$	^{2}P° – ^{2}S	*1191.3*	*128467*	212407	6	2	20	0.14	3.4	−0.06	D	1
			1195.21	128740	212407	4	2	14	0.15	2.3	−0.23	D	1
			1183.64	127921	212407	2	2	6.9	0.14	1.1	−0.54	D	1
8.	$4p$–$5d$	^{2}P° – ^{2}D	*766.91*	*128467*	*258861*	6	10	1.5	0.022	0.34	−0.87	D	1
			[768.42]	128740	258877	4	6	1.5	0.019	0.20	−1.11	D−	1
			[763.84]	127921	258838	2	4	1.3	0.023	0.12	−1.33	D−	1
			[768.65]	128740	258838	4	4	0.25	0.0022	0.022	−2.06	E	1
9.	$4p$–$6s$	^{2}P° – ^{2}S	*727.91*	*128467*	265847	6	2	8.7	0.023	0.33	−0.86	D	1
			[729.36]	128740	265847	4	2	5.7	0.023	0.22	−1.04	D−	1
			[725.03]	127921	265847	2	2	2.8	0.022	0.11	−1.35	D−	1
10.	$4d$–$4f$	^{2}D – ^{2}F° (uv 4)	*2544.9*	*196856*	*236139*	10	14	7.3	0.99	83	1.00	D	1
			2546.88	196890	236142	6	8	7.4	0.96	48	0.76	D	1
			2541.79	196804	236135	4	6	6.9	1.0	33	0.60	D	1
			2547.31	196890	236135	6	6	0.49	0.048	2.4	−0.54	D	1

Ti IV: Allowed transitions — Continued

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} (10^8 s^{-1})	f_{ik}	S (at. u.)	log gf	Accuracy	Source
11.	$4d$-$5p$	^{2}D - ^{2}P°	*2943.5*	*196856*	*230819*	10	6	3.3	0.26	25	0.41	D	1
			2937.33	196890	230924	6	4	3.0	0.26	15	0.19	D	1
			2957.31	196804	230609	4	2	3.3	0.22	8.5	−0.06	D	1
			2929.96	196804	230924	4	4	0.34	0.043	1.7	−0.76	D	1
12.	$4f$-$5d$	^{2}F° - ^{2}D	*4399.8*	*236139*	*258861*	14	10	0.76	0.16	32	0.34	D	1
			4397.33	236142	258877	8	6	0.71	0.15	18	0.09	D	1
			4403.45	236135	258838	6	4	0.75	0.15	13	−0.06	D	1
			4395.92	236135	258877	6	6	0.035	0.010	0.89	−1.21	D−	1
13.	$5s$-$5p$	^{2}S - ^{2}P°	*5429.7*	212407	*230819*	2	6	1.0	1.3	48	0.43	D	1
			5398.93	212407	230924	2	4	1.0	0.91	32	0.26	D	1
			5492.51	212407	230609	2	2	0.99	0.45	16	−0.05	D	1
14.	$5p$-$5d$	^{2}P° - ^{2}D	*3565.1*	*230819*	*258861*	6	10	4.5	1.4	100	0.93	D	1
			3576.44	230924	258877	4	6	4.6	1.3	62	0.72	D	1
			3541.36	230609	258838	2	4	3.8	1.4	34	0.46	D	1
			3581.39	230924	258838	4	4	0.77	0.15	6.9	−0.23	D	1
15.	$5p$-$6s$	^{2}P° - ^{2}S	*2854.0*	*230819*	265847	6	2	6.1	0.25	14	0.17	D	1
			2862.60	230924	265847	4	2	4.1	0.25	9.4	−0.00	D	1
			2836.97	230609	265847	2	2	2.0	0.24	4.6	−0.31	D	1

Ti V

Ar Isoelectronic Sequence

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

Ionization Energy: 99.30 eV = 800900 cm^{-1}

Allowed Transitions

Line strengths for the $3p^6$–$3p^53d$ resonance transitions of this argon-like ion were interpolated from the superposition-of-configurations (SOC) calculations of Weiss,[1] which are expected to be fairly accurate.

Oscillator strengths for transitions of the $3p^6$–$3p^54s$ array were interpolated from the Dirac-Hartree-Fock data of Lin *et al.*,[2] who included correlation only in the lower state. Because the $3p^54s$ configuration lies slightly above $3p^53d$ in energy, it is possible that errors in the results of Lin *et al.* due to the exclusion of configuration interaction in the upper state are rather significant; hence the low accuracy ratings. The results of Ref. 2 for lines of the $3p^6$–$3p^54d$ array in nearby Ar-like species have not been interpolated to provide f-values for Ti V, since cancellation effects at or near V VI—one of the ions treated—introduce considerable uncertainty into the results at the low-Z end of the Ar sequence.

Lifetimes for a number of levels in Ti V have been measured by Baudinet-Robinet *et al.*[3] and Dumont *et al.*[4] using the beam-foil technique, but they could not be converted to transition probabilities since the branching ratios are not known.

References

[1]A. W. Weiss, private communication.
[2]D. L. Lin, W. Fielder, Jr., and L. Armstrong, Jr., Phys. Rev. A 16, 589 (1977).
[3]Y. Baudinet-Robinet, P. D. Dumont, H. P. Garnir, N. Grevesse, and E. Biemont, J. Opt. Soc. Am. 70, 464 (1980).
[4]P. D. Dumont, H. P. Garnir, Y. Baudinet-Robinet, and M. Kapenyak, J. Opt. Soc. Am. 71, 502 (1981).

Ti v: Allowed transitions

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} (10^8 s^{-1})	f_{ik}	S (at. u.)	log gf	Accuracy	Source
1.	$3p^6$–$3p^53d$	^{1}S - ^{3}D°											
			323.365	0	309252	1	3	0.40	0.0019	0.0020	−2.73	E	*interp.*
2.		^{1}S - ^{1}P°	252.958	0	395321	1	3	1260	3.63	3.02	0.56	C	*interp.*
3.	$3p^6$–$3p^54s$	^{1}S - ^{3}P°											
			228.909	0	436850	1	3	41	0.097	0.073	−1.01	E	*interp.*
4.		^{1}S - ^{1}P°	225.347	0	443753	1	3	140	0.33	0.24	−0.48	E	*interp.*

Ti VI

Cl Isoelectronic Sequence

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

Ionization Energy: 119.53 eV = 964100 cm^{-1}

Allowed Transitions

Line strengths for transitions of the arrays $3s^23p^5$–$3s3p^6$ and $3p^5$–$3p^43d$ are the results of the multiconfiguration Dirac-Fock (MCDF) calculations of Huang *et al.*[1] These relativistic calculations include a perturbative treatment of the Breit interaction and the Lamb shift. Configuration mixing was limited to some configurations within the $n=3$ complex. Those configurations which were assumed to lie far above $3p^5$ or $3p^43d$ in energy were excluded, as were all configurations outside the complex.

According to the semi-empirical HX (Hartree-Fock with statistical allowance for exchange) calculations of Bromage *et al.*[2] for Fe X, some levels of the $3p^43d$ configuration are strongly mixed in the *LS* basis, and in a few cases the *LS* designations given in Ref. 2 differed from those of Huang *et al.* The level designations used in this compilation are in accord with the theoretical results of Refs. 1 and 2 for Fe X. Percentage compositions published by Bromage[3] for the levels of the $3p^43d$ configuration in V VII and Ni XII indicate that the designations for the iron ion are appropriate for the neighboring ions of the chlorine isoelectronic sequence. Transitions involving highly mixed levels have been excluded, as have the very weak transitions.

The calculated wavelengths of Huang *et al.* differ appreciably from the observed ones found in the literature. Thus the available experimentally determined wavelengths were used in making the conversion from line strengths to f- and A-values. (Otherwise, the calculated wavelengths of Huang *et al.* were used, but they provide only a rough idea of the spectral-line positions.) Bromage *et al.* indicate that it was necessary to scale down some configuration-interaction parameters by a greater amount than usual in order to fit their calculated energy levels for Fe X to the experimental data. This could be an indication that neglecting to take configuration interaction into account on a larger scale yields significant errors in the energy levels and/or f-values.

The lifetime of the $3s3p^6\ ^2S_{1/2}$ level has been measured by Dumont *et al.*[4] using the beam-foil technique. The sum of our tabulated A-values for the two possible downward transitions from this level, along with our estimated accuracy ratings, yields a value for the lifetime which is smaller than the measured value (incorporating the author's stated error estimate). Thus it is possible that undetected cascading could have led to an underestimate of the uncertainty in the experimental result.

References

[1] K.-N. Huang, Y.-K. Kim, K. T. Cheng, and J. P. Desclaux, At. Data Nucl. Data Tables **28**, 355 (1983).

[2] G. E. Bromage, R. D. Cowan, and B. C. Fawcett, Phys. Scr. **15**, 177 (1977).

[3] G. E. Bromage, Astron. Astrophys., Suppl. Ser. **41**, 79 (1980).

[4] P. D. Dumont, H. P. Garnir, Y. Baudinet-Robinet, and M. Kapenyak, J. Opt. Soc. Am. **71**, 502 (1981).

Ti VI: Allowed transitions

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} (10^8 s^{-1})	f_{ik}	S (at. u.)	log gf	Accuracy	Source
1.	$3s^23p^5$–$3s3p^6$	$^2P^o$ – ^2S	*513.65*	*1943*	196628	6	2	26.7	0.0352	0.357	−0.68	C−	1
			508.575	0	196628	4	2	18.3	0.0355	0.238	−0.85	C−	1
			524.113	5829	196628	2	2	8.4	0.0345	0.119	−1.161	C−	1
2.	$3p^5$–$3p^4(^3P)3d$	$^2P^o$ – ^4F											
			[330]			2	4	0.035	1.2(−4)[a]	2.5(−4)	−3.64	E	1
3.		$^2P^o$ – ^4P											
			[322]			2	4	0.73	0.0023	0.0048	−2.34	E	1
			[316]			4	4	0.51	7.7(−4)	0.0032	−2.51	E	1
			[324]			2	2	0.12	1.9(−4)	4.1(−4)	−3.42	E	1
			[319]			4	2	0.25	1.9(−4)	8.1(−4)	−3.11	E	1
4.		$^2P^o$ – ^2D	*250.47*	*1943*	*401187*	6	10	1200	1.9	9.3	1.05	C−	1
			250.482	0	399230	4	6	1200	1.7	5.6	0.83	C	1
			251.071	5829	404122	2	4	1130	2.14	3.53	0.63	C	1
			247.450	0	404122	4	4	70	0.064	0.21	−0.59	D	1
5.	$3p^5$–$3p^4(^1D)3d$	$^2P^o$ – ^2F											
			301.913	0	331221	4	6	0.18	3.8(−4)	0.0015	−2.82	E	1
6.		$^2P^o$ – ^2S	*264.60*	*1943*	379873	6	2	1030	0.362	1.89	0.336	C−	1
			263.246	0	379873	4	2	730	0.381	1.32	0.183	C−	1
			267.343	5829	379873	2	2	300	0.32	0.57	−0.19	C−	1
7.	$3p^5$–$3p^4(^1S)3d$	$^2P^o$ – ^2D											
			282.215	0	354340	4	6	0.59	0.0010	0.0039	−2.38	E	1
			288.355	5829	352624	2	4	2.7	0.0068	0.013	−1.86	E	1

[a] The number in parentheses following the tabulated value indicates the power of ten by which this value has to be multiplied.

Ti VI

Forbidden Transitions

Line strengths for the magnetic dipole and electric quadrupole contributions to the transition between the two levels of the $3p^5$ configuration are the results of the multiconfiguration Dirac-Fock (MCDF) calculations of Huang *et al.*[1] These relativistic calculations included a perturbative treatment of the Breit interaction and the Lamb shift. Allowance for mixing among odd-parity configurations was limited to the set $3s^23p^5$, $3s3p^53d$, $3p^53d^2$, and $3s^23p^33d^2$. The strength of the electric quadrupole transition as defined in Ref. 1 was multiplied by the factor 2/3 which is needed to bring this value into conformance with the definition of quadrupole strengths used in the NBS tables.

Reference

[1]K.-N. Huang, Y.-K. Kim, K. T. Cheng, and J. P. Desclaux, At. Data Nucl. Data Tables **28**, 355 (1983).

Ti VI: Forbidden transitions

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	Type of transition	A_{ki} (s^{-1})	S (at. u.)	Accu-racy	Source
1.	$3p^5$–$3p^5$	$^2P^\circ$ – $^2P^\circ$										
			[17150]	0	5829	4	2	M1	3.56	1.33	B	1
			"	"	"	4	2	E2	3.7(−4)[a]	0.66	D−	1

[a]The number in parentheses following the tabulated value indicates the power of ten by which this value has to be multiplied.

Ti VII

S Isoelectronic Sequence

Ground State: $1s^22s^22p^63s^23p^4\ ^3P_2$

Ionization Energy: 140.8 eV = 1136000 cm^{-1}

Allowed Transitions

The A-value for the single transition tabulated here is the reciprocal of the lifetime of the $3s3p^5\ ^1P_1^\circ$ level as determined by Dumont *et al.*[1] with the beam-foil technique. A few additional downward transitions from this level are possible, but theoretically calculated transition probabilities for these lines in Fe XI[2] indicate that they are weak in comparison to the $3s^23p^4\ ^1D_2 - 3s3p^5\ ^1P_1^\circ$ transition. (The lifetime of the $3s3p^5\ ^3P_2^\circ$ level could not be converted to a single transition probability, since in Fe XI there are two significant downward branches, the weaker of which has an A-value which represents approximately one-fourth of the total radiative decay.)

Since Ti VII has such a complex structure, with many possibilities for cascading, and in view of the assumptions made concerning the branching ratio, we have assigned a very conservative accuracy rating to the tabulated A-value.

References

[1]P. D. Dumont, H. P. Garnir, Y. Baudinet-Robinet, and M. Kapenyak, J. Opt. Soc. Am. **71**, 502 (1981).
[2]H. E. Mason, Mon. Not. R. Astron. Soc. **170**, 651 (1975).

Ti VII: Allowed transitions

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} (10^8 s^{-1})	f_{ik}	S (at. u.)	log gf	Accuracy	Source
1.	$3s^23p^4$–$3s3p^5$	^{1}D - ^{1}P°	440.361	24123	251209	5	3	33	0.058	0.42	−0.54	D	1

Ti VII

Forbidden Transitions

Transition probabilities for magnetic dipole and electric quadrupole lines within the $3p^4$ configuration are the results of the scaled Thomas-Fermi calculations of Mendoza and Zeippen.[1] They included a number of correlation configurations in their basis set and introduced Breit-Pauli relativistic corrections as a perturbation to the nonrelativistic Hamiltonian.

Reference

[1]C. Mendoza and C. J. Zeippen, Mon. Not. R. Astron. Soc. **202**, 981 (1983).

Ti VII: Forbidden transitions

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	Type of transition	A_{ki} (s^{-1})	S (at. u.)	Accuracy	Source
1.	$3p^4$–$3p^4$	^{3}P - ^{3}P										
			[22050]	0	4533	5	3	M1	2.06	2.46	C+	1
			〃	〃	〃	5	3	E2	6.5(−5)[a]	0.61	D−	1
			[73840]	4533	5887	3	1	M1	0.132	1.97	C+	1
			[16980]	0	5887	5	1	E2	3.4(−4)	0.29	D−	1
2.		^{3}P - ^{1}D										
			[4144.3]	0	24123	5	5	M1	8.3	0.11	D−	1
			〃	〃	〃	5	5	E2	0.017	0.062	E	1
			[5103.2]	4533	24123	3	5	M1	1.5	0.037	E	1
			〃	〃	〃	3	5	E2	9.0(−4)	0.0093	E	1
			[5482.1]	5887	24123	1	5	E2	2.4(−4)	0.0035	E	1
3.		^{3}P - ^{1}S										
			[1825.0]	0	54794	5	1	E2	0.39	0.0047	E	1
			[1989.6]	4533	54794	3	1	M1	98	0.029	E	1

Ti VII: Forbidden transitions — Continued

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	Type of transition	A_{ki} (s^{-1})	S (at. u.)	Accuracy	Source
4.		^{1}D - ^{1}S	[3259.5]	24123	54794	5	1	E2	4.9	1.1	D−	1

[a]The number in parentheses following the tabulated value indicates the power of ten by which this value has to be multiplied.

Ti VIII

P Isoelectronic Sequence

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

Ionization Energy: 170.4 eV = 1374000 cm^{-1}

Allowed Transitions

Line strengths for transitions of the arrays $3s^23p^3$–$3s3p^4$ and $3p^3$–$3p^23d$ are the results of the multiconfiguration Dirac-Fock (MCDF) calculations of Huang.[1] These relativistic calculations included a perturbative treatment of the Breit interaction and the Lamb shift. Allowance for configuration mixing was limited to configurations within the $n=3$ complex having no more than two electrons in the $3d$ subshell.

Huang published diagrams of energy levels (designated in *LS* coupling) in the $3s^23p^3$, $3s3p^4$, and $3s^23p^23d$ configurations of Cl III, Ti VIII, and Fe XII, but he has not provided percentage compositions. We have used the percentages given by Bromage *et al.*[2] for Fe XII, and by Bromage[3] for V IX and Ni XIV, as a guide to naming the levels; their values resulted from Hartree-Fock calculations with relativistic effects and statistical allowance for exchange (HXR), and incorporated correlation effects due to a few configurations within the $n=3$ complex. Whenever a term designation of a level in Fe XII, as given in Ref. 1, is different from that indicated in Ref. 2, all transitions involving the corresponding level in Ti VIII are omitted from this compilation. Furthermore, any level indicated by Huang to have changed its energy ranking relative to other levels of the same *J*-value and parity, in proceeding along the isoelectronic sequence from Cl III to Ti VIII, is omitted here, since, unlike the case of V IX through Ni XIV, there are no data available on percentage compositions of these levels in Ti VIII.

Transitions involving levels which are indicated to be of low purity in *LS* coupling are omitted here. Lines which are characterized by very small *f*-values are assigned lower accuracy ratings; the weakest lines have been excluded.

References

[1]K.-N. Huang, At. Data Nucl. Data Tables **30**, 313 (1984).
[2]G. E. Bromage, R. D. Cowan, and B. C. Fawcett, Mon. Not. R. Astron. Soc. **183**, 19 (1978).
[3]G. E. Bromage, Astron. Astrophys., Suppl. Ser. **41**, 79 (1980).

Ti VIII: Allowed transitions

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} (10^8 s^{-1})	f_{ik}	S (at. u.)	log gf	Accuracy	Source
1.	$3s^23p^3$–$3s3p^4$	^{4}S° - ^{4}P	*508.66*	0	*196596*	4	12	8.5	0.099	0.66	−0.40	D	1
			514.206	0	194475	4	6	8.2	0.049	0.33	−0.71	D	1
			504.801	0	198098	4	4	8.7	0.033	0.22	−0.88	D	1
			500.116	0	199954	4	2	8.9	0.017	0.11	−1.18	D	1
2.		^{2}D° - ^{2}D	*479.81*			10	10	16	0.056	0.88	−0.25	E	1
			480.376			6	6	15	0.052	0.49	−0.51	D	1
			478.971			4	4	17	0.057	0.36	−0.64	D	1
			481.428			6	4	0.73	0.0017	0.016	−2.00	E	1
			[476]			4	6	0.41	0.0021	0.013	−2.08	E	1

Ti VIII: Allowed transitions — Continued

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} ($10^8 s^{-1}$)	f_{ik}	S (at. u.)	log gf	Accuracy	Source
3.		$^2P^\circ - ^2D$											
			538.241			4	6	2.8	0.018	0.13	−1.13	D	1
			535.381			2	4	1.7	0.014	0.051	−1.54	D	1
4.	$3p^3-3p^2(^3P)3d$	$^4S^\circ - ^4P$											
			269.533	0	371012	4	6	600	0.99	3.5	0.60	D	1
5.		$^2D^\circ - ^4P$											
			[287]			6	6	3.1	0.0039	0.022	−1.63	E	1
			[286]			4	6	0.65	0.0012	0.0045	−2.32	E	1
6.		$^2D^\circ - ^2F$											
			258.610			6	8	750	1.0	5.1	0.78	E	1
7.	$3p^3-3p^2(^1D)3d$	$^2D^\circ - ^2D$											
			272.037			4	4	430	0.47	1.7	0.28	D	1
			272.843			6	4	62	0.046	0.25	−0.56	D	1
8.		$^2D^\circ - ^2P$											
			[249]			6	4	10	0.0065	0.032	−1.41	E	1
			[249]			4	4	3.1	0.0029	0.0095	−1.94	E	1
9.		$^2P^\circ - ^2D$											
			289.375			2	4	36	0.089	0.17	−0.75	D	1
10.		$^2P^\circ - ^2P$											
			277.813			4	4	380	0.44	1.6	0.24	E	1
			276.701			2	4	93	0.21	0.39	−0.37	E	1

Ti VIII

Forbidden Transitions

Line strengths for magnetic dipole and electric quadrupole transitions within the $3p^3$ configuration are the results of the multiconfiguration Dirac-Fock (MCDF) calculations of Huang.[1] These relativistic calculations included a perturbative treatment of the Breit interaction and the Lamb shift. Allowance for configuration mixing was limited to configurations within the $n=3$ complex having no more than two electrons in the $3d$ subshell. Strengths of electric quadrupole transitions as defined in Ref. 1 were multiplied by the factor $^2/_3$ which is needed to bring these values into conformance with the definition of quadrupole strengths used in the NBS tables. We have excluded from this compilation the electric quadrupole contributions to the $^4S^\circ_{3/2} - ^2P^\circ_{3/2}$ and $^4S^\circ_{3/2} - ^2P^\circ_{1/2}$ transitions, since their strengths are very small and thus subject to considerable uncertainty.

Data for these same transitions calculated by Mendoza and Zeippen[2] with the scaled Thomas-Fermi approach with allowance for correlation are generally in very good agreement with the results of Ref. 1. These latter calculations treated relativistic effects by introducing Breit-Pauli corrections as a perturbation to the nonrelativistic Hamiltonian.

References

[1]K.-N. Huang, At. Data Nucl. Data Tables **30**, 313 (1984).

[2]C. Mendoza and C. J. Zeippen, Mon. Not. R. Astron. Soc. **198**, 127 (1982).

Ti VIII: Forbidden transitions

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	Type of transition	A_{ki} (s^{-1})	S (at. u.)	Accuracy	Source
1.	$3p^3$–$3p^3$	$^4S°$ – $^2D°$										
			[3006]			4	6	M1	0.045	2.7(−4)[a]	E	1
			〃			4	6	E2	0.015	0.013	E	1
			[3106]			4	4	M1	2.0	0.0089	E	1
			〃			4	4	E2	0.0083	0.0057	E	1
2.		$^4S°$ – $^2P°$										
			[1798]			4	4	M1	39	0.034	D	1
			[1845]			4	2	M1	18	0.0082	E	1
3.		$^2D°$ – $^2D°$										
			[93780]			4	6	M1	0.0125	2.29	C+	1
			〃			4	6	E2	3.7(−9)	0.096	E	1
4.		$^2D°$ – $^2P°$										
			[4776.0]			6	2	E2	0.21	0.61	D−	1
			[4467.0]			6	4	M1	8.3	0.11	C	1
			〃			6	4	E2	0.47	2.0	D−	1
			[4544.6]			4	2	M1	8.9	0.062	D	1
			〃			4	2	E2	0.38	0.88	D−	1
			[4264.3]			4	4	M1	17	0.20	C	1
			〃			4	4	E2	0.22	0.74	D−	1
5.		$^2P°$ – $^2P°$										
			[69230]			2	4	M1	0.0256	1.26	C+	1
			〃			2	4	E2	8.7(−9)	0.033	E	1

[a]The number in parentheses following the tabulated value indicates the power of ten by which this value has to be multiplied.

Ti IX

Si Isoelectronic Sequence

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

Ionization Energy: 192.1 eV = 1549000 cm^{-1}

Allowed Transitions

List of tabulated lines

Wavelength (Å)	No.	Wavelength (Å)	No.	Wavelength (Å)	No.	Wavelength (Å)	No.
242.82	7	296.28	9	439.745	2	516.215	1
253.49	6	324	3	447.484	2	518.100	1
267.941	10	354	8	447.701	2	518.33	1
278.713	5	433.567	2	499.479	1		
281.446	4	439.302	2	507.174	1		
285.128	11	439.513	2	507.38	1		

Line strengths for transitions of the arrays $3s^23p^2$–$3s3p^3$ and $3p^2$–$3p3d$ are the results of the multiconfiguration Dirac-Fock (MCDF) calculations of Huang.[1] These relativistic calculations included a perturbative treatment of the Breit interaction and the Lamb shift. Allowance for configuration mixing included all configurations within the $n=3$ complex.

Huang published diagrams of energy levels (designated in *LS* coupling) in the $3s^23p^2$, $3s3p^3$, and $3s^23p3d$ configurations of siliconlike S, Ar, Ti, Fe, and Zn, but he has not provided percentage compositions. We have used the percentages given by Bromage *et al.*[2] for Fe XIII, and by Bromage[3] for V X and Ni XV, as a guide to naming the levels; their values resulted from Hartree-Fock calculations with relativistic effects and statistical allowance for exchange (HXR), and incorporated correlation effects due to a partial set of configurations within the $n=3$ complex. Whenever the term designation of a level in Fe XIII, as given in Ref. 1, is different from that indicated in Ref. 2, all transitions involving the corresponding level in Ti IX are omitted from this compilation. Furthermore, any level indicated by Huang to have changed its energy ranking relative to other levels of the same J-value and parity, in proceeding along the isoelectronic sequence from S III to Ti IX, is omitted here, since, unlike the case of V X through Ni XV, there are no data available on percentage compositions of these levels in Ti IX.

Transitions involving levels which are indicated to be of low purity in *LS* coupling are omitted here. Lines which are characterized by very small f-values are assigned lower accuracy ratings; the weakest lines have been excluded.

References

[1]K.-N. Huang, At. Data Nucl. Data Tables **32**, 503 (1985).
[2]G. E. Bromage, R. D. Cowan, and B. C. Fawcett, Mon. Not. R. Astron. Soc. **183**, 19 (1978).
[3]G. E. Bromage, Astron. Astrophys., Suppl. Ser. **41**, 79 (1980).

Ti IX: Allowed transitions

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} (10^8 s^{-1})	f_{ik}	S (at. u.)	log gf	Accuracy	Source
1.	$3s^23p^2$–$3s3p^3$	^{3}P – ^{3}D°	*511.45*	*5085*	*200606*	9	15	7.2	0.047	0.71	−0.38	D−	1
			516.215	7281	200999	5	7	6.9	0.039	0.33	−0.71	D	1
			507.174	3120	200294	3	5	6.5	0.042	0.21	−0.90	D	1
			499.479	0	200209	1	3	5.2	0.058	0.096	−1.23	D	1
			518.100	7281	200294	5	5	0.79	0.0032	0.027	−1.80	D−	1
			[507.38]	3120	200209	3	3	2.4	0.0092	0.046	−1.56	D−	1
			[518.33]	7281	200209	5	3	0.073	1.8(−4)[a]	0.0015	−3.06	E	1
2.		^{3}P – ^{3}P°	*443.25*	*5085*	*230691*	9	9	20	0.060	0.79	−0.27	D	1
			447.484	7281	230753	5	5	16	0.049	0.36	−0.61	D	1
			439.513	3120	230644	3	3	7.5	0.022	0.094	−1.19	D	1
			447.701	7281	230644	5	3	6.5	0.012	0.087	−1.23	D	1
			439.745	3120	230525	3	1	21	0.020	0.089	−1.21	C−	1
			439.302	3120	230753	3	5	3.6	0.017	0.075	−1.29	D	1
			433.567	0	230644	1	3	6.9	0.058	0.083	−1.24	D	1
3.	$3p^2$–$3p3d$	^{3}P – ^{3}F°											
			[324]			5	7	0.50	0.0011	0.0059	−2.26	E	1
4.		^{3}P – ^{3}P°											
			281.446	3120	358428	3	1	320	0.13	0.35	−0.42	D	1
5.		^{3}P – ^{3}D°											
			278.713	7281	366073	5	7	470	0.76	3.5	0.58	D	1
6.		^{3}P – ^{1}F°											
			[253.49]	7281	401770	5	7	5.3	0.0072	0.030	−1.44	E	1
7.		^{3}P – ^{1}P°											
			[242.82]	0	411831	1	3	1.4	0.0036	0.0029	−2.44	E	1

Ti IX: Allowed transitions — Continued

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} (10^8 s^{-1})	f_{ik}	S (at. u.)	log gf	Accu-racy	Source
8.		^{1}D - ^{3}F°											
			[354]			5	5	0.65	0.0012	0.0071	−2.22	E	1
9.		^{1}D - ^{3}D°											
			[296.28]	28554	366073	5	7	4.0	0.0074	0.036	−1.43	E	1
10.		^{1}D - ^{1}F°	267.941	28554	401770	5	7	510	0.76	3.37	0.58	C	1
11.		^{1}S - ^{1}P°	285.128	61111	411831	1	3	410	1.5	1.4	0.17	D	1

[a]The number in parentheses following the tabulated value indicates the power of ten by which this value has to be multiplied.

Ti IX

Forbidden Transitions

List of tabulated lines

Wavelength (Å)	No.	Wavelength (Å)	No.	Wavelength (Å)	No.	Wavelength (Å)	No.
605.79	11	1857.7	3	3306.9	8	32040	1
632.38	10	3070.6	4	3359.9	8	127000	7
840	9	3273.0	8	3372.3	8	142000	7
860	9	3282.2	8	3930.6	2	1200000	7
1100	6	3284.7	8	4699.5	2		
1700	5	3293.9	8	13730	1		
1724.4	3	3297.6	8	24030	1		

Line strengths for magnetic dipole and electric quadrupole transitions are the results of the multiconfiguration Dirac-Fock (MCDF) calculations of Huang.[1] These relativistic calculations included a perturbative treatment of the Breit interaction and the Lamb shift. Allowance for configuration interaction encompassed all configurations within the $n=3$ complex. Huang calculated line strengths for transitions within the $3p^2$ configuration, as well as for transitions between pairs of odd-parity levels whose lower level is one of the four lowest-lying odd-parity levels in the $n=3$ complex. Transitions involving odd-parity levels which are indicated by Bromage *et al.*[2] (for Fe XIII) or Bromage[3] (for V X and Ni XV) to be of low purity in *LS* coupling in Fe-group species are omitted here, as are lines whose strengths are very small. Strengths of electric quadrupole transitions as reported in Ref. 1 were multiplied by the factor 2/3 which is needed to bring these values into conformance with the definition of quadrupole strengths used in the NBS tables.

References

[1]K.-N. Huang, At. Data Nucl. Data Tables **32**, 503 (1985) and private communication.

[2]G. E. Bromage, R. D. Cowan, and B. C. Fawcett, Mon. Not. R. Astron. Soc. **183**, 19 (1978).

[3]G. E. Bromage, Astron. Astrophys., Suppl. Ser. **41**, 79 (1980).

Ti IX: Forbidden transitions — Continued

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	Type of transition	A_{ki} (s^{-1})	S (at. u.)	Accu-racy	Source
1.	$3p^2$–$3p^2$	^{3}P - ^{3}P										
			[24030]	3120	7281	3	5	M1	0.952	2.45	C+	1
			″	″	″	3	5	E2	2.0(−5)[a]	0.48	D−	1
			[32040]	0	3120	1	3	M1	0.539	1.97	C+	1
			[13730]	0	7281	1	5	E2	1.6(−4)	0.23	D−	1
2.		^{3}P - ^{1}D										
			[4699.5]	7281	28554	5	5	M1	7.8	0.15	E	1
			″	″	″	5	5	E2	0.010	0.070	E	1
			[3930.6]	3120	28554	3	5	M1	4.5	0.051	E	1
			″	″	″	3	5	E2	0.0035	0.0099	E	1
3.		^{3}P - ^{1}S										
			[1857.7]	7281	61111	5	1	E2	0.55	0.0072	E	1
			[1724.4]	3120	61111	3	1	M1	120	0.022	E	1
4.		^{1}D - ^{1}S	[3070.6]	28554	61111	5	1	E2	5.7	0.93	D−	1
5.	$3s3p^3$–$3s3p^3$	^{5}S° - ^{3}D°										
			[1700]			5	7	E2	0.081	0.0048	E	1
			[1700]			5	5	M1	1.3	0.0012	E	1
			″	″	″	5	5	E2	0.076	0.0032	E	1
6.		^{5}S° - ^{3}P°										
			[1100]			5	5	M1	77	0.019	E	1
			[1100]			5	3	M1	43	0.0063	E	1
7.		^{3}D° - ^{3}D°										
			[142000]	200294	200999	5	7	M1	0.0062	4.6	D+	1
			″	″	″	5	7	E2	2.0(−10)	0.048	E	1
			[1200000]	200209	200294	3	5	M1	1.4(−5)	4.5	E	1
			[127000]	200209	200999	3	7	E2	8.0(−11)	0.011	E	1
8.		^{3}D° - ^{3}P°										
			[3372.3]	200999	230644	7	3	E2	1.2	0.94	D−	1
			[3306.9]	200294	230525	5	1	E2	2.8	0.65	D−	1
			[3359.9]	200999	230753	7	5	M1	11	0.075	E	1
			″	″	″	7	5	E2	1.4	1.8	D−	1
			[3293.9]	200294	230644	5	3	E2	0.22	0.15	D−	1
			[3297.6]	200209	230525	3	1	M1	13	0.017	E	1
			[3282.2]	200294	230753	5	5	M1	7.3	0.048	E	1
			″	″	″	5	5	E2	0.97	1.1	D−	1
			[3284.7]	200209	230644	3	3	M1	12	0.049	E	1
			″	″	″	3	3	E2	1.3	0.87	D−	1
			[3273.0]	200209	230753	3	5	M1	2.5	0.016	E	1
			″	″	″	3	5	E2	0.29	0.32	D−	1
9.	$3s3p^3$–$3s^23p3d$	^{3}D° - ^{3}F°										
			[840]			5	9	E2	3.0	0.0068	E	1
			[860]			3	7	E2	1.5	0.0030	E	1
			[840]			7	9	M1	340	0.067	E	1

Ti IX: Forbidden transitions — Continued

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	Type of transition	A_{ki} (s^{-1})	S (at. u.)	Accuracy	Source
10.		^{3}D° - ^{3}P°										
			[632.38]	200294	358428	5	1	E2	150	0.0091	E	1
11.		^{3}D° - ^{3}D°										
			[605.79]	200999	366073	7	7	M1	31	0.0018	E	1

[a]The number in parentheses following the tabulated value indicates the power of ten by which this value has to be multiplied.

Ti X

Al Isoelectronic Sequence

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

Ionization Energy: 215.92 eV = 1741500 cm^{-1}

Allowed Transitions

List of tabulated lines

Wavelength (Å)	No.	Wavelength (Å)	No.	Wavelength (Å)	No.	Wavelength (Å)	No.
232	20	296.05	15	355.815	3	471.574	1
245	27	297	23	360.133	3	478	6
253	26	298	23,29,30	363	13,14	479	6,10
254	26	300	17	365.628	3	481	6
259	19	302	24	378.135	2	482	6
281	28	305	24	379.74	4	487.654	1
289	17	317	25	382	12	488.971	1
289.579	15	321	25	383	12	491	8
290.294	18	322	25	383.93	4	492	10
291	17,18	325	25	385	12	493	8,10
292	23	326	5	389.237	2	535	9
293.684	18	329	5	389.99	4	537	9
293.798	18	333	16	391	7	547	9
294	18,30	338	22	392	7	549	9
295.584	15	345	21	404	11		
296	17	350.610	3	405	11		

Line strengths for transitions of the arrays $3s^23p$–$3s3p^2$, $3s3p^2$–$3p^3$, $3s^23d$–$3s3p3d$, $3s^23p$–$3s^23d$, and $3s3p^2$–$3s3p3d$ are the results of the multiconfiguration Dirac-Fock (MCDF) calculations of Huang.[1] These relativistic calculations included a perturbative treatment of the Breit interaction and the Lamb shift. Allowance for configuration mixing included all configurations within the $n=3$ complex.

Huang published two diagrams of energy levels (designated in LS coupling) in the $3s^23p$, $3s3p^2$, $3s^23d$, $3p^3$, and $3s3p3d$ configurations of Ti X, but he has not provided percentage compositions. We have used the percentages given by Fawcett[2] as a guide to naming the levels; the latter's values resulted from Hartree-Fock calculations with relativistic effects and statistical allowance for exchange (HXR), and incorporated correlation effects due to all configurations within the $n=3$ complex.

Transitions involving levels which are indicated to be of low purity in LS coupling are omitted here. Lines which are characterized by very small f-values are assigned lower accuracy ratings; the weakest lines have been excluded. A few wavelengths computed by Huang differ significantly from those which resulted from the fitting and scaling procedure applied by Fawcett;[2] whose lines for which the wavelengths are in serious disagreement have been omitted.

References

[1]K.-N. Huang, At. Data Nucl. Data Tables **34**, 1 (1986) and private communication.

[2]B. C. Fawcett, At. Data Nucl. Data Tables **28**, 557 (1983).

Ti x: Allowed transitions

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} ($10^8 s^{-1}$)	f_{ik}	S (at. u.)	log gf	Accuracy	Source
1.	$3s^23p-3s3p^2$	$^2P^\circ - ^2D$	*482.26*	*5030*	*212387*	6	10	11	0.065	0.62	−0.41	E	1
			487.654	7545	212608	4	6	11	0.058	0.37	−0.64	D	1
			471.574	0	212056	2	4	11	0.074	0.23	−0.83	D	1
			488.971	7545	212056	4	4	0.95	0.0034	0.022	−1.86	E	1
2.		$^2P^\circ - ^2S$	*385.47*	*5030*	264456	6	2	94	0.070	0.53	−0.38	D	1
			389.237	7545	264456	4	2	27	0.031	0.16	−0.90	D	1
			378.135	0	264456	2	2	69	0.15	0.37	−0.53	D	1
3.		$^2P^\circ - ^2P$	*358.69*	*5030*	*283826*	6	6	260	0.51	3.6	0.48	D	1
			360.133	7545	285217	4	4	219	0.426	2.02	0.231	C−	1
			355.815	0	281045	2	2	130	0.26	0.60	−0.29	D	1
			365.628	7545	281045	4	2	120	0.12	0.57	−0.32	D	1
			350.610	0	285217	2	4	46.8	0.172	0.398	−0.462	C−	1
4.	$3s3p^2-3p^3$	$^4P - ^4S^\circ$	*386.22*			12	4	230	0.17	2.6	0.31	D	1
			389.99			6	4	110	0.17	1.3	0.01	D	1
			383.93			4	4	79	0.17	0.88	−0.16	D	1
			379.74			2	4	41	0.18	0.44	−0.45	D	1
5.		$^4P - ^2P^\circ$											
			[329]			4	4	0.98	0.0016	0.0069	−2.20	E	1
			[326]			2	4	0.41	0.0013	0.0028	−2.58	E	1
6.		$^2D - ^2D^\circ$	*480*			10	10	20	0.070	1.1	−0.16	E	1
			[479]			6	6	19	0.067	0.63	−0.40	E	1
			[481]			4	4	16	0.057	0.36	−0.64	E	1
			[482]			6	4	4.1	0.0095	0.090	−1.25	E	1
			[478]			4	6	1.7	0.0086	0.054	−1.46	E	1
7.		$^2D - ^2P^\circ$	*392*			10	6	78	0.11	1.4	0.04	D	1
			[392]			6	4	68	0.10	0.81	−0.20	D	1
			[392]			4	2	82	0.095	0.49	−0.42	D	1
			[391]			4	4	8.3	0.019	0.098	−1.12	D	1
8.		$^2S - ^2P^\circ$	*492*			2	6	9.1	0.099	0.32	−0.70	D	1
			[491]			2	4	12	0.084	0.27	−0.78	D	1
			[493]			2	2	4.2	0.015	0.050	−1.51	D	1
9.		$^2P - ^2P^\circ$	*544*			6	6	19	0.084	0.90	−0.30	E	1
			[547]			4	4	16	0.072	0.52	−0.54	D	1
			[537]			2	2	18	0.076	0.27	−0.82	D	1
			[549]			4	2	5.2	0.012	0.085	−1.33	D	1
			[535]			2	4	0.69	0.0060	0.021	−1.92	E	1

Ti x: Allowed transitions — Continued

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} (10^8 s^{-1})	f_{ik}	S (at. u.)	log gf	Accuracy	Source
10.	$3s^23d-3s3p(^3P^\circ)3d$	$^2D-^2F^\circ$	*485*			10	14	14	0.069	1.1	−0.16	E	1
			[479]			6	8	15	0.067	0.63	−0.40	E	1
			[492]			4	6	11	0.060	0.39	−0.62	E	1
			[493]			6	6	1.5	0.0056	0.055	−1.47	E	1
11.		$^2D-^2P^\circ$											
			[405]			6	4	0.84	0.0014	0.011	−2.08	E	1
			[404]			4	4	1.0	0.0024	0.013	−2.01	E	1
12.	$3s^23d-3s3p(^1P^\circ)3d$	$^2D-^2F^\circ$	*384*			10	14	180	0.57	7.2	0.76	E	1
			[385]			6	8	180	0.54	4.1	0.51	E	1
			[382]			4	6	180	0.58	2.9	0.36	E	1
			[383]			6	6	9.6	0.021	0.16	−0.90	E	1
13.		$^2D-^2D^\circ$											
			[363]			6	6	130	0.26	1.9	0.20	E	1
			[363]			4	6	5.4	0.016	0.077	−1.19	E	1
14.		$^2D-^2P^\circ$											
			[363]			4	2	210	0.21	1.0	−0.08	D	1
15.	$3p-3d$	$^2P^\circ-^2D$	*293.59*	*5030*	*345646*	6	10	300	0.64	3.7	0.58	D	1
			295.584	7545	345858	4	6	290	0.57	2.2	0.35	D	1
			289.579	0	345329	2	4	250	0.63	1.2	0.10	D	1
			[296.05]	7545	345329	4	4	53	0.069	0.27	−0.56	D	1
16.	$3s3p^2-3s3p(^3P^\circ)3d$	$^4P-^4F^\circ$											
			[333]			6	8	0.51	0.0011	0.0075	−2.16	E	1
17.		$^4P-^4P^\circ$											
			[300]			6	6	41	0.056	0.33	−0.48	D	1
			[289]			2	2	76	0.095	0.18	−0.72	E	1
			[291]			4	2	180	0.11	0.44	−0.34	E	1
			[296]			4	6	140	0.28	1.1	0.05	D	1
18.		$^4P-^4D^\circ$											
			293.684			6	8	297	0.51	2.97	0.487	C−	1
			290.294			4	6	110	0.21	0.82	−0.07	D	1
			293.798			6	6	170	0.22	1.3	0.13	D	1
			[291]			2	2	230	0.29	0.55	−0.24	E	1
			[294]			4	2	16	0.010	0.040	−1.38	E	1
19.		$^4P-^2F^\circ$											
			[259]			6	8	0.82	0.0011	0.0056	−2.18	E	1
20.		$^4P-^2P^\circ$											
			[232]			2	4	0.73	0.0012	0.0018	−2.63	E	1

Ti x: Allowed transitions — Continued

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} ($10^8 s^{-1}$)	f_{ik}	S (at. u.)	log gf	Accuracy	Source
21.		$^2D - ^4P^\circ$											
			[345]			6	6	2.1	0.0038	0.026	−1.64	E	1
22.		$^2D - ^4D^\circ$											
			[338]			6	8	0.65	0.0015	0.0099	−2.05	E	1
23.		$^2D - ^2F^\circ$	*294*			10	14	110	0.21	2.0	0.32	E	1
			[292]			6	8	110	0.19	1.1	0.06	E	1
			[297]			4	6	99	0.20	0.77	−0.10	E	1
			[298]			6	6	12	0.016	0.093	−1.02	E	1
24.		$^2S - ^2P^\circ$	*304*			2	6	220	0.90	1.8	0.25	D	1
			[305]			2	4	250	0.70	1.4	0.14	D	1
			[302]			2	2	160	0.22	0.44	−0.35	D	1
25.		$^2P - ^2P^\circ$	*322*			6	6	120	0.19	1.2	0.05	D	1
			[325]			4	4	87	0.14	0.59	−0.26	D	1
			[317]			2	2	150	0.22	0.46	−0.36	D	1
			[322]			4	2	36	0.028	0.12	−0.95	D	1
			[321]			2	4	11	0.033	0.069	−1.19	D	1
26.	$3s3p^2 - 3s3p(^1P^\circ)3d$	$^2D - ^2F^\circ$	*254*			10	14	230	0.31	2.6	0.49	E	1
			[254]			6	8	230	0.30	1.5	0.25	E	1
			[253]			4	6	210	0.30	1.0	0.08	E	1
			[254]			6	6	13	0.013	0.064	−1.12	E	1
27.		$^2D - ^2P^\circ$											
			[245]			4	2	1.9	8.4(−4)[a]	0.0027	−2.48	E	1
28.		$^2S - ^2P^\circ$											
			[281]			2	2	110	0.14	0.25	−0.57	D	1
29.		$^2P - ^2D^\circ$											
			[298]			4	6	430	0.87	3.4	0.54	E	1
30.		$^2P - ^2P^\circ$											
			[294]			2	2	72	0.093	0.18	−0.73	D	1
			[298]			4	2	59	0.0395	0.155	−0.80	C−	1

[a]The number in parentheses following the tabulated value indicates the power of ten by which this value has to be multiplied.

Ti X

Forbidden Transitions

Line strengths for magnetic dipole and electric quadrupole transitions within the $3s^23p\ ^2P°$ and $3s3p^2\ ^4P$ terms are the results of the multiconfiguration Dirac-Fock (MCDF) calculations of Huang.[1] These relativistic calculations included a perturbative treatment of the Breit interaction and the Lamb shift. Allowance for configuration mixing included all configurations within the $n=3$ complex. Strengths of electric quadrupole transitions as reported in Ref. 1 were multiplied by the factor 2/3 which is needed to bring these values into conformance with the definition of quadrupole strengths used in the NBS tables.

Reference

[1]K.-N. Huang, At. Data Nucl. Data Tables **34**, 1 (1986).

Ti X: Forbidden transitions

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	Type of transition	A_{ki} (s^{-1})	S (at. u.)	Accuracy	Source
1.	$3p$–$3p$	$^2P°$ – $^2P°$										
			[13250]	0	7545	2	4	M1	3.86	1.33	C+	1
			"	"	"	2	4	E2	4.2(−4)[a]	0.41	D−	1
2.	$3s3p^2$–$3s3p^2$	^4P – ^4P										
			[24700]			4	6	M1	1.07	3.59	C	1
			"			4	6	E2	1.9(−5)	0.64	D−	1
			[34700]			2	4	M1	0.54	3.32	C	1
			"			2	4	E2	4.3(−7)	0.052	E	1
			[14400]			2	6	E2	2.1(−4)	0.46	D−	1

[a]The number in parentheses following the tabulated value indicates the power of ten by which this value has to be multiplied.

Ti XI

Mg Isoelectronic Sequence

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

Ionization Energy: 265.07 eV = 2137900 cm^{-1}

Allowed Transitions

List of tabulated lines

Wavelength (Å)	No.	Wavelength (Å)	No.	Wavelength (Å)	No.	Wavelength (Å)	No.
65.403	13	318	19	417.85	3	522.66	6
87.725	12	322.75	20	419.45	3	533.55	6
261	18	323	21	425.74	3	535.0	6
266	17	327.192	15	429.60	3	543.23	6
306.144	14	332	23	434.0	8	544.1	6
308.250	14	349.91	16	434.94	8	545.6	6
308.568	14	386.140	2	439	7	569.3	1
313.229	14	408	22	440	11	667.12	4
313.710	14	408.28	3	446.69	5	768.88	9
314.0	14	415.07	3	453	10		

Oscillator strengths for the three transitions $3s^2\ {}^1S_0 - 3snp\ {}^1P^\circ_1$ ($n = 3$–5) and the intercombination transition $3s^2\ {}^1S_0 - 3s3p\ {}^3P^\circ_1$ are the results of the relativistic random phase approximation (RRPA) calculations of Shorer *et al.*,[1] who allowed for correlation within the context of a frozen core. Oscillator strength data of Fawcett,[2] quoted for transitions of the arrays $3s3p$–$3p^2$, $3s3d$–$3p3d$, $3s3p$–$3s3d$, and $3p^2$–$3p3d$ were derived by means of Hartree-Fock calculations which included relativistic effects and statistical allowance for exchange (HXR); he incorporated correlation effects due to all configurations in the $n = 3$ complex. Froese Fischer and Godefroid[3] determined f-values for singlet–singlet transitions within the complex by applying a nonrelativistic multiconfiguration Hartree-Fock (MCHF) technique with large-scale allowance for configuration interaction; their results are quoted for two transitions of the $3p3d$–$3d^2$ array for which we estimate the contribution of singlet–triplet mixing to the f-value to be insignificant.

Transitions involving levels which are indicated in Ref. 2 to be of low purity in LS coupling are omitted here. Lines which are characterized by very small f-values are assigned lower accuracy ratings.

References

[1] P. Shorer, C. D. Lin, and W. R. Johnson, Phys. Rev. A **16**, 1109 (1977).

[2] B. C. Fawcett, At. Data Nucl. Data Tables **28**, 579 (1983).

[3] C. Froese Fischer and M. Godefroid, Nucl. Instrum. Methods **202**, 307 (1982).

Ti XI: Allowed transitions

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} (10^8 s^{-1})	f_{ik}	S (at. u.)	log gf	Accuracy	Source
1.	$3s^2$–$3s3p$	$^1S - {}^3P^\circ$											
			569.3	0	175700	1	3	0.089	0.0013	0.0024	−2.89	E	1
2.		$^1S - {}^1P^\circ$	386.140	0	258973	1	3	148	0.995	1.26	−0.002	B	1
3.	$3s3p$–$3p^2$	$^3P^\circ - {}^3P$	*418.8*	*178500*	*417300*	9	9	118	0.311	3.86	0.447	C−	2
			417.85	181300	420600	5	5	86	0.224	1.54	0.049	C−	2
			419.45	175700	414100	3	3	31	0.083	0.34	−0.60	C	2
			429.60	181300	414100	5	3	49	0.082	0.58	−0.39	C	2
			425.74	175700	410600	3	1	120	0.11	0.46	−0.48	C	2
			408.28	175700	420600	3	5	29	0.12	0.48	−0.44	C−	2
			415.07	173200	414100	1	3	44	0.34	0.46	−0.47	C	2
4.		$^1P^\circ - {}^1D$	667.12	258973	408870	3	5	9.9	0.11	0.72	−0.48	D	2
5.		$^1P^\circ - {}^1S$	446.69	258973	482840	3	1	120	0.12	0.53	−0.44	C	2
6.	$3s3d$–$3p3d$	$^3D - {}^3F^\circ$	*531.3*	*500300*	*688500*	15	21	33	0.19	5.1	0.46	D	2
			522.66	500600	691900	7	9	35.3	0.186	2.24	0.115	C	2
			533.55	500100	687500	5	7	28	0.17	1.5	−0.07	C	2
			543.23	499800	683900	3	5	23	0.17	0.91	−0.29	D	2
			[535.0]	500600	687500	7	7	4.9	0.021	0.26	−0.83	C	2
			[544.1]	500100	683900	5	5	5.4	0.024	0.21	−0.92	D	2
			[545.6]	500600	683900	7	5	0.12	3.9(−4)[a]	0.0049	−2.56	E	2
7.		$^3D - {}^3P^\circ$											
			[439]			3	1	70	0.067	0.29	−0.70	C	2
8.		$^3D - {}^3D^\circ$											
			434.94	500600	730500	7	7	51	0.146	1.46	0.009	C	2
			[434.0]	500100	730500	5	7	9.1	0.036	0.26	−0.74	C	2
9.		$^1D - {}^1D^\circ$	[768.88]	564604	694660	5	5	4.5	0.040	0.51	−0.70	D	2
10.		$^1D - {}^1F^\circ$	[453]			5	7	130	0.54	4.0	0.43	D	2
11.		$^1D - {}^1P^\circ$	[440]			5	3	86	0.15	1.1	−0.12	D	2

Ti XI: Allowed transitions — Continued

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} ($10^8 s^{-1}$)	f_{ik}	S (at. u.)	log gf	Accuracy	Source
12.	$3s^2$–$3s4p$	$^1S - {^1P^\circ}$	87.725	0	1139900	1	3	850	0.294	0.085	−0.53	C	1
13.	$3s^2$–$3s5p$	$^1S - {^1P^\circ}$	65.403	0	1529000	1	3	510	0.099	0.021	−1.00	C	1
14.	$3s3p$–$3s3d$	$^3P^\circ - {^3D}$	*310.8*	*178500*	*500300*	9	15	163	0.394	3.63	0.55	C	2
			313.229	181300	500600	5	7	160	0.330	1.70	0.217	C	2
			308.250	175700	500100	3	5	130	0.30	0.91	−0.05	C	2
			306.144	173200	499800	1	3	95	0.40	0.40	−0.40	C	2
			313.710	181300	500100	5	5	39	0.058	0.30	−0.54	C	2
			308.568	175700	499800	3	3	70	0.10	0.30	−0.52	C	2
			[314.0]	181300	499800	5	3	4.5	0.0040	0.021	−1.70	D	2
15.		$^1P^\circ - {^1D}$	327.192	258973	564604	3	5	290	0.78	2.5	0.37	D	2
16.	$3p^2$–$3p3d$	$^1D - {^1D^\circ}$	349.91	408870	694660	5	5	110	0.21	1.2	0.02	D	2
17.		$^1D - {^1F^\circ}$	[266]			5	7	180	0.26	1.1	0.11	D	2
18.		$^1D - {^1P^\circ}$	[261]			5	3	2.4	0.0015	0.0064	−2.12	E	2
19.		$^3P - {^3P^\circ}$											
			[318]			3	1	140	0.070	0.22	−0.68	C	2
20.		$^3P - {^3D^\circ}$											
			322.75	420600	730500	5	7	199	0.434	2.31	0.336	C−	2
21.		$^1S - {^1P^\circ}$	[323]			1	3	180	0.85	0.90	−0.07	C	2
22.	$3p3d$–$3d^2$	$^1F^\circ - {^1G}$	[408]			7	9	137	0.440	4.14	0.489	C−	3
23.		$^1P^\circ - {^1S}$	[332]			3	1	325	0.179	0.59	−0.270	C−	3

[a]The number in parentheses following the tabulated value indicates the power of ten by which this value has to be multiplied.

Ti XII

Na Isoelectronic Sequence

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

Ionization Energy: 291.502 eV = 2351080 cm^{-1}

Allowed Transitions

List of tabulated lines

Wavelength (Å)	No.	Wavelength (Å)	No.	Wavelength (Å)	No.	Wavelength (Å)	No.
47.906	6	53.457	4	59.133	13	62.433	27
49.912	5	55.181	15	59.435	13	62.469	27
52.896	17	55.443	15	60.701	3	62.470	27
53.138	17	55.445	15	60.762	3	63.072	26
53.140	17	56.161	14	60.971	12	63.107	26
53.433	4	56.431	14	61.286	12	65.540	25

List of tabulated lines — Continued

Wavelength (Å)	No.	Wavelength (Å)	No.	Wavelength (Å)	No.	Wavelength (Å)	No.
65.577	25	116.497	19	182.0	45	307.1	43
65.578	25	116.597	19	185.5	52	308.3	43
66.596	24	116.62	19	194.6	29	326.4	69
66.636	24	124.0	39	195.2	29	326.6	69
67.171	11	124.5	39	207.2	35	329.2	74
67.555	11	127.8	50	207.8	58	329.3	74
67.563	11	127.9	50	208.5	35	340.672	7
70.986	23	129.1	38	208.6	35	349.929	7
71.031	23	129.6	38	220.7	65	351.024	7
71.033	23	130.5	49	221.5	65	376.8	56
71.545	10	130.6	49	246.0	72	377.9	56
71.987	10	135.4	54	246.1	72	394.2	61
73.014	22	135.5	30	251.6	57	396.7	61
73.057	22	135.7	30	252.8	44	460.741	1
73.062	22	139.71	18	253.1	44	468.4	68
82.121	2	139.884	18	255.3	34	468.8	68
82.307	21	140.361	18	256.2	71	479.881	1
82.344	2	141.6	48	256.3	71	492.9	60
82.366	21	141.7	48	257.5	34	496.8	60
82.368	21	146.0	37	261.8	75	547.6	73
87.298	20	146.6	47	266.8	63	573.4	67
87.364	20	146.7	37,47	267.9	63	574.1	67
87.426	20	151.4	53	268.0	63	576.0	67
89.844	9	151.5	53	291.3	62	934.6	33
90.512	9	157.7	36	292.7	62	959.945	33
90.547	9	158.5	36	296.7	51	964.3	33
104.8	32	169.7	46	296.9	51	1188.8	28
113.1	41	169.8	46	302.5	70	1237.7	28
113.5	41	181.8	45	302.7	70		
115.0	31	181.9	45	306.7	43		

Strengths of the lines of the $3s$–$3p$ and $3p$–$3d$ transitions were taken from Edlén's interpolation formulae.[1] These were based on the results of Weiss' Hartree-Fock calculations,[2] in which ratios of relativistic Dirac to nonrelativistic line strengths in hydrogenic ions were applied as scaling factors to the nonrelativistic Hartree-Fock line strengths in the corresponding sodiumlike species. Oscillator strengths for the $4p$–$4d$ transitions were derived by Gruzdev and Sherstyuk[3] using the relativistic variant of their effective orbital quantum number method, which utilizes a Coulomb potential in conjunction with a semiempirical orbital quantum number which is determined from experimental energy levels.

Multiplet f-values calculated by Biemont[4] using a fully variational Hartree-Fock approach are quoted for numerous transitions nl–$n'l'$($3 \leqslant n \leqslant 5$; $4 \leqslant n' \leqslant 8$; $l,l'=s,p,d,f$). Data for additional transitions (namely, those for which $n > 5$, where n is the principal quantum number of the lower state) can be found in Ref. 4. Whenever wavelengths of individual lines within a multiplet either were available directly or could be determined from the energy levels, the multiplet strength was distributed among the lines according to LS-coupling rules, except in cases where the wavelengths of all the lines in the multiplet are identical. The strength of the $3p\ ^2P° - 4s\ ^2S$ multiplet was not distributed between the two lines in the multiplet, however, since the relativistic single-configuration Hartree-Fock calculations of Kim and Cheng[5] indicate that in the corresponding transition in sodiumlike iron the ratio of the two line strengths deviates somewhat from the value that would be obtained in the case of pure LS coupling.

Transitions with small f-values were generally assigned lower accuracy ratings.

References

[1] B. Edlén, Phys. Scr. **17**, 565 (1978).
[2] A. W. Weiss, J. Quant. Spectrosc. Radiat. Transfer **18**, 481 (1977).
[3] P. F. Gruzdev and A. I. Sherstyuk, Opt. Spectrosc. (USSR) **46**, 353 (1979).
[4] E. Biemont, Astron. Astrophys., Suppl. Ser. **31**, 285 (1978).
[5] Y.-K. Kim and K.-T. Cheng, J. Opt. Soc. Am. **68**, 836 (1978).

Ti XII: Allowed transitions

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} (10^8 s^{-1})	f_{ik}	S (at. u.)	log gf	Accuracy	Source
1.	3s–3p	^{2}S – ^{2}P°	*466.95*	0	*214156*	2	6	48.1	0.472	1.45	−0.025	B	1
			460.741	0	217042	2	4	50.2	0.320	0.970	−0.194	B	1
			479.881	0	208385	2	2	44.0	0.152	0.480	−0.517	B	1
2.	3s–4p	^{2}S – ^{2}P°	*82.196*	0	*1216585*	2	6	590	0.180	0.097	−0.444	C	4
			82.121	0	1217692	2	4	590	0.12	0.065	−0.62	C	*ls*
			82.344	0	1214371	2	2	580	0.059	0.032	−0.93	C	*ls*
3.	3s–5p	^{2}S – ^{2}P°	*60.720*	0	*1646900*	2	6	350	0.058	0.023	−0.94	C	4
			60.701	0	1647400	2	4	340	0.038	0.015	−1.12	C	*ls*
			60.762	0	1645800	2	2	350	0.019	0.0077	−1.41	C	*ls*
4.	3s–6p	^{2}S – ^{2}P°	*53.442*	0	*1871200*	2	6	207	0.0266	0.0094	−1.274	C	4
			53.433	0	1871500	2	4	210	0.018	0.0063	−1.45	C	*ls*
			53.457	0	1870700	2	2	210	0.0088	0.0031	−1.75	D	*ls*
5.	3s–7p	^{2}S – ^{2}P°	49.912	0	2003500	2	6	132	0.0148	0.00486	−1.53	C	4
6.	3s–8p	^{2}S – ^{2}P°	47.906	0	2087400	2	6	88	0.0091	0.0029	−1.74	D	4
7.	3p–3d	^{2}P° – ^{2}D	*346.86*	*214156*	*502457*	6	10	123	0.369	2.53	0.345	B	1
			349.929	217042	502814	4	6	120	0.330	1.52	0.120	B	1
			340.672	208385	501922	2	4	108	0.376	0.843	−0.124	B	1
			351.024	217042	501922	4	4	19.7	0.0363	0.168	−0.837	B	1
8.	3p–4s	^{2}P° – ^{2}S	*108.76*	*214156*	1133573	6	2	1200	0.071	0.15	−0.37	C	4
9.	3p–4d	^{2}P° – ^{2}D	*90.302*	*214156*	*1321600*	6	10	1170	0.238	0.425	0.155	C	4
			90.512	217042	1321800	4	6	1160	0.214	0.255	−0.068	C	*ls*
			89.844	208385	1321400	2	4	990	0.240	0.142	−0.319	C	*ls*
			90.547	217042	1321400	4	4	190	0.023	0.028	−1.03	D	*ls*
10.	3p–5s	^{2}P° – ^{2}S	*71.844*	*214156*	1606100	6	2	520	0.0135	0.0192	−1.092	C	4
			71.987	217042	1606100	4	2	348	0.0135	0.0128	−1.268	C	*ls*
			71.545	208385	1606100	2	2	180	0.014	0.0064	−1.57	C	*ls*
11.	3p–5d	^{2}P° – ^{2}D	*67.431*	*214156*	*1697200*	6	10	730	0.083	0.11	−0.30	C	4
			67.555	217042	1697300	4	6	720	0.074	0.066	−0.53	C	*ls*
			67.171	208385	1697100	2	4	620	0.084	0.037	−0.78	C	*ls*
			[67.563]	217042	1697100	4	4	120	0.0082	0.0073	−1.48	D	*ls*
12.	3p–6s	^{2}P° – ^{2}S	*61.181*	*214156*	1848700	6	2	280	0.0052	0.0063	−1.51	D	4
			61.286	217042	1848700	4	2	180	0.0052	0.0042	−1.68	D	*ls*
			60.971	208385	1848700	2	2	94	0.0052	0.0021	−1.98	D	*ls*

Ti XII: Allowed transitions — Continued

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} (10^8 s^{-1})	f_{ik}	S (at. u.)	log gf	Accuracy	Source
13.	$3p$–$6d$	^{2}P° – ^{2}D	*59.337*	*214156*	1899500	6	10	442	0.0389	0.0456	−0.63	C	4
			59.435	217042	1899500	4	6	441	0.0350	0.0274	−0.85	C	*ls*
			59.133	208385	1899500	2	4	372	0.0390	0.0152	−1.107	C	*ls*
			[59.435]	217042	1899500	4	4	72	0.0038	0.0030	−1.81	D	*ls*
14.	$3p$–$7s$	^{2}P° – ^{2}S	*56.341*	*214156*	1989100	6	2	160	0.0026	0.0029	−1.81	D	4
			56.431	217042	1989100	4	2	110	0.0026	0.0019	−1.99	D	*ls*
			56.161	208385	1989100	2	2	55	0.0026	9.7(−4)[a]	−2.28	D	*ls*
15.	$3p$–$7d$	^{2}P° – ^{2}D	*55.356*	*214156*	*2020700*	6	10	283	0.0217	0.0237	−0.89	C	4
			55.443	217042	2020700	4	6	281	0.0194	0.0142	−1.109	C	*ls*
			55.181	208385	2020600	2	4	240	0.022	0.0079	−1.36	C	*ls*
			[55.445]	217042	2020600	4	4	48	0.0022	0.0016	−2.06	D	*ls*
16.	$3p$–$8s$	^{2}P° – ^{2}S				6	2		0.0016		−2.02	D	4
17.	$3p$–$8d$	^{2}P° – ^{2}D	*53.062*	*214156*	*2098800*	6	10	192	0.0135	0.0141	−1.092	C	4
			53.140	217042	2098800	4	6	190	0.012	0.0085	−1.31	C	*ls*
			52.896	208385	2098900	2	4	161	0.0135	0.00470	−1.57	C	*ls*
			[53.138]	217042	2098900	4	4	32	0.0013	9.4(−4)	−2.27	D	*ls*
18.	$3d$–$4p$	^{2}D – ^{2}P°	*140.03*	*502457*	*1216585*	10	6	290	0.052	0.24	−0.28	C	4
			139.884	502814	1217692	6	4	260	0.051	0.14	−0.52	C	*ls*
			140.361	501922	1214371	4	2	290	0.043	0.080	−0.76	C	*ls*
			[139.71]	501922	1217692	4	4	30	0.0087	0.016	−1.46	D	*ls*
19.	$3d$–$4f$	^{2}D – ^{2}F°	*166.56*	*502457*	*1360402*	10	14	3200	0.91	3.5	0.96	C	4
			116.597	502814	1360469	6	8	3200	0.87	2.0	0.72	C	*ls*
			116.497	501922	1360313	4	6	3000	0.91	1.4	0.56	C	*ls*
			[116.62]	502814	1360313	6	6	210	0.043	0.10	−0.58	D	*ls*
20.	$3d$–$5p$	^{2}D – ^{2}P°	*87.382*	*502457*	*1646900*	10	6	110	0.0078	0.022	−1.11	D	4
			87.364	502814	1647400	6	4	99	0.0075	0.013	−1.34	D	*ls*
			87.426	501922	1645800	4	2	110	0.0063	0.0073	−1.60	D	*ls*
			[87.298]	501922	1647400	4	4	11	0.0013	0.0015	−2.28	E	*ls*
21.	$3d$–$5f$	^{2}D – ^{2}F°	*82.345*	*502457*	1716900	10	14	1200	0.171	0.464	0.233	C	4
			82.368	502814	1716900	6	8	1200	0.163	0.265	−0.010	C	*ls*
			82.307	501922	1716900	4	6	1130	0.172	0.186	−0.163	C	*ls*
			[82.366]	502814	1716900	6	6	79	0.0080	0.013	−1.32	D	*ls*
22.	$3d$–$6p$	^{2}D – ^{2}P°	*73.062*	*502457*	*1871200*	10	6	58	0.0028	0.0067	−1.55	D	4
			[73.062]	502814	1871500	6	4	52	0.0028	0.0040	−1.78	D	*ls*
			[73.057]	501922	1870700	4	2	57	0.0023	0.0022	−2.04	D	*ls*
			[73.014]	501922	1871500	4	4	5.9	4.7(−4)	4.5(−4)	−2.73	E	*ls*

Ti XII: Allowed transitions — Continued

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} (10^8 s^{-1})	f_{ik}	S (at. u.)	log gf	Accuracy	Source
23.	$3d$–$6f$	^{2}D – ^{2}F°	*71.018*	*502457*	1910600	10	14	600	0.064	0.15	−0.19	C	4
			71.031	502814	1910600	6	8	610	0.061	0.086	−0.43	C	*ls*
			70.986	501922	1910600	4	6	570	0.064	0.060	−0.59	C	*ls*
			[71.033]	502814	1910600	6	6	41	0.0031	0.0043	−1.74	D	*ls*
24.	$3d$–$7p$	^{2}D – ^{2}P°	*66.622*	*502457*	2003500	10	6	33	0.0013	0.0029	−1.89	D	4
			[66.636]	502814	2003500	6	4	29	0.0013	0.0017	−2.11	D	*ls*
			[66.596]	501922	2003500	4	2	33	0.0011	9.7(−4)	−2.35	D	*ls*
			[66.596]	501922	2003500	4	4	3.3	2.2(−4)	1.9(−4)	−3.06	E	*ls*
25.	$3d$–$7f$	^{2}D – ^{2}F°	*65.565*	*502457*	2027700	10	14	349	0.0315	0.068	−0.50	C	4
			65.577	502814	2027700	6	8	350	0.030	0.039	−0.74	C	*ls*
			65.540	501922	2027700	4	6	320	0.031	0.027	−0.90	C	*ls*
			[65.578]	502814	2027700	6	6	23	0.0015	0.0019	−2.06	D	*ls*
26.	$3d$–$8p$	^{2}D – ^{2}P°	*63.095*	*502457*	2087400	10	6	21	7.6(−4)	0.0016	−2.12	E	4
			[63.107]	502814	2087400	6	4	19	7.7(−4)	9.6(−4)	−2.34	E	*ls*
			[63.072]	501922	2087400	4	2	21	6.4(−4)	5.3(−4)	−2.59	E	*ls*
			[63.072]	501922	2087400	4	4	2.2	1.3(−4)	1.1(−4)	−3.28	E	*ls*
27.	$3d$–$8f$	^{2}D – ^{2}F°	*62.457*	*502457*	2103600	10	14	222	0.0182	0.0374	−0.74	C	4
			62.470	502814	2103600	6	8	222	0.0173	0.0214	−0.98	C	*ls*
			62.433	501922	2103600	4	6	208	0.0182	0.0150	−1.137	C	*ls*
			[62.469]	502814	2103600	6	6	15	8.9(−4)	0.0011	−2.27	E	*ls*
28.	$4s$–$4p$	^{2}S – ^{2}P°	*1204.6*	1133573	*1216585*	2	6	10	0.67	5.3	0.13	C	4
			[1188.8]	1133573	1217692	2	4	11	0.45	3.5	−0.05	C	*ls*
			[1237.7]	1133573	1214371	2	2	9.6	0.22	1.8	−0.35	C	*ls*
29.	$4s$–$5p$	^{2}S – ^{2}P°	*194.8*	1133573	*1646900*	2	6	110	0.188	0.241	−0.425	C	4
			[194.6]	1133573	1647400	2	4	111	0.126	0.161	−0.60	C	*ls*
			[195.2]	1133573	1645800	2	2	110	0.062	0.080	−0.90	C	*ls*
30.	$4s$–$6p$	^{2}S – ^{2}P°	*135.6*	1133573	*1871200*	2	6	75	0.062	0.055	−0.91	C	4
			[135.5]	1133573	1871500	2	4	75	0.041	0.037	−1.08	C	*ls*
			[135.7]	1133573	1870700	2	2	73	0.020	0.018	−1.39	C	*ls*
31.	$4s$–$7p$	^{2}S – ^{2}P°	[115.0]	1133573	2003500	2	6	50	0.0296	0.0224	−1.228	C	4
32.	$4s$–$8p$	^{2}S – ^{2}P°	[104.8]	1133573	2087400	2	6	34.0	0.0168	0.0116	−1.474	C	4
33.	$4p$–$4d$	^{2}P° – ^{2}D	*952.4*	*1216585*	*1321600*	6	10	23	0.53	9.9	0.50	C	3
			959.945	1217692	1321800	4	6	23	0.47	5.9	0.27	C	3
			[934.6]	1214371	1321400	2	4	21	0.54	3.3	0.03	C	3
			[964.3]	1217692	1321400	4	4	3.7	0.052	0.66	−0.68	C	3
34.	$4p$–$5s$	^{2}P° – ^{2}S	*256.7*	*1216585*	1606100	6	2	370	0.122	0.62	−0.135	C	4
			[257.5]	1217692	1606100	4	2	240	0.12	0.41	−0.32	C	*ls*
			[255.3]	1214371	1606100	2	2	130	0.12	0.21	−0.60	C	*ls*

Ti XII: Allowed transitions — Continued

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} (10^8 s^{-1})	f_{ik}	S (at. u.)	log gf	Accuracy	Source
35.	$4p$–$5d$	$^2P^\circ$ – ^2D	*208.1*	*1216585*	*1697200*	6	10	180	0.195	0.80	0.068	C	4
			[208.5]	1217692	1697300	4	6	180	0.17	0.48	−0.16	C	*ls*
			[207.2]	1214371	1697100	2	4	150	0.20	0.27	−0.40	C	*ls*
			[208.6]	1217692	1697100	4	4	30	0.019	0.053	−1.11	D	*ls*
36.	$4p$–$6s$	$^2P^\circ$ – ^2S	*158.2*	*1216585*	1848700	6	2	185	0.0232	0.072	−0.86	C	4
			[158.5]	1217692	1848700	4	2	120	0.023	0.048	−1.04	C	*ls*
			[157.7]	1214371	1848700	2	2	62	0.023	0.024	−1.34	C	*ls*
37.	$4p$–$6d$	$^2P^\circ$ – ^2D	*146.4*	*1216585*	1899500	6	10	140	0.073	0.21	−0.36	C	4
			[146.7]	1217692	1899500	4	6	140	0.067	0.13	−0.57	C	*ls*
			[146.0]	1214371	1899500	2	4	110	0.073	0.070	−0.84	C	*ls*
			[146.7]	1217692	1899500	4	4	22	0.0072	0.014	−1.54	D	*ls*
38.	$4p$–$7s$	$^2P^\circ$ – ^2S	*129.4*	*1216585*	1989100	6	2	110	0.0090	0.023	−1.27	D	4
			[129.6]	1217692	1989100	4	2	70	0.0088	0.015	−1.45	D	*ls*
			[129.1]	1214371	1989100	2	2	36	0.0091	0.0077	−1.74	D	*ls*
39.	$4p$–$7d$	$^2P^\circ$ – ^2D	*124.4*	*1216585*	*2020700*	6	10	93	0.0361	0.089	−0.66	C	4
			[124.5]	1217692	2020700	4	6	93	0.032	0.053	−0.89	C	*ls*
			[124.0]	1214371	2020600	2	4	80	0.037	0.030	−1.13	C	*ls*
			[124.5]	1217692	2020600	4	4	15	0.0036	0.0059	−1.84	D	*ls*
40.	$4p$–$8s$	$^2P^\circ$ – ^2S				6	2		0.0046		−1.56	D	4
41.	$4p$–$8d$	$^2P^\circ$ – ^2D	*113.4*	*1216585*	*2098800*	6	10	65	0.0209	0.0468	−0.90	C	4
			[113.5]	1217692	2098800	4	6	65	0.0188	0.0281	−1.124	C	*ls*
			[113.1]	1214371	2098900	2	4	55	0.0209	0.0156	−1.378	C	*ls*
			[113.5]	1217692	2098900	4	4	11	0.0021	0.0031	−2.08	D	*ls*
42.	$4d$–$4f$	^2D – $^2F^\circ$				10	14		0.131		0.117	C	4
43.	$4d$–$5p$	^2D – $^2P^\circ$	*307.4*	*1321600*	*1646900*	10	6	133	0.113	1.14	0.053	C	4
			[307.1]	1321800	1647400	6	4	120	0.11	0.68	−0.17	C	*ls*
			[308.3]	1321400	1645800	4	2	131	0.094	0.380	−0.427	C	*ls*
			[306.7]	1321400	1647400	4	4	13	0.019	0.076	−1.12	D	*ls*
44.	$4d$–$5f$	^2D – $^2F^\circ$	*253.0*	*1321600*	1716900	10	14	520	0.70	5.8	0.85	C	4
			[253.1]	1321800	1716900	6	8	520	0.66	3.3	0.60	C	*ls*
			[252.8]	1321400	1716900	4	6	480	0.69	2.3	0.44	C	*ls*
			[253.1]	1321800	1716900	6	6	35	0.034	0.17	−0.69	D	*ls*
45.	$4d$–$6p$	^2D – $^2P^\circ$	*182.0*	*1321600*	*1871200*	10	6	61	0.0182	0.109	−0.74	C	4
			[181.9]	1321800	1871500	6	4	55	0.018	0.065	−0.96	C	*ls*
			[182.0]	1321400	1870700	4	2	61	0.0151	0.0363	−1.218	C	*ls*
			[181.8]	1321400	1871500	4	4	6.2	0.0030	0.0073	−1.91	D	*ls*
46.	$4d$–$6f$	^2D – $^2F^\circ$	*169.8*	*1321600*	1910600	10	14	292	0.177	0.99	0.248	C	4
			[169.8]	1321800	1910600	6	8	290	0.17	0.57	0.01	C	*ls*
			[169.7]	1321400	1910600	4	6	280	0.18	0.40	−0.15	C	*ls*
			[169.8]	1321800	1910600	6	6	19	0.0083	0.028	−1.30	D	*ls*

Ti XII: Allowed transitions — Continued

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} (10^8 s^{-1})	f_{ik}	S (at. u.)	log gf	Accuracy	Source
47.	$4d-7p$	$^2D - ^2P°$	*146.6*	*1321600*	2003500	10	6	34	0.0066	0.032	−1.18	D	4
			[146.7]	1321800	2003500	6	4	30	0.0066	0.019	−1.41	D	*ls*
			[146.6]	1321400	2003500	4	2	35	0.0057	0.011	−1.64	D	*ls*
			[146.6]	1321400	2003500	4	4	3.4	0.0011	0.0021	−2.36	E	*ls*
48.	$4d-7f$	$^2D - ^2F°$	*141.6*	*1321600*	2027700	10	14	180	0.074	0.34	−0.13	C	4
			[141.7]	1321800	2027700	6	8	170	0.068	0.19	−0.39	C	*ls*
			[141.6]	1321400	2027700	4	6	170	0.075	0.14	−0.52	C	*ls*
			[141.7]	1321800	2027700	6	6	12	0.0035	0.0097	−1.68	D	*ls*
49.	$4d-8p$	$^2D - ^2P°$	*130.6*	*1321600*	2087400	10	6	22	0.0033	0.014	−1.48	D	4
			[130.6]	1321800	2087400	6	4	19	0.0033	0.0084	−1.71	D	*ls*
			[130.5]	1321400	2087400	4	2	21	0.0027	0.0047	−1.96	D	*ls*
			[130.5]	1321400	2087400	4	4	2.1	5.4(−4)	9.3(−4)	−2.66	E	*ls*
50.	$4d-8f$	$^2D - ^2F°$	*127.9*	*1321600*	2103600	10	14	114	0.0390	0.164	−0.409	C	4
			[127.9]	1321800	2103600	6	8	110	0.037	0.094	−0.65	C	*ls*
			[127.8]	1321400	2103600	4	6	110	0.039	0.066	−0.80	C	*ls*
			[127.9]	1321800	2103600	6	6	7.6	0.0019	0.0047	−1.95	D	*ls*
51.	$4f-5d$	$^2F° - ^2D$	*296.9*	*1360402*	*1697200*	14	10	22.4	0.0211	0.289	−0.53	C	4
			[296.9]	1360469	1697300	8	6	21.3	0.0211	0.165	−0.77	C	*ls*
			[296.9]	1360313	1697100	6	4	22.5	0.0198	0.116	−0.93	C	*ls*
			[296.7]	1360313	1697300	6	6	1.1	0.0014	0.0083	−2.07	D	*ls*
52.	$4f-6d$	$^2F° - ^2D$	[185.5]	*1360402*	1899500	14	10	9.5	0.0035	0.030	−1.31	D	4
53.	$4f-7d$	$^2F° - ^2D$	*151.4*	*1360402*	*2020700*	14	10	4.9	0.0012	0.0084	−1.77	D	4
			[151.5]	1360469	2020700	8	6	4.7	0.0012	0.0048	−2.02	D	*ls*
			[151.4]	1360313	2020600	6	4	5.0	0.0011	0.0034	−2.17	D	*ls*
			[151.4]	1360313	2020700	6	6	0.23	8.0(−5)	2.4(−4)	−3.32	E	*ls*
54.	$4f-8d$	$^2F° - ^2D$	[135.4]	*1360402*	2098800	14	10	3.1	6.0(−4)	0.0037	−2.08	E	4
55.	$5s-5p$	$^2S - ^2P°$				2	6		0.87		0.24	C	4
56.	$5s-6p$	$^2S - ^2P°$	*377.2*	1606100	*1871200*	2	6	31.3	0.200	0.497	−0.398	C	4
			[376.8]	1606100	1871500	2	4	31.3	0.133	0.331	−0.57	C	*ls*
			[377.9]	1606100	1870700	2	2	31.2	0.067	0.166	−0.87	C	*ls*
57.	$5s-7p$	$^2S - ^2P°$	[251.6]	1606100	2003500	2	6	24	0.067	0.11	−0.87	C	4
58.	$5s-8p$	$^2S - ^2P°$	[207.8]	1606100	2087400	2	6	16.6	0.0323	0.0442	−1.190	C	4
59.	$5p-5d$	$^2P° - ^2D$				6	10		0.76		0.66	C	4
60.	$5p-6s$	$^2P° - ^2S$	*495.5*	*1646900*	1848700	6	2	141	0.173	1.69	0.016	C	4
			[496.8]	1647400	1848700	4	2	93	0.173	1.13	−0.161	C	*ls*
			[492.9]	1645800	1848700	2	2	47	0.17	0.56	−0.46	C	*ls*
61.	$5p-6d$	$^2P° - ^2D$	*395.9*	*1646900*	1899500	6	10	44.9	0.176	1.38	0.024	C	4
			[396.7]	1647400	1899500	4	6	45	0.16	0.83	−0.20	C	*ls*
			[394.2]	1645800	1899500	2	4	38.0	0.177	0.460	−0.450	C	*ls*
			[396.7]	1647400	1899500	4	4	7.5	0.018	0.092	−1.15	D	*ls*

Ti XII: Allowed transitions — Continued

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} (10^8 s^{-1})	f_{ik}	S (at. u.)	log gf	Accuracy	Source
62.	$5p$–$7s$	$^2P^\circ$ - ^2S	*292.2*	*1646900*	1989100	6	2	77	0.0329	0.190	−0.70	C	4
			[292.7]	1647400	1989100	4	2	51	0.0329	0.127	−0.88	C	*ls*
			[291.3]	1645800	1989100	2	2	26	0.033	0.063	−1.18	C	*ls*
63.	$5p$–$7d$	$^2P^\circ$ - ^2D	*267.5*	*1646900*	*2020700*	6	10	38	0.068	0.36	−0.39	C	4
			[267.9]	1647400	2020700	4	6	39	0.062	0.22	−0.60	C	*ls*
			[266.8]	1645800	2020600	2	4	32	0.068	0.12	−0.86	C	*ls*
			[268.0]	1647400	2020600	4	4	6.3	0.0068	0.024	−1.57	D	*ls*
64.	$5p$–$8s$	$^2P^\circ$ - ^2S				6	2		0.0128		−1.115	C	4
65.	$5p$–$8d$	$^2P^\circ$ - ^2D	*221.3*	*1646900*	*2098800*	6	10	28.2	0.0345	0.151	−0.68	C	4
			[221.5]	1647400	2098800	4	6	28	0.031	0.091	−0.90	C	*ls*
			[220.7]	1645800	2098900	2	4	24	0.034	0.050	−1.16	C	*ls*
			[221.5]	1647400	2098900	4	4	4.7	0.0034	0.010	−1.86	D	*ls*
66.	$5d$–$5f$	^2D - $^2F^\circ$				10	14		0.231		0.364	C	4
67.	$5d$–$6p$	^2D - $^2P^\circ$	*574.7*	*1697200*	*1871200*	10	6	60	0.179	3.39	0.253	C	4
			[574.1]	1697300	1871500	6	4	54	0.179	2.03	0.031	C	*ls*
			[576.0]	1697100	1870700	4	2	60	0.149	1.13	−0.225	C	*ls*
			[573.4]	1697100	1871500	4	4	6.2	0.030	0.23	−0.91	D	*ls*
68.	$5d$–$6f$	^2D - $^2F^\circ$	*468.6*	*1697200*	1910600	10	14	130	0.61	9.4	0.79	C	4
			[468.8]	1697300	1910600	6	8	130	0.58	5.4	0.54	C	*ls*
			[468.4]	1697100	1910600	4	6	120	0.62	3.8	0.39	C	*ls*
			[468.8]	1697300	1910600	6	6	8.8	0.029	0.27	−0.76	D	*ls*
69.	$5d$–$7p$	^2D - $^2P^\circ$	*326.5*	*1697200*	2003500	10	6	30.8	0.0295	0.317	−0.53	C	4
			[326.6]	1697300	2003500	6	4	27.6	0.0295	0.190	−0.75	C	*ls*
			[326.4]	1697100	2003500	4	2	30.9	0.0247	0.106	−1.006	C	*ls*
			[326.4]	1697100	2003500	4	4	3.1	0.0049	0.021	−1.71	D	*ls*
70.	$5d$–$7f$	^2D - $^2F^\circ$	*302.6*	*1697200*	2027700	10	14	89	0.172	1.71	0.236	C	4
			[302.7]	1697300	2027700	6	8	89	0.16	0.98	−0.01	C	*ls*
			[302.5]	1697100	2027700	4	6	83	0.17	0.68	−0.17	C	*ls*
			[302.7]	1697300	2027700	6	6	6.0	0.0082	0.049	−1.31	D	*ls*
71.	$5d$–$8p$	^2D - $^2P^\circ$	*256.3*	*1697200*	2087400	10	6	18.3	0.0108	0.091	−0.97	C	4
			[256.3]	1697300	2087400	6	4	17	0.011	0.055	−1.19	C	*ls*
			[256.2]	1697100	2087400	4	2	18	0.0089	0.030	−1.45	D	*ls*
			[256.2]	1697100	2087400	4	4	1.8	0.0018	0.0061	−2.14	D	*ls*
72.	$5d$–$8f$	^2D - $^2F^\circ$	*246.1*	*1697200*	2103600	10	14	60	0.076	0.62	−0.12	C	4
			[246.1]	1697300	2103600	6	8	59	0.072	0.35	−0.36	C	*ls*
			[246.0]	1679100	2103600	4	6	57	0.077	0.25	−0.51	C	*ls*
			[246.1]	1697300	2103600	6	6	4.1	0.0037	0.018	−1.65	D	*ls*
73.	$5f$–$6d$	$^2F^\circ$ - ^2D	[547.6]	1716900	1899500	14	10	16	0.051	1.3	−0.15	C	4
74.	$5f$–$7d$	$^2F^\circ$ - ^2D	*329.2*	1716900	*2020700*	14	10	7.8	0.0090	0.14	−0.90	D	4
			[329.2]	1716900	2020700	8	6	7.6	0.0092	0.080	−1.13	D	*ls*
			[329.3]	1716900	2020600	6	4	7.9	0.0086	0.056	−1.29	D	*ls*
			[329.2]	1716900	2020700	6	6	0.38	6.2(−4)	0.0040	−2.43	E	*ls*

Ti XII: Allowed transitions — Continued

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} ($10^8 s^{-1}$)	f_{ik}	S (at. u.)	log gf	Accuracy	Source
75.	$5f$–$8d$	$^2F^\circ$ - ^2D	[261.8]	1716900	*2098800*	14	10	4.5	0.0033	0.040	−1.34	D	4

[a]The number in parentheses following the tabulated value indicates the power of ten by which this value has to be multiplied.

Ti XII

Forbidden Transitions

List of tabulated lines

Wavelength (Å)	No.	Wavelength (Å)	No.	Wavelength (Å)	No.	Wavelength (Å)	No.
52.645	38	144.3	50	263.0	65	518.1	31
58.917	37	149.8	15,55	266.0	9	531.3	43
58.924	37	149.9	15,55	266.2	9	532.5	43
59.046	41	152.2	6	266.3	9	565.6	80
66.291	40	153.0	6	266.5	9	581.4	73
66.671	40	153.1	6	269.9	71	581.7	73
69.493	2	155.5	58	279.6	18	636.9	76
69.911	2	158.32	42	280.4	13	640.2	76
69.989	2	158.54	42	280.6	13	646.8	69
75.654	36	173.0	10	280.8	18	650.2	69
75.677	36	173.1	10	309.0	21	659.6	67
83.668	4	177.4	44	309.1	21	660.5	67
83.717	4	177.5	44	309.2	21	685.20	48
86.811	39	181.7	14	309.3	21	700.39	48
87.456	39	181.8	14	321.8	24	701.16	48
87.468	39	189.6	54	340.8	60	753.0	26
99.078	1	189.8	54	342.5	68	757.6	26
99.935	1	195.6	57	342.7	68	825.1	28
100.27	1	195.7	57	348.3	56	825.8	28
103.6	47	195.9	57	348.6	56	854.0	30
112.5	52	198.88	35	348.9	70	910.7	82
112.7	46	199.0	49	350.3	56	911.6	82
112.9	52	199.23	35	351.2	53	999.0	84
114.5	8	200.3	49	351.7	53	1080	79
115.0	8	202.9	62	377.6	64	1100	59
122.0	3	203.0	62	379.9	64	1120	78
122.1	3	218.4	66	399.7	74	1190	32
122.2	3	219.2	66	399.8	74	1280	33
123.0	51	226.4	19	429.4	77	1320	34
123.5	51	227.3	19	430.8	77	1410	63
126.7	7	230.9	5	443.1	17	1440	63
127.3	7	232.7	5	446.2	17	1680	85
128.6	12	233.6	5	447.8	17	1970	72
128.7	12	241.2	61	461.5	27	2510	75
130.6	45	241.3	61	463.2	27	2560	75
134.5	16	248.9	22	494.1	20	3160	81
134.6	16	249.0	22	494.6	20	3170	81
143.0	11	249.1	22	501.5	29	4130	83
143.1	11	258.6	25	501.8	29	6170	86
143.6	50	261.8	65	516.3	23		

Electric quadrupole gf-values for numerous multiplets in this sodiumlike ion were determined by Biemont and Godefroid[1] using a fully variational Hartree-Fock approach with no allowance for configuration mixing. These f-values were converted to multiplet strengths, and LS-coupling rules were applied to obtain strengths of lines within multiplets. The gf-values for d–d and f–f transitions as given in Ref. 1 are overstated,[2] and had to be reduced by factors of 9 and 25, respectively. The strongest lines for which fairly accurate wavelengths could be derived from experimentally determined energy levels are quoted in this compilation.

References

[1]E. Biemont and M. Godefroid, Phys. Scr. **18**, 323 (1978).
[2]E. Biemont, private communication (1986).

Ti XII: Forbidden transitions

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	Type of transition	A_{ki} (s^{-1})	S (at. u.)	Accuracy	Source
1.	$3p$–$4p$	$^2P^\circ$ - $^2P^\circ$										
			[99.935]	217042	1217692	4	4	E2	6.9(+6)[a]	0.164	C	1,ls
			[100.27]	217042	1214371	4	2	E2	1.36(+7)	0.164	C	1,ls
			[99.078]	208385	1217692	2	4	E2	7.2(+6)	0.164	C	1,ls
2.	$3p$–$5p$	$^2P^\circ$ - $^2P^\circ$										
			[69.911]	217042	1647400	4	4	E2	3.8(+6)	0.015	D	1,ls
			[69.989]	217042	1645800	4	2	E2	7.5(+6)	0.015	D	1,ls
			[69.493]	208385	1647400	2	4	E2	3.9(+6)	0.015	D	1,ls
3.	$3d$–$4d$	^2D - ^2D										
			[122.1]	502814	1321800	6	6	E2	3.20(+6)	0.310	C	1,ls
			[122.0]	501922	1321400	4	4	E2	2.81(+6)	0.181	C	1,ls
			[122.2]	502814	1321400	6	4	E2	1.2(+6)	0.078	D	1,ls
			[122.0]	501922	1321800	4	6	E2	8.1(+5)	0.078	D	1,ls
4.	$3d$–$5d$	^2D - ^2D										
			[83.717]	502814	1697300	6	6	E2	1.5(+6)	0.022	D	1,ls
			[83.668]	501922	1697100	4	4	E2	1.3(+6)	0.013	D	1,ls
5.	$4p$–$5p$	$^2P^\circ$ - $^2P^\circ$										
			[232.7]	1217692	1647400	4	4	E2	1.05(+6)	1.70	C	1,ls
			[233.6]	1217692	1645800	4	2	E2	2.05(+6)	1.70	C	1,ls
			[230.9]	1214371	1647400	2	4	E2	1.09(+6)	1.70	C	1,ls
6.	$4p$–$6p$	$^2P^\circ$ - $^2P^\circ$										
			[153.0]	1217692	1871500	4	4	E2	6.6(+5)	0.132	C	1,ls
			[153.1]	1217692	1870700	4	2	E2	1.32(+6)	0.132	C	1,ls
			[152.2]	1214371	1871500	2	4	E2	6.8(+5)	0.132	C	1,ls
7.	$4p$–$7p$	$^2P^\circ$ - $^2P^\circ$										
			[127.3]	1217692	2003500	4	4	E2	4.3(+5)	0.034	D	1,ls
			[127.3]	1217692	2003500	4	2	E2	8.5(+5)	0.034	D	1,ls
			[126.7]	1214371	2003500	2	4	E2	4.4(+5)	0.034	D	1,ls
8.	$4p$–$8p$	$^2P^\circ$ - $^2P^\circ$										
			[115.0]	1217692	2087400	4	4	E2	2.9(+5)	0.014	D	1,ls
			[115.0]	1217692	2087400	4	2	E2	5.8(+5)	0.014	D	1,ls
			[114.5]	1214371	2087400	2	4	E2	3.0(+5)	0.014	D	1,ls
9.	$4d$–$5d$	^2D - ^2D										
			[266.3]	1321800	1697300	6	6	E2	7.1(+5)	3.42	C	1,ls
			[266.2]	1321400	1697100	4	4	E2	6.3(+5)	2.00	C	1,ls
			[266.5]	1321800	1697100	6	4	E2	2.7(+5)	0.86	C−	1,ls
			[266.0]	1321400	1697300	4	6	E2	1.8(+5)	0.86	C−	1,ls

Ti XII: Forbidden transitions — Continued

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	Type of transition	A_{ki} (s^{-1})	S (at. u.)	Accu-racy	Source
10.	$4d$–$6d$	^{2}D - ^{2}D										
			[173.1]	1321800	1899500	6	6	E2	4.22(+5)	0.234	C	1,*ls*
			[173.0]	1321400	1899500	4	4	E2	3.69(+5)	0.136	C	1,*ls*
			[173.1]	1321800	1899500	6	4	E2	1.6(+5)	0.058	D	1,*ls*
			[173.0]	1321400	1899500	4	6	E2	1.0(+5)	0.058	D	1,*ls*
11.	$4d$–$7d$	^{2}D - ^{2}D										
			[143.1]	1321800	2020700	6	6	E2	2.6(+5)	0.056	D	1,*ls*
			[143.0]	1321400	2020600	4	4	E2	2.3(+5)	0.033	D	1,*ls*
			[143.1]	1321800	2020600	6	4	E2	9.8(+4)	0.014	E	1,*ls*
			[143.0]	1321400	2020700	4	6	E2	6.6(+4)	0.014	E	1,*ls*
12.	$4d$–$8d$	^{2}D - ^{2}D										
			[128.7]	1321800	2098800	6	6	E2	1.7(+5)	0.022	D	1,*ls*
			[128.6]	1321400	2098900	4	4	E2	1.6(+5)	0.013	D	1,*ls*
13.	$4f$–$5f$	^{2}F° - ^{2}F°										
			[280.6]	1360469	1716900	8	8	E2	4.08(+5)	3.38	C	1,*ls*
			[280.4]	1360313	1716900	6	6	E2	3.94(+5)	2.44	C	1,*ls*
			[280.6]	1360469	1716900	8	6	E2	6.5(+4)	0.406	C−	1,*ls*
			[280.4]	1360313	1716900	6	8	E2	4.92(+4)	0.406	C−	1,*ls*
14.	$4f$–$6f$	^{2}F° - ^{2}F°										
			[181.8]	1360469	1910600	8	8	E2	2.02(+5)	0.191	C	1,*ls*
			[181.7]	1360313	1910600	6	6	E2	1.94(+5)	0.137	C	1,*ls*
			[181.8]	1360469	1910600	8	6	E2	3.2(+4)	0.023	D	1,*ls*
			[181.7]	1360313	1910600	6	8	E2	2.4(+4)	0.023	D	1,*ls*
15.	$4f$–$7f$	^{2}F° - ^{2}F°										
			[149.9]	1360469	2027700	8	8	E2	1.1(+5)	0.041	D	1,*ls*
			[149.8]	1360313	2027700	6	6	E2	1.1(+5)	0.030	D	1,*ls*
16.	$4f$–$8f$	^{2}F° - ^{2}F°										
			[134.6]	1360469	2103600	8	8	E2	7.1(+4)	0.015	D	1,*ls*
			[134.5]	1360313	2103600	6	6	E2	7.0(+4)	0.011	D	1,*ls*
17.	$5p$–$6p$	^{2}P° - ^{2}P°										
			[446.2]	1647400	1871500	4	4	E2	2.37(+5)	10.0	C	1,*ls*
			[447.8]	1647400	1870700	4	2	E2	4.66(+5)	10.0	C	1,*ls*
			[443.1]	1645800	1871500	2	4	E2	2.46(+5)	10.0	C	1,*ls*
18.	$5p$–$7p$	^{2}P° - ^{2}P°										
			[280.8]	1647400	2003500	4	4	E2	1.7(+5)	0.71	C	1,*ls*
			[280.8]	1647400	2003500	4	2	E2	2.4(+5)	0.71	C	1,*ls*
			[279.6]	1645800	2003500	2	4	E2	1.7(+5)	0.71	C	1,*ls*
19.	$5p$–$8p$	^{2}P° - ^{2}P°										
			[227.3]	1647400	2087400	4	4	E2	1.19(+5)	0.172	C	1,*ls*
			[227.3]	1647400	2087400	4	2	E2	2.38(+5)	0.172	C	1,*ls*
			[226.4]	1645800	2087400	2	4	E2	1.21(+5)	0.172	C	1,*ls*

Ti XII: Forbidden transitions — Continued

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	Type of transition	A_{ki} (s^{-1})	S (at. u.)	Accuracy	Source
20.	5d–6d	$^2D - ^2D$										
			[494.6]	1697300	1899500	6	6	E2	1.89(+5)	20.0	C	1,*ls*
			[494.1]	1697100	1899500	4	4	E2	1.65(+5)	11.6	C	1,*ls*
			[494.6]	1697300	1899500	6	4	E2	7.1(+4)	4.99	C–	1,*ls*
			[494.1]	1697100	1899500	4	6	E2	4.74(+4)	4.99	C–	1,*ls*
21.	5d–7d	$^2D - ^2D$										
			[309.2]	1697300	2020700	6	6	E2	1.30(+5)	1.31	C	1,*ls*
			[309.1]	1697100	2020600	4	4	E2	1.1(+5)	0.76	C	1,*ls*
			[309.3]	1697300	2020600	6	4	E2	4.84(+4)	0.326	C–	1,*ls*
			[309.0]	1697100	2020700	4	6	E2	3.24(+4)	0.326	C–	1,*ls*
22.	5d–8d	$^2D - ^2D$										
			[249.1]	1697300	2098800	6	6	E2	8.8(+4)	0.303	C	1,*ls*
			[248.9]	1697100	2098900	4	4	E2	7.8(+4)	0.177	C	1,*ls*
			[249.0]	1697300	2098900	6	4	E2	3.3(+4)	0.076	D	1,*ls*
			[248.9]	1697100	2098800	4	6	E2	2.2(+4)	0.076	D	1,*ls*
23.	5f–6f	$^2F^\circ - ^2F^\circ$										
			[516.3]	1716900	1910600	8	8	E2	1.41(+5)	24.7	C	1,*ls*
			[516.3]	1716900	1910600	6	6	E2	1.36(+5)	17.8	C	1,*ls*
			[516.3]	1716900	1910600	8	6	E2	2.27(+4)	2.97	C–	1,*ls*
			[516.3]	1716900	1910600	6	8	E2	1.70(+4)	2.97	C–	1,*ls*
24.	5f–7f	$^2F^\circ - ^2F^\circ$										
			[321.8]	1716900	2027700	8	8	E2	8.8(+4)	1.44	C	1,*ls*
			[321.8]	1716900	2027700	6	6	E2	8.4(+4)	1.04	C	1,*ls*
			[321.8]	1716900	2027700	8	6	E2	1.40(+4)	0.173	C–	1,*ls*
			[321.8]	1716900	2027700	6	8	E2	1.05(+4)	0.173	C–	1,*ls*
25.	5f–7f	$^2F^\circ - ^2F^\circ$										
			[258.6]	1716900	2103600	8	8	E2	5.6(+4)	0.310	C	1,*ls*
			[258.6]	1716900	2103600	6	6	E2	5.4(+4)	0.223	C	1,*ls*
			[258.6]	1716900	2103600	8	6	E2	9000	0.037	D	1,*ls*
			[258.6]	1716900	2103600	6	8	E2	6700	0.037	D	1,*ls*
26.	6p–7p	$^2P^\circ - ^2P^\circ$										
			[757.6]	1871500	2003500	4	4	E2	7.0(+4)	41.7	C	1,*ls*
			[757.6]	1871500	2003500	4	2	E2	1.40(+5)	41.7	C	1,*ls*
			[753.0]	1870700	2003500	2	4	E2	7.2(+4)	41.7	C	1,*ls*
27.	6p–8p	$^2P^\circ - ^2P^\circ$										
			[463.2]	1871500	2087400	4	4	E2	5.5(+4)	2.77	C	1,*ls*
			[463.2]	1871500	2087400	4	2	E2	1.09(+5)	2.77	C	1,*ls*
			[461.5]	1870700	2087400	2	4	E2	5.6(+4)	2.77	C	1,*ls*
28.	6d–7d	$^2D - ^2D$										
			[825.1]	1899500	2020700	6	6	E2	6.1(+4)	83	C	1,*ls*
			[825.8]	1899500	2020600	4	4	E2	5.3(+4)	48.4	C	1,*ls*
			[825.8]	1899500	2020600	6	4	E2	2.27(+4)	20.8	C–	1,*ls*
			[825.1]	1899500	2020700	4	6	E2	1.52(+4)	20.8	C–	1,*ls*

Ti XII: Forbidden transitions — Continued

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	Type of transition	A_{ki} (s^{-1})	S (at. u.)	Accuracy	Source
29.	6d–8d	^{2}D – ^{2}D										
			[501.8]	1899500	2098800	6	6	E2	4.6(+4)	5.2	C	1,ls
			[501.5]	1899500	2098900	4	4	E2	4.04(+4)	2.05	C	1,ls
			[501.5]	1899500	2098900	6	4	E2	1.73(+4)	1.31	C–	1,ls
			[501.8]	1899500	2908800	4	6	E2	1.15(+4)	1.31	C–	1,ls
30.	6f–7f	^{2}F° – ^{2}F°										
			[854.0]	1910600	2027700	8	8	E2	5.1(+4)	110	C	1,ls
			[854.0]	1910600	2027700	6	6	E2	4.9(+4)	79	C	1,ls
			[854.0]	1910600	2027700	8	6	E2	8100	13.2	C–	1,ls
			[854.0]	1910600	2027700	6	8	E2	6100	13.2	C–	1,ls
31.	6f–8f	^{2}F° – ^{2}F°										
			[518.1]	1910600	2103600	8	8	E2	3.5(+4)	6.3	C	1,ls
			[518.1]	1910600	2103600	6	6	E2	3.42(+4)	4.56	C	1,ls
			[518.1]	1910600	2103600	8	6	E2	5700	0.76	C–	1,ls
			[518.1]	1910600	2103600	6	8	E2	4300	0.76	C–	1,ls
32.	7p–8p	^{2}P° – ^{2}P°										
			[1190]	2003500	2087400	4	4	E2	2.50(+4)	142	C	1,ls
			[1190]	2003500	2087400	4	2	E2	5.0(+4)	142	C	1,ls
			[1190]	2003500	2087400	2	4	E2	2.50(+4)	142	C	1,ls
33.	7d–8d	^{2}D – ^{2}D										
			[1280]	2020700	2098800	6	6	E2	2.27(+4)	278	C	1,ls
			[1280]	2020600	2098900	4	4	E2	1.98(+4)	162	C	1,ls
			[1280]	2020700	2098900	6	4	E2	8600	70	C–	1,ls
			[1280]	2020600	2098800	4	6	E2	5700	70	C–	1,ls
34.	7f–8f	^{2}F° – ^{2}F°										
			[1320]	2027700	2103600	8	8	E2	1.99(+4)	380	C	1,ls
			[1320]	2027700	2103600	6	6	E2	1.91(+4)	274	C	1,ls
			[1320]	2027700	2103600	8	6	E2	3190	45.6	C–	1,ls
			[1320]	2027700	2103600	6	8	E2	2390	45.6	C–	1,ls
35.	3s–3d	^{2}S – ^{2}D										
			[198.88]	0	502814	2	6	E2	4.35(+5)	0.483	C	1,ls
			[199.23]	0	501922	2	4	E2	4.31(+5)	0.322	C	1,ls
36.	3s–4d	^{2}S – ^{2}D										
			[75.654]	0	1321800	2	6	E2	2.76(+7)	0.244	C	1,ls
			[75.677]	0	1321400	2	4	E2	2.74(+7)	0.162	C	1,ls
37.	3s–5d	^{2}S – ^{2}D										
			[58.917]	0	1697300	2	6	E2	1.6(+7)	0.041	D	1,ls
			[58.924]	0	1697100	2	4	E2	1.7(+7)	0.028	D	1,ls
38.	3s–6d	^{2}S – ^{2}D										
			[52.645]	0	1899500	2	6	E2	9.7(+6)	0.014	D	1,ls

Ti XII: Forbidden transitions — Continued

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	Type of transition	A_{ki} (s^{-1})	S (at. u.)	Accuracy	Source
39.	$3p-4f$	$^2P^o - ^2F^o$										
			[87.456]	217042	1360469	4	8	E2	5.5(+7)	1.35	C	1,*ls*
			[86.811]	208385	1360313	2	6	E2	4.5(+7)	0.79	C	1,*ls*
			[87.468]	217042	1360313	4	6	E2	1.23(+7)	0.225	C−	1,*ls*
40.	$3p-5f$	$^2P^o - ^2F^o$										
			[66.671]	217042	1716900	4	8	E2	1.2(+7)	0.078	D	1,*ls*
			[66.291]	208385	1716900	2	6	E2	9.8(+6)	0.045	D	1,*ls*
			[66.671]	217042	1716900	4	6	E2	2.8(+6)	0.013	E	1,*ls*
41.	$3p-6f$	$^2P^o - ^2F^o$										
			[59.046]	217042	1910600	4	8	E2	4.1(+6)	0.014	D	1,*ls*
42.	$3d-4s$	$^2D - ^2S$										
			[158.54]	502814	1133573	6	2	E2	2.13(+6)	0.254	C	1,*ls*
			[158.32]	501922	1133573	4	2	E2	1.44(+6)	0.170	C	1,*ls*
43.	$4s-4d$	$^2S - ^2D$										
			[531.3]	1133573	1321800	2	6	E2	5.0(+4)	7.6	C	1,*ls*
			[532.5]	1133573	1321400	2	4	E2	4.9(+4)	5.0	C	1,*ls*
44.	$4s-5d$	$^2S - ^2D$										
			[177.4]	1133573	1697300	2	6	E2	2.58(+6)	1.62	C	1,*ls*
			[177.5]	1133573	1697100	2	4	E2	2.57(+6)	1.08	C	1,*ls*
45.	$4s-6d$	$^2S - ^2D$										
			[130.6]	1133573	1899500	2	6	E2	1.98(+6)	0.269	C	1,*ls*
			[130.6]	1133573	1899500	2	4	E2	1.98(+6)	0.179	C	1,*ls*
46.	$4s-7d$	$^2S - ^2D$										
			[112.7]	1133573	2020700	2	6	E2	1.4(+6)	0.089	D	1,*ls*
			[112.7]	1133573	2020600	2	4	E2	1.4(+6)	0.060	D	1,*ls*
47.	$4s-8d$	$^2S - ^2D$										
			[103.6]	1133573	2098800	2	6	E2	9.6(+5)	0.041	D	1,*ls*
			[103.6]	1133573	2098900	2	4	E2	9.5(+5)	0.027	D	1,*ls*
48.	$4p-4f$	$^2P^o - ^2F^o$										
			[700.39]	1217692	1360469	4	8	E2	1.1(+4)	8.6	C	1,*ls*
			[685.20]	1214371	1360313	2	6	E2	9300	5.0	C	1,*ls*
			[701.16]	1217692	1360313	4	6	E2	2360	1.43	C−	1,*ls*
49.	$4p-5f$	$^2P^o - ^2F^o$										
			[200.3]	1217692	1716900	4	8	E2	5.7(+6)	8.7	C	1,*ls*
			[199.0]	1214371	1716900	2	6	E2	4.6(+6)	5.1	C	1,*ls*
			[200.3]	1217692	1716900	4	6	E2	1.27(+6)	1.46	C−	1,*ls*
50.	$4p-6f$	$^2P^o - ^2F^o$										
			[144.3]	1217692	1910600	4	8	E2	2.9(+6)	0.85	C	1,*ls*
			[143.6]	1214371	1910600	2	6	E2	2.26(+6)	0.493	C	1,*ls*
			[144.3]	1217692	1910600	4	6	E2	6.3(+5)	0.141	C−	1,*ls*

Ti XII: Forbidden transitions — Continued

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	Type of transition	A_{ki} (s^{-1})	S (at. u.)	Accuracy	Source
51.	$4p$–$7f$	$^2P^\circ$ – $^2F^\circ$										
			[123.5]	1217692	2027700	4	8	E2	1.45(+6)	0.199	C	1,*ls*
			[123.0]	1214371	2027700	2	6	E2	1.15(+6)	0.116	C	1,*ls*
			[123.5]	1217692	2027700	4	6	E2	3.2(+5)	0.033	D	1,*ls*
52.	$4p$–$8f$	$^2P^\circ$ – $^2F^\circ$										
			[112.9]	1217692	2103600	4	8	E2	8.4(+5)	0.073	D	1,*ls*
			[112.5]	1214371	2103600	2	6	E2	6.7(+5)	0.043	D	1,*ls*
			[112.9]	1217692	2103600	4	6	E2	1.8(+5)	0.012	E	1,*ls*
53.	$4d$–$5s$	^2D – ^2S										
			[351.7]	1321800	1606100	6	2	E2	5.9(+5)	3.77	C	1,*ls*
			[351.2]	1321400	1606100	4	2	E2	3.96(+5)	2.52	C	1,*ls*
54.	$4d$–$6s$	^2D – ^2D										
			[189.8]	1321800	1848700	6	2	E2	3.0(+5)	0.089	D	1,*ls*
			[189.6]	1321400	1848700	4	2	E2	2.1(+5)	0.060	D	1,*ls*
55.	$4d$–$7s$	^2D – ^2S										
			[149.9]	1321800	1989100	6	2	E2	1.9(+5)	0.017	D	1,*ls*
			[149.8]	1321400	1989100	4	2	E2	1.2(+5)	0.011	D	1,*ls*
56.	$4f$–$5p$	$^2F^\circ$ – $^2P^\circ$										
			[348.6]	1360469	1647400	8	4	E2	1.58(+5)	1.94	C	1,*ls*
			[350.3]	1360313	1645800	6	2	E2	1.80(+5)	1.13	c	1,*ls*
			[348.3]	1360313	1647400	6	4	E2	2.65(+4)	0.324	C–	1,*ls*
57.	$4f$–$6p$	$^2F^\circ$ – $^2P^\circ$										
			[195.7]	1360469	1871500	8	4	E2	9.5(+4)	0.065	D	1,*ls*
			[195.9]	1360313	1870700	6	2	E2	1.1(+5)	0.038	D	1,*ls*
			[195.6]	1360313	1871500	6	4	E2	1.6(+4)	0.011	E	1,*ls*
58.	$4f$–$7p$	$^2F^\circ$ – $^2P^\circ$										
			[155.5]	1360469	2003500	8	4	E2	6.0(+4)	0.013	D	1,*ls*
59.	$5s$–$5d$	^2S – ^2D										
			[1100]	1606100	1697300	2	6	E2	9600	55	C	1,*ls*
			[1100]	1606100	1697100	2	4	E2	9500	36.4	C	1,*ls*
60.	$5s$–$6d$	^2S – ^2D										
			[340.8]	1606100	1899500	2	6	E2	4.3(+5)	7.0	C	1,*ls*
			[340.8]	1606100	1899500	2	4	E2	4.28(+5)	4.68	C	1,*ls*
61.	$5s$–$7d$	^2S – ^2D										
			[241.2]	1606100	2020700	2	6	E2	3.98(+5)	1.16	C	1,*ls*
			[241.3]	1606100	2020600	2	4	E2	4.0(+5)	0.78	C	1,*ls*
62.	$5s$–$8d$	^2S – ^2D										
			[203.0]	1606100	2098800	2	6	E2	3.08(+5)	0.379	C	1,*ls*
			[202.9]	1606100	2098900	2	4	E2	3.08(+5)	0.252	C	1,*ls*

Ti XII: Forbidden transitions — Continued

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	Type of transition	A_{ki} (s^{-1})	S (at. u.)	Accuracy	Source
63.	$5p$–$5f$	$^2P^\circ$ – $^2F^\circ$										
			[1440]	1647400	1716900	4	8	E2	2800	82	C	1,*ls*
			[1410]	1645800	1716900	2	6	E2	2400	47.7	C	1,*ls*
			[1440]	1647400	1716900	4	6	E2	610	13.6	C–	1,*ls*
64.	$5p$–$6f$	$^2P^\circ$ – $^2F^\circ$										
			[379.9]	1647400	1910600	4	8	E2	9.8(+5)	37.0	C	1,*ls*
			[377.6]	1645800	1910600	2	6	E2	7.9(+5)	21.6	C	1,*ls*
			[379.9]	1647400	1910600	4	6	E2	2.2(+5)	6.2	C–	1,*ls*
65.	$5p$–$7f$	$^2P^\circ$ – $^2F^\circ$										
			[263.0]	1647400	2027700	4	8	E2	6.7(+5)	4.02	C	1,*ls*
			[261.8]	1645800	2027700	2	6	E2	5.3(+5)	2.34	C	1,*ls*
			[263.0]	1647400	2027700	4	6	E2	1.5(+5)	0.67	C–	1,*ls*
66.	$5p$–$8f$	$^2P^\circ$ – $^2F^\circ$										
			[219.2]	1647400	2103600	4	8	E2	4.27(+5)	1.03	C	1,*ls*
			[218.4]	1645800	2103600	2	6	E2	2.4(+5)	0.60	C	1,*ls*
			[219.2]	1647400	2103600	4	6	E2	9.5(+4)	0.172	C–	1,*ls*
67.	$5d$–$6s$	^2D – ^2S										
			[660.5]	1697300	1848700	6	2	E2	1.80(+5)	26.9	C	1,*ls*
			[659.6]	1697100	1848700	4	2	E2	1.20(+5)	17.9	C	1,*ls*
68.	$5d$–$7s$	^2D – ^2S										
			[342.7]	1697300	1989100	6	2	E2	9.6(+4)	0.54	C	1,*ls*
			[342.5]	1697100	1989100	4	2	E2	6.4(+4)	0.360	C	1,*ls*
69.	$5f$–$6p$	$^2F^\circ$ – $^2P^\circ$										
			[646.8]	1716900	1871500	8	4	E2	7.6(+4)	20.4	C	1,*ls*
			[650.2]	1716900	1870700	6	2	E2	8.6(+4)	11.9	C	1,*ls*
			[646.8]	1716900	1871500	6	4	E2	1.26(+4)	3.40	C–	1,*ls*
70.	$5f$–$7p$	$^2F^\circ$ – $^2P^\circ$										
			[348.9]	1716900	2003500	8	4	E2	5.0(+4)	0.61	C	1,*ls*
			[348.9]	1716900	2003500	6	2	E2	5.7(+4)	0.353	C	1,*ls*
			[348.9]	1716900	2003500	6	4	E2	8200	0.101	C–	1,*ls*
71.	$5f$–$8p$	$^2F^\circ$ – $^2P^\circ$										
			[269.9]	1716900	2087400	8	4	E2	3.43(+4)	0.117	C	1,*ls*
			[269.9]	1716900	2087400	6	2	E2	4.0(+4)	0.068	D	1,*ls*
			[269.9]	1716900	2087400	6	4	E2	5900	0.020	E	1,*ls*
72.	$6s$–$6d$	^2S – ^2D										
			[1970]	1848700	1899500	2	6	E2	2280	242	C–	1,*ls*
			[1970]	1848700	1899500	2	4	E2	2290	162	C–	1,*ls*
73.	$6s$–$7d$	^2S – ^2D										
			[581.4]	1848700	2020700	2	6	E2	1.03(+5)	24.4	C	1,*ls*
			[581.7]	1848700	2020600	2	4	E2	1.02(+5)	16.2	C	1,*ls*

Ti XII: **Forbidden transitions — Continued**

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	Type of transition	A_{ki} (s^{-1})	S (at. u.)	Accuracy	Source
74.	$6s$–$8d$	^{2}S – ^{2}D										
			[399.8]	1848700	2098800	2	6	E2	1.07(+5)	3.90	C	1,*ls*
			[399.7]	1848700	2098900	2	4	E2	1.07(+5)	2.60	C	1,*ls*
75.	$6p$–$6f$	^{2}P° – ^{3}F°										
			[2560]	1871500	1910600	4	8	E2	820	430	D+	1,*ls*
			[2510]	1870700	1910600	2	6	E2	700	250	D+	1,*ls*
			[2560]	1871500	1910600	4	6	E2	180	71	D–	1,*ls*
76.	$6p$–$7f$	^{2}P° – ^{2}F°										
			[640.2]	1871500	2027700	4	8	E2	2.30(+5)	118	C	1,*ls*
			[636.9]	1870700	2027700	2	6	E2	1.8(+5)	69	C	1,*ls*
			[640.2]	1871500	2027700	4	6	E2	5.1(+4)	19.7	C–	1,*ls*
77.	$6p$–$8f$	^{2}P° – ^{2}F°										
			[430.8]	1871500	2103600	4	8	E2	1.94(+5)	13.7	C	1,*ls*
			[429.4]	1870700	2103600	2	6	E2	1.5(+5)	8.0	C	1,*ls*
			[430.8]	1871500	2103600	4	6	E2	4.30(+4)	2.28	C–	1,*ls*
78.	$6d$–$7s$	^{2}D – ^{2}S										
			[1120]	1899500	1989100	6	2	E2	6.1(+4)	128	C	1,*ls*
			[1120]	1899500	1989100	4	2	E2	4.1(+4)	86	C	1,*ls*
79.	$6f$–$7p$	^{2}F° – ^{2}P°										
			[1080]	1910600	2003500	8	4	E2	3.26(+4)	114	C	1,*ls*
			[1080]	1910600	2003500	6	2	E2	3.8(+4)	67	C	1,*ls*
			[1080]	1910600	2003500	6	4	E2	5400	19.0	C–	1,*ls*
80.	$6f$–$8p$	^{2}F° – ^{2}P°										
			[565.6]	1910600	2087400	8	4	E2	2.25(+4)	3.10	C	1,*ls*
			[565.6]	1910600	2087400	6	2	E2	2.63(+4)	1.81	C	1,*ls*
			[565.6]	1910600	2087400	6	4	E2	3800	0.52	C–	1,*ls*
81.	$7s$–$7d$	^{2}S – ^{2}D										
			[3160]	1989100	2020700	2	6	E2	760	850	D+	1,*ls*
			[3170]	1980100	2020600	2	4	E2	750	570	D+	1,*ls*
82.	$7s$–$8d$	^{2}S – ^{2}D										
			[911.6]	1989100	2098800	2	6	E2	3.1(+4)	70	C	1,*ls*
			[910.7]	1989100	2098900	2	4	E2	2.14(+4)	46.8	C	1,*ls*
83.	$7p$–$7f$	^{2}P° – ^{2}F°										
			[4130]	2003500	2027700	4	8	E2	300	1700	D	1,*ls*
			[4130]	2003500	2027700	2	6	E2	230	970	D	1,*ls*
			[4130]	2003500	2027700	4	6	E2	65	280	E	1,*ls*
84.	$7p$–$8f$	^{2}P° – ^{2}F°										
			[999.0]	2003500	2103600	4	8	E2	7.0(+4)	330	C	1,*ls*
			[999.0]	2003500	2103600	2	6	E2	5.4(+4)	192	C	1,*ls*
			[999.0]	2003500	2103600	4	6	E2	1.5(+4)	55	C–	1,*ls*

Ti XII: Forbidden transitions — Continued

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	Type of transition	A_{ki} (s^{-1})	S (at. u.)	Accuracy	Source
85.	$7f-8p$	$^2F^\circ - ^2P^\circ$										
			[1680]	2027700	2087400	8	4	E2	1.45(+4)	462	C−	1,*ls*
			[1680]	2027700	2087400	6	2	E2	1.69(+4)	270	C−	1,*ls*
			[1680]	2027700	2087400	6	4	E2	2400	77	D+	1,*ls*
86.	$8p-8f$	$^2P^\circ - ^2F^\circ$										
			[6170]	2087400	2103600	4	8	E2	120	5000	D	1,*ls*
			[6170]	2087400	2103600	2	6	E2	91	2900	D	1,*ls*
			[6170]	2087400	2103600	4	6	E2	26	830	E	1,*ls*

[a]The number in parentheses following the tabulated value indicates the power of ten by which this value has to be multiplied.

Ti XIII

Ne Isoelectronic Sequence

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

Ionization Energy: 787.84 eV = 6354300 cm^{-1}

Allowed Transitions

List of tabulated lines

Wavelength (Å)	No.	Wavelength (Å)	No.	Wavelength (Å)	No.	Wavelength (Å)	No.
23.356	9	117.1	3	346.163	13	373.1	14
23.698	8	117.3	3	351.58	13	458.1	16
23.991	7	120.2	1,4	362.86	15	474.611	11
26.641	6	128.7	2	369.531	15	552.115	10
26.960	5	336.029	13	370.5	17	745.7	12

For resonance transitions to $J = 1$ levels of the $2p^53s$ and $2p^53d$ configurations, we quote A-values which were calculated by Vainshtein and Safronova[1] using a charge-expansion perturbation theory approach with allowance for mixing of the $2p^53s$, $2p^53d$, and $2s2p^63p$ configurations. Their results for the $2p^6$–$2p^53d$ transitions in the isoelectronic ions Ar IX and Fe XVII are in rather good agreement with those of Shorer,[2] who used the relativistic random phase approximation (RRPA) with allowance for mixing between configurations of type $2p^5ns$ and $2p^5nd$, as well as correlation effects due to configurations having a vacancy in the $1s$ or $2s$ subshell. But the data of Ref. 1 for the two $2p^6$–$2p^53s$ transitions are approximately a factor of two smaller than those of Shorer for the abovementioned neonlike species, so we have increased the transition probabilities of Ref. 1 for these two lines by a factor of two.

A-values quoted here for a number of transitions involving an electron jump of the type $2s$–$2p$, $3s$–$3p$, or $3p$–$3d$ were taken from the work of Pokleba and Safronova,[3] who used wavefunctions calculated by a charge-expansion perturbation theory approach with allowance for mixing of configurations in which a single $2s$ or $2p$ electron is excited to an $n = 3$ orbital but with no inclusion of configurations in which an electron occupies the $n = 4$ shell. In cases where better wavelength data were available, these transition probabilities were first converted to line strengths, which were then reconverted to f- and A-values by using the more accurate wavelengths. Transitions involving levels of the $2p^53p$ and $2p^53d$ configurations which are indicated by Jupen and Litzen[4] or by Fawcett[5] to be of low to moderate purity in LS coupling in Ti XIII are excluded here, as are very weak lines. The pattern of levels within the $2s2p^63d$ configuration in the isoelectronic ions Fe XVII and Ni XIX resulting from the scaled Thomas-Fermi calculations of Loulergue and Nussbaumer[6] with extensive allowance for correlation is entirely different from that determined by Vainshtein and Safronova, whose energy levels were apparently used by Pokleba and Safronova in their transition probability calculations. We have thus excluded transitions out of these levels from our tabulation.

References

[1]L. A. Vainshtein and U. I. Safronova, *Spektroskopicheskie Konstanty Atomov*, 5–122 (Ed. V. B. Belyanin, Akad. Nauk SSSR, Ot. Ob. Fiz. Astron., Nauch. Sov. Spektrosk., Moscow, 1977).

[2]P. Shorer, Phys. Rev. A **20**, 642 (1979).

[3]A. K. Pokleba and U. I. Safronova, Preprint No. 11, Akad. Nauk SSSR, Ot. Ob. Fiz. Astron., Inst. Spektrosk. (Moscow, 1981).

[4]C. Jupen and U. Litzen, Phys. Scr. **30**, 112 (1984).

[5]B. C. Fawcett, private communication, as quoted in E. Träbert, Z. Phys. A **319**, 25 (1984).

[6]M. Loulergue and H. Nussbaumer, Astron. Astrophys. **45**, 125 (1975).

Ti XIII: Allowed transitions

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} (10^8 s^{-1})	f_{ik}	S (at. u.)	log gf	Accuracy	Source
1.	$2s^22p^5(^2P^\circ_{3/2})3s-$ $2s2p^63s$	$(^3/_2,^1/_2)^\circ - {}^3S$											
			[120.2]	3698200	4530300	5	3	540	0.071	0.14	−0.45	D	3
2.	$2s^22p^5(^2P^\circ_{1/2})3s-$ $2s2p^63s$	$(^1/_2,^1/_2)^\circ - {}^3S$											
			[128.7]	3753600	4530300	3	3	120	0.029	0.037	−1.06	D	3
3.	$2s^22p^53p-$ $2s2p^63p$	$^3S - {}^3P^\circ$											
			[117.1]	3879300	4733300	3	3	130	0.028	0.032	−1.08	E	3
			[117.3]	3879300	4731800	3	1	280	0.019	0.022	−1.24	D	3
4.		$^3D - {}^3P^\circ$											
			[120.2]	3908900	4741100	7	5	440	0.069	0.19	−0.32	D	3
5.	$2p^6-$ $2p^5(^2P^\circ_{3/2})3s$	$^1S - (^3/_2,^1/_2)^\circ$											
			26.960	0	3709200	1	3	3060	0.100	0.0089	−1.000	C−	1*n*
6.	$2p^6-$ $2p^5(^2P^\circ_{1/2})3s$	$^1S - (^1/_2,^1/_2)^\circ$											
			26.641	0	3753600	1	3	4060	0.130	0.0114	−0.89	C−	1*n*
7.	$2p^6-2p^53d$	$^1S - {}^3P^\circ$											
			23.991	0	4168200	1	3	340	0.0088	7.0(−4)[a]	−2.06	E	1
8.		$^1S - {}^3D^\circ$											
			23.698	0	4219800	1	3	1.2(+4)	0.30	0.024	−0.52	D	1
9.		$^1S - {}^1P^\circ$	23.356	0	4281600	1	3	1.02(+5)	2.50	0.192	0.398	C−	1
10.	$2p^5(^2P^\circ_{3/2})3s-$ $2p^53p$	$(^3/_2,^1/_2)^\circ - {}^3S$											
			552.115	3698200	3879300	5	3	18	0.048	0.44	−0.62	D	3
11.		$(^3/_2,^1/_2)^\circ - {}^3D$											
			474.611	3698200	3908900	5	7	35	0.17	1.3	−0.08	D	3

Ti XIII: Allowed transitions — Continued

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} ($10^8\ s^{-1}$)	f_{ik}	S (at. u.)	log gf	Accuracy	Source
12.	$2p^5(^2P^\circ_{1/2})3s - 2p^53p$	$(1/2,1/2)^\circ - {}^3S$											
			[745.7]	3745200	3879300	1	3	0.26	0.0065	0.016	−2.19	E	3
13.	$2p^53p-2p^53d$	$^3S - {}^3P^\circ$	*341.1*	3879300	*4172500*	3	9	47	0.25	0.83	−0.13	E	3
			336.029	3879300	4176900	3	5	37	0.11	0.35	−0.50	E	3
			346.163	3879300	4168200	3	3	55	0.099	0.34	−0.53	D	3
			351.58	3879300	4163700	3	1	65	0.040	0.14	−0.92	D	3
14.		$^3D - {}^3P^\circ$											
			[373.1]	3908900	4176900	7	5	2.7	0.0041	0.035	−1.55	E	3
15.		$^3D - {}^3F^\circ$											
			369.531	3908900	4179500	7	9	67	0.18	1.5	0.09	D	3
			362.86	3908900	4184500	7	7	10	0.020	0.17	−0.85	E	3
16.		$^3P - {}^3P^\circ$											
			[458.1]	3949900	4168200	1	3	2.0	0.019	0.028	−1.73	D	3
17.		$^3P - {}^3D^\circ$											
			[370.5]	3949900	4219800	1	3	33	0.20	0.25	−0.69	D	3

[a]The number in parentheses following the tabulated value indicates the power of ten by which this value has to be multiplied.

Ti XIII

Forbidden Transitions

A-values were calculated by Bhatia *et al.*[1] for numerous forbidden transitions within the $2p^53s$, $2p^53p$, and $2p^53d$ configurations, as well as for lines of the $2p^53s$–$2p^53d$, $2p^6$–$2p^53s$, and $2p^6$–$2p^53p$ arrays. Their calculations employed scaled Thomas-Fermi wavefunctions with limited allowance for configuration interaction. A number of these data are quoted here, but the A-values were first converted to line strengths, which were then reconverted to transition probabilities by using more accurate wavelengths. Bhatia *et al.* did not indicate which of their results were due to magnetic dipole, and which were due to electric quadrupole, radiation. In those cases where it was impossible to make a definitive determination of the type of radiation solely on the basis of selection rules, the A-value could not be converted to a line strength. It appears, however, that the A-values quoted for the three transitions within the $2p^53s$ configuration for which the type of transition is not indicated in our tabulation are due to magnetic dipole radiation. Transitions involving levels of the $2p^53p$ and $2p^53d$ configurations which are indicated by Jupen and Litzen[2] or by Fawcett[3] to be of low to moderate purity in LS coupling are excluded here, as are very weak lines.

References

[1]A. K. Bhatia, U. Feldman, and J. F. Seely, At. Data Nucl. Data Tables **32**, 435 (1985).

[2]C. Jupen and U. Litzen, Phys. Scr. **30**, 112 (1984).

[3]B. C. Fawcett, private communication, as quoted in E. Träbert, Z. Phys. A **319**, 25 (1984).

Ti XIII: Forbidden transitions

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	Type of transition	A_{ki} (s^{-1})	S (at. u.)	Accuracy	Source
1.	$2p^5(^2P^\circ_{3/2})3s$ – $2p^5(^2P^\circ_{3/2})3s$	$(^3/_2,^1/_2)^\circ - (^3/_2,^1/_2)^\circ$										
			[9090]	3698200	3709200	5	3		17		D+	1
2.	$2p^5(^2P^\circ_{3/2})3s$ – $2p^5(^2P^\circ_{1/2})3s$	$(^3/_2,^1/_2)^\circ - (^1/_2,^1/_2)^\circ$										
			[1810]	3698200	3753600	5	3		1730		C–	1
			[2780]	3709200	3745200	3	1	M1	1370	1.09	C–	1
			[2250]	3709200	3753600	3	3		290		D+	1
3.	$2p^53d$–$2p^53d$	$^3P^\circ - {}^3P^\circ$										
			[7570]	4163700	4176900	1	5	E2	6.5(–4)[a]	0.048	E	1
4.		$^3F^\circ - {}^3D^\circ$										
			[2830]	4184500	4219800	7	3	E2	0.096	0.031	E	1
5.	$2p^6$– $2p^5(^2P^\circ_{3/2})3s$	$^1S - (^3/_2,^1/_2)^\circ$										
			[27.040]	0	3698200	1	5	M2	2.8(+4)	0.31	D–	1
6.	$2p^5(^2P^\circ_{3/2})3s$– $2p^53d$	$(^3/_2,^1/_2)^\circ - {}^3P^\circ$										
			[212.8]	3698200	4168200	5	3		2.3(+5)		E	1
			[231.8]	3709200	4176900	3	5		6.8(+4)		E	1
			[214.8]	3698200	4163700	5	1	E2	2.4(+5)	0.065	E	1
7.		$(^3/_2,^1/_2)^\circ - {}^3F^\circ$										
			[207.8]	3698200	4179500	5	9	E2	2.7(+5)	0.57	D–	1
			[210.4]	3709200	4184500	3	7	E2	1.5(+5)	0.25	D–	1
			[205.6]	3698200	4184500	5	7		1.3(+5)		E	1
8.	$2p^5(^2P^\circ_{1/2})3s$– $2p^53d$	$(^1/_2,^1/_2)^\circ - {}^3P^\circ$										
			[231.6]	3745200	4176900	1	5	E2	7600	0.015	E	1

[a]The number in parentheses following the tabulated value indicates the power of ten by which this value has to be multiplied.

Ti XIV

F Isoelectronic Sequence

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

Ionization Energy: 863.1 eV = 6961000 cm^{-1}

Allowed Transitions

Oscillator strengths for lines of the multiplet $2s^22p^5\ ^2P^\circ - 2s2p^6\ ^2S$ are the results of the Dirac-Fock calculations of Cheng *et al.*,[1] which included a perturbative treatment of the Breit interaction and the Lamb shift.

For lines of the arrays $2p^5$–$2p^43s$ and $2p^5$–$2p^43d$, we quote the *f*-values calculated by Fawcett[2] using Cowan's Hartree-Fock-Relativistic (HFR) method and incorporating scaling of energy parameters on the basis of a least-squares fit to observed energies. Fawcett's calculations included fairly extensive allowance for configuration mixing in both odd- and even-parity states. Transitions involving levels which are indicated by Fawcett to be of low to moderate purity in *LS* coupling in neighboring fluorinelike ions are excluded from this compilation, as are lines characterized by very small *f*-values.

The ratio of *A*-values for the two resonance lines out of the $2s2p^6\ {}^2S_{1/2}$ level as given in Ref. 1 is in reasonably good agreement with the result of Stratton *et al.*[3] derived from relative-intensity measurements.

References

[1] K. T. Cheng, Y.-K. Kim, and J. P. Desclaux, At. Data Nucl. Data Tables **24**, 111 (1979).

[2] B. C. Fawcett, At. Data Nucl. Data Tables **31**, 495 (1984).

[3] B. C. Stratton, H. W. Moos, S. Suckewer, U. Feldman, J. F. Seely, and A. K. Bhatia, Phys. Rev. A **31**, 2534 (1985).

Ti XIV: Allowed transitions

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} ($10^8\ s^{-1}$)	f_{ik}	S (at. u.)	log gf	Accuracy	Source
1.	$2s^22p^5$–$2s2p^6$	$^2P^\circ$ – ^2S	*124.37*	*15740*	819766	6	2	885	0.0684	0.168	−0.387	C+	1
			121.986	0	819766	4	2	627	0.0699	0.112	−0.553	C+	1
			129.440	47220	819766	2	2	259	0.0651	0.0555	−0.885	C+	1
2.	$2p^5$–$2p^4(^3P)3s$	$^2P^\circ$ – ^4P											
			25.025	0	3996000	4	6	180	0.0025	8.2(−4)[a]	−2.00	E	2
3.		$^2P^\circ$ – ^2P											
			24.891	47220	4064700	2	2	7500	0.070	0.011	−0.85	C−	2
			24.592	0	4064700	4	2	6100	0.0275	0.0089	−0.96	C−	2
4.	$2p^5$–$2p^4(^1D)3s$	$^2P^\circ$ – ^2D											
			24.315	0	4112700	4	6	5000	0.067	0.021	−0.57	D	2
			24.592	47220	4113600	2	4	5500	0.10	0.016	−0.70	D	2
5.	$2p^5$–$2p^4(^1S)3s$	$^2P^\circ$ – ^2S	*23.778*	*15740*	4221200	6	2	5900	0.017	0.0078	−1.00	E	2
			23.690	0	4221200	4	2	2100	0.0090	0.0028	−1.44	E	2
			23.960	47220	4221200	2	2	3700	0.032	0.0050	−1.19	D	2
6.	$2p^5$–$2p^4(^3P)3d$	$^2P^\circ$ – ^4P											
			22.328	0	4478700	4	2	5900	0.022	0.0065	−1.06	E	2
7.	$2p^5$–$2p^4(^1D)3d$	$^2P^\circ$ – ^2S	*21.90*	*15740*	4583000	6	2	7.8(+4)	0.19	0.081	0.05	D	2
			21.82	0	4583000	4	2	6.4(+4)	0.23	0.066	−0.04	D	2
			[22.05]	47220	4583000	2	2	1.4(+4)	0.10	0.015	−0.70	D	2
8.		$^2P^\circ$ – ^2F											
			[21.816]	0	4583700	4	6	4500	0.048	0.014	−0.72	E	2
9.		$^2P^\circ$ – ^2P											
			[21.733]	0	4601300	4	4	8.8(+4)	0.62	0.18	0.39	D	2
			21.958	47220	4601300	2	4	1.2(+4)	0.18	0.026	−0.44	D	2
10.		$^2P^\circ$ – ^2D											
			21.883	47220	4617400	2	4	7.0(+4)	1.0	0.14	0.30	D	2
			21.657	0	4617400	4	4	1.3(+4)	0.088	0.025	−0.45	D	2

Ti XIV: Allowed transitions — Continued

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} (10^8 s^{-1})	f_{ik}	S (at. u.)	log gf	Accuracy	Source
11.	$2p^5$-$2p^4(^1S)3d$	$^2P^\circ$ - ^2D	*21.398*	*15740*	*4689100*	6	10	2.5(+4)	0.28	0.12	0.23	E	2
			21.341	0	4685800	4	6	9800	0.10	0.028	−0.40	D	2
			21.522	47220	4694000	2	4	4.5(+4)	0.62	0.088	0.09	D	2
			21.304	0	4694000	4	4	960	0.0065	0.0018	−1.59	E	2

[a]The number in parentheses following the tabulated value indicates the power of ten by which this value has to be multiplied.

Ti XIV

Forbidden Transitions

Line strengths for the magnetic dipole and electric quadrupole contributions to the transition between the two levels of the $2p^5$ configuration are the results of the Dirac-Fock calculations of Cheng *et al.*[1] These relativistic calculations included a perturbative treatment of the Breit interaction and the Lamb shift. The strength of the electric quadrupole transition as defined in Ref. 1 was multiplied by the factor 2/3 which is needed to bring this value into conformance with the definition of quadrupole strengths used in the NBS tables.

Reference

[1]K. T. Cheng, Y.-K. Kim, and J. P. Desclaux, At. Data Nucl. Data Tables **24**, 111 (1979).

Ti XIV: Forbidden transitions

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	Type of transition	A_{ki} (s^{-1})	S (at. u.)	Accuracy	Source
1.	$2p^5$-$2p^5$	$^2P^\circ$ - $^2P^\circ$										
			2117.07	0	47220	4	2	M1	1890	1.33	B	1
			"	"	"	4	2	E2	0.091	0.0046	D	1

Ti XV

O Isoelectronic Sequence

Ground State: $1s^22s^22p^4\ ^3P_2$

Ionization Energy: 941.9 eV = 7597000 cm^{-1}

Allowed Transitions

List of tabulated lines

Wavelength (Å)	No.	Wavelength (Å)	No.	Wavelength (Å)	No.	Wavelength (Å)	No.
19.970	32	20.29	30	20.476	23	20.60	19
20.074	31	20.30	30	20.538	22	20.63	19
20.19	29	20.313	23	20.54	22	20.65	33
20.234	24,31	20.36	29	20.551	22	20.689	28
20.246	31	20.374	22	20.56	20	20.698	38
20.250	35	20.418	21	20.58	34	20.771	27

List of tabulated lines — Continued

Wavelength (Å)	No.	Wavelength (Å)	No.	Wavelength (Å)	No.	Wavelength (Å)	No.
20.80	19	22.21	14	22.739	11	131.146	6
20.882	26	22.30	14	22.936	13	134.609	1
20.893	18	22.32	14	22.966	10	138.357	1
20.897	18	22.33	14	23.034	17	140.395	1
20.928	18	22.378	12	23.177	10	142.130	1
20.982	37	22.464	11	23.193	10	142.750	1
21.03	25	22.482	16	23.20	9	147.436	8
21.04	36	22.518	11	102.247	2	148.588	1
21.065	18	22.56	15	106.53	2	165.690	3
21.079	18	22.576	12	106.874	2	189.62	5
21.102	18	22.66	15	109.48	7		
22.02	14	22.724	11	115.031	4		

The tabulated oscillator strengths for transitions of the arrays $2s^22p^4$–$2s2p^5$ and $2s2p^5$–$2p^6$ are the results of the multiconfiguration Dirac-Fock (MCDF) calculations of Cheng *et al.*[1] These relativistic calculations included a perturbative treatment of the Breit interaction and the Lamb shift. Allowance for configuration mixing was limited to the $n=2$ complex. The results should be quite accurate, except in the case of weak lines. (The $2s^22p^4\,{}^1D_2 - 2s2p^5\,{}^3P_1^\circ$ transition has been omitted from this tabulation, because its f-value as reported in Ref. 1 is extremely small, and thus very uncertain.)

Transition probabilities for lines of the $2s^22p^4$–$2s2p^5$ array were calculated by Froese Fischer and Saha[2] using the multiconfiguration Hartree-Fock (MCHF) method with Breit-Pauli corrections. Their basis set included many configurations outside the $n=2$ complex, but relativistic effects were not treated to the same degree as in Ref. 1. Line strengths derived from these two sources are in reasonably good agreement, particularly for the stronger transitions.

The A-value for the $2p^4\,{}^3P_2 - 2p^3({}^4S^\circ)3s\,{}^5S_2^\circ$ transition is taken from the scaled Thomas-Fermi approach of Kastner *et al.*[3] with configuration interaction and relativistic effects. For all other lines of the $2p^4$–$2p^33s$ array, and for lines of the $2p^4$–$2p^33d$ array, we quote the f-values calculated by Fawcett[4] using Cowan's Hartree-Fock-Relativistic (HFR) method and incorporating scaling of energy parameters on the basis of a least-squares fit to observed energies. Fawcett's calculations included fairly extensive allowance for configuration mixing in both odd- and even-parity states. The weakest lines were not reported, and thus are not tabulated here. Transitions involving levels which are indicated by Fawcett to be of low to moderate purity in LS coupling in neighboring oxygenlike ions are excluded from this compilation.

References

[1] K. T. Cheng, Y.-K. Kim, and J. P. Desclaux, At. Data Nucl. Data Tables **24**, 111 (1979).

[2] C. Froese Fischer and H. P. Saha, J. Phys. B **17**, 943 (1984).

[3] S. O. Kastner, A. K. Bhatia, and L. Cohen, Phys. Scr. **15**, 259 (1977).

[4] B. C. Fawcett, At. Data Nucl. Data Tables **34**, 215 (1986).

Ti XV: Allowed transitions

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} ($10^8\ s^{-1}$)	f_{ik}	S (at. u.)	log gf	Accuracy	Source
1.	$2s^22p^4$–$2s2p^5$	$^3P - {}^3P^\circ$	*140.80*	*17802*	*728015*	9	9	380	0.11	0.47	0.01	C	1
			140.395	0	712285	5	5	280	0.082	0.19	−0.39	C	1
			142.130	39292	742882	3	3	93	0.0282	0.0396	−1.073	C	1
			134.609	0	742882	5	3	191	0.0311	0.069	−0.81	C	1
			138.357	39292	762060	3	1	410	0.0392	0.054	−0.93	C	1
			148.588	39292	712285	3	5	82	0.0452	0.066	−0.87	C	1
			142.750	42345	742882	1	3	118	0.108	0.051	−0.97	C	1
2.		$^3P - {}^1P^\circ$											
			102.247	0	978030	5	3	51	0.0048	0.0081	−1.62	E	1
			[106.53]	39292	978030	3	3	2.2	3.8(−4)[a]	4.0(−4)	−2.94	E	1
			106.874	42345	978030	1	3	5.1	0.0026	9.1(−4)	−2.59	E	1

Ti XV: Allowed transitions — Continued

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} ($10^8 s^{-1}$)	f_{ik}	S (at. u.)	log gf	Accuracy	Source
3.		$^1D - {}^3P^\circ$											
			165.690	108720	712285	5	5	8.5	0.0035	0.0095	−1.76	E	1
4.		$^1D - {}^1P^\circ$	115.031	108720	978030	5	3	1150	0.137	0.259	−0.164	C	1
5.		$^1S - {}^3P^\circ$											
			[189.62]	215521	742882	1	3	2.7	0.0043	0.0027	−2.37	E	1
6.		$^1S - {}^1P^\circ$	131.146	215521	978030	1	3	84	0.065	0.028	−1.19	C	1
7.	$2s2p^5–2p^6$	$^3P^\circ - {}^1S$											
			[109.48]	742882	1656290	3	1	27	0.0016	0.0017	−2.32	E	1
8.		$^1P^\circ - {}^1S$	147.436	978030	1656290	3	1	1200	0.130	0.189	−0.409	C	1
9.	$2p^4–2p^3(^4S^\circ)3s$	$^3P - {}^5S^\circ$											
			[23.20]			5	5	48	3.9(−4)	1.5(−4)	−2.71	E	3
10.	$2p^4–2p^3(^2D^\circ)3s$	$^3P - {}^3D^\circ$	*23.060*	*17802*	4354300	9	3	1.8(+4)	0.047	0.032	−0.38	C−	4
			22.966	0	4354300	5	3	1.1(+4)	0.054	0.020	−0.57	C−	4
			23.177	39292	4354300	3	3	4680	0.0377	0.0086	−0.95	C−	4
			23.193	42345	4354300	1	3	2000	0.049	0.0037	−1.31	C−	4
11.	$2p^4 - 2p^3(^2D^\circ)3s$	$^3P - {}^3D^\circ$											
			22.464	0	4451600	5	7	5200	0.055	0.020	−0.56	C−	4
			22.724	39292	4440900	3	5	1800	0.023	0.0052	−1.16	D	4
			22.739	42345	4440000	1	3	1500	0.034	0.0025	−1.47	C−	4
			22.518	0	4440900	5	5	3700	0.028	0.010	−0.85	D	4
			[22.724]	39292	4440000	3	3	3900	0.030	0.0067	−1.05	C−	4
12.		$^3P - {}^1D^\circ$											
			[22.378]	0	4468700	5	5	640	0.0048	0.0018	−1.62	E	4
			[22.576]	39292	4468700	3	5	860	0.011	0.0025	−1.48	E	4
13.		$^1D - {}^1D^\circ$	22.936	108720	4468700	5	5	1.1(+4)	0.090	0.034	−0.35	C−	4
14.	$2p^4 - 2p^3(^2P^\circ)3s$	$^3P - {}^3P^\circ$											
			[22.02]			5	5	1200	0.0090	0.0033	−1.35	D−	4
			[22.30]			3	3	980	0.0073	0.0016	−1.66	D	4
			[22.33]			3	1	5200	0.013	0.0029	−1.41	C	4
			[22.21]			3	5	2800	0.034	0.0075	−0.99	D	4
			[22.32]			1	3	3100	0.070	0.0051	−1.15	C	4
15.		$^1D - {}^3P^\circ$											
			[22.56]			5	5	2500	0.019	0.0071	−1.02	E	4
			[22.66]			5	3	1300	0.0058	0.0022	−1.54	E	4
16.		$^1D - {}^1P^\circ$	22.482	108720	4556900	5	3	6400	0.029	0.011	−0.84	D	4
17.		$^1S - {}^1P^\circ$	23.034	215521	4556900	1	3	6300	0.15	0.011	−0.82	D	4

Ti xv: **Allowed transitions — Continued**

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} (10^8 s^{-1})	f_{ik}	S (at. u.)	log gf	Accuracy	Source
18.	$2p^4 - 2p^3(^4S^\circ)3d$	$^3P - ^3D^\circ$	*20.985*	*17802*	*4783200*	9	15	2.6(+4)	0.29	0.18	0.42	D	4
			20.897	0	4785400	5	7	2.85(+4)	0.261	0.090	0.116	C−	4
			21.102	39292	4778200	3	5	1.3(+4)	0.15	0.031	−0.35	D	4
			21.079	42345	4786400	1	3	1.58(+4)	0.316	0.0291	−0.50	C−	4
			[20.928]	0	4778200	5	5	8400	0.055	0.019	−0.56	D	4
			[21.065]	39292	4786400	3	3	1.1(+4)	0.072	0.015	−0.67	C−	4
			[20.893]	0	4786400	5	3	1100	0.0042	0.0014	−1.68	D	4
19.	$2p^4 - 2p^3(^2D^\circ)3d$	$^3P - ^3F^\circ$											
			[20.60]			5	7	4400	0.039	0.013	−0.71	E	4
			[20.80]			3	5	1900	0.020	0.0041	−1.22	E	4
			[20.63]			5	5	1900	0.012	0.0041	−1.22	E	4
20.		$^3P - ^3G^\circ$											
			[20.56]			5	7	1800	0.016	0.0054	−1.10	E	4
21.	$2p^4 - 2p^3(^2D^\circ)3d$	$^3P - ^3D^\circ$											
			20.418	0	4897600	5	7	8.0(+4)	0.70	0.24	0.54	C−	4
22.		$^3P - ^3P^\circ$											
			20.538	39292	4908300	3	3	3.8(+4)	0.24	0.049	−0.14	D	4
			[20.374]	0	4908300	5	3	2400	0.0088	0.0030	−1.36	D−	4
			[20.54]			3	1	4.1(+4)	0.086	0.017	−0.59	C−	4
			[20.551]	42345	4908300	1	3	1.3(+4)	0.24	0.0016	−0.62	D	4
23.		$^3P - ^3S^\circ$											
			20.313	0	492300	5	3	7.5(+4)	0287	0.094	0.15	D	4
			[20.476]	39292	492300	3	3	2700	0.017	0.0034	−1.29	D	4
24.		$^3P - ^1F^\circ$											
			[20.234]	0	4942200	5	7	1.9(+4)	0.16	0.053	−0.10	E	4
25.	$2p^4 - 2p^3(^2D^\circ)3d$	$^1D - ^3G^\circ$											
			[21.03]			5	7	900	0.0084	0.0029	−1.38	E	4
26.		$^1D - ^3D^\circ$											
			[20.882]	108720	4897600	5	7	960	0.0088	0.0030	−1.36	E	4
27.		$^1P - ^1F^\circ$	[20.771]	108720	4923000	5	3	1.1(+4)	0.041	0.014	−0.69	E	4
28.		$^1D - ^1F^\circ$	20.689	108720	4942200	5	7	4.3(+4)	0.39	0.13	0.29	D	4
29.	$2p^4 - 2p^3(^2P^\circ)3d$												
			[20.19]			5	7	6900	0.059	0.020	−0.53	E	4
			[20.36]			3	5	2800	0.029	0.0058	−1.06	E	4
30.		$^3P - ^3P^\circ$											
			[20.29]			3	3	1.1(+4)	0.068	0.014	−0.69	D	4
			[20.30]			1	1	5.8(+4)	0.119	0.0239	−0.447	C−	4
			[20.30]			1	3	3.4(+4)	0.63	0.042	−0.20	D	4

Ti XV: Allowed transitions — Continued

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} (10^8 s^{-1})	f_{ik}	S (at. u.)	log gf	Accuracy	Source
31.	$2p^4 - 2p^3(^2D^\circ)3d$	$^3P - {}^3D^\circ$											
			[20.246]	42345	4981500	1	3	4.2(+4)	0.78	0.052	−0.11	C−	4
			20.234	39292	4981500	3	3	4.90+4)	0.301	0.060	−0.044	C−	4
			[20.074]	0	4981500	5	3	1200	0.0042	0.0014	−1.68	D	4
32.		$^3P - {}^1P^\circ$											
			[19.970]	39292	5046900	3	3	1300	0.0080	0.0016	−1.62	E	4
33.		$^1D - {}^3F^\circ$											
			[20.65]			5	5	4800	0.031	0.011	−0.81	E	4
34.		$^1D - {}^3P^\circ$											
			[20.58]			5	3	2900	0.011	0.0037	−1.26	E	4
35.		$^1S - {}^3D^\circ$	[20.250]	108720	5046900	5	3	6500	0.024	0.0080	−0.92	D	4
36.	$2p^4 - 2p^3(^2P^\circ)3d$	$^1S - {}^3P^\circ$											
			[21.04]			1	3	1300	0.025	0.0017	−1.60	E	4
37.		$^1S - {}^3D^\circ$											
			[20.982]	215521	4981500	1	3	1600	0.032	0.0022	−1.49	E	4
38.		$^1S - {}^1P^\circ$	20.698	215521	5046900	1	3	1.1(+5)	2.2	0.15	0.34	D	4

[a]The number in parenthesis following the tabulated value indicates the power of ten by which this value has to be multiplied.

Ti XV

Forbidden Transitions

Line strengths tabulated for magnetic dipole and electric quadrupole transitions within the $2p^4$ configuration are the results of the multiconfiguration Dirac-Fock (MCDF) calculations of Cheng *et al.*[1] These relativistic calculations included a perturbative treatment of the Breit interaction and the Lamb shift. Allowance for configuration mixing was limited to the $n=2$ complex. Strengths of electric quadrupole transitions as defined in Ref. 1 were multiplied by the factor $2/3$ which is needed to bring these values into conformance with the definition of quadrupole strengths used in the NBS tables.

Transition probabilities for these same lines were calculated by Froese Fischer and Saha[2] using the multiconfiguration Hartree-Fock (MCHF) method with Breit-Pauli corrections. Their basis included many configurations outside the $n=2$ complex, but relativistic effects were not treated to the same degree as in Ref. 1. Line strengths derived from these data are in quite good agreement with the data of Cheng *et al.* For this ion of the oxygen isoelectronic sequence, correlation effects due to mixing with configurations outside the complex were found by Froese Fischer and Saha to be rather small, as shown by a comparison of the results of their calculations employing an extensive basis to those derived by the same technique but limited to configurations within the $n=2$ complex.

A-values for forbidden transitions within the $2s2p^5$ configuration, and for transitions of the $2s^22p^4$–$2p^6$ array, were calculated by Bhatia *et al.*[3] using scaled Thomas-Fermi wavefunctions with allowance for configuration interaction and relativistic effects. We utilized their M1 and E2 line strength data, which were communicated to us by Bhatia,[4] and we converted these to A-values with wavelengths derived from experimental data. This approach normally yields transition probabilities that are more accurate than those based on calculated wavelengths (as published in Ref. 3).

The weakest lines are excluded from this compilation, as their transition probabilities are considered to be very uncertain. (This applies to all lines of the $2s^22p^4$–$2p^6$ array.)

References

[1]K. T. Cheng, Y.-K Kim, and J. P. Desclaux, At. Data Nucl. Data Tables **24**, 111 (1979).
[2]C. Froese Fischer and H. P. Saha, Phys. Rev. A **28**, 3169 (1983).
[3]A. K. Bhatia, U. Feldman, and G. A. Doschek, J. Appl. Phys. **51**, 1464 (1980).
[4]A. K. Bhatia, private communication (1986).

Ti xv: Forbidden transitions

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	Type of transition	A_{ki} (s^{-1})	S (at. u.)	Accuracy	Source
1.	$2p^4$-$2p^4$	^3P - ^3P										
			2545.08	0	39292	5	3	M1	1290	2.37	C+	1
			"	"	"	5	3	E2	0.024	0.0045	E	1
			[32750]	39292	42345	3	1	M1	1.40	1.82	C+	1
			[2360.8]	0	42345	5	1	E2	0.055	0.0024	E	1
2.		^3P - ^1D										
			919.73	0	108720	5	5	M1	2400	0.35	D	1
			"	"	"	5	5	E2	0.77	0.0015	E	1
			1440.2	39292	108720	3	5	M1	220	0.12	D	1
3.		^3P - ^1S										
			[567.44]	39292	215521	3	1	M1	2.5(+4)[a]	0.17	D	1
4.		^1D - ^1S	[936.32]	108720	215521	5	1	E2	18	0.0078	E	1
5.	$2s2p^5$-$2s2p^5$	$^3P^\circ$ - $^3P^\circ$										
			[3267.4]	712285	742882	5	3	M1	640	2.48	C	3,4
			[5212.9]	742882	762060	3	1	M1	377	1.98	C	3,4
			[2008.4]	712285	762060	5	1	E2	0.11	0.0022	E	3,4
6.		$^3P^\circ$ - $^1P^\circ$										
			[376.30]	712285	978030	5	3	M1	3700	0.022	D−	3,4
			[425.26]	742882	978030	3	3	M1	1500	0.013	D−	3,4
			[463.03]	762060	978030	1	3	M1	1600	0.018	D−	3,4

[a]The number in parentheses following the tabulated value indicates the power of ten by which this value has to be multiplied.

Ti XVI

N Isoelectronic Sequence

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

Ionization Energy: 1044 eV = 8420000 cm^{-1}

Allowed Transitions

List of tabulated lines

Wavelength (Å)	No.	Wavelength (Å)	No.	Wavelength (Å)	No.	Wavelength (Å)	No.
97.991	4	121.538	12	143.459	6	169.740	1
102.393	4	122.99	2	145.665	6	176.267	16
104.80	13	124.805	12	146.55	6	178.240	16
105.43	13	128.373	12	154.34	15	193.19	5
106.39	3	129.075	14	157.812	1	193.36	16
109.03	13	132.022	12	161.168	1	211.37	5
110.561	8	134.724	11	162.503	10	218.14	5
110.62	13	138.020	14	163.610	16	229.38	9
116.198	8	138.760	11	167.242	10	249.24	9
118.215	8	138.800	14	167.297	15	270.35	9
121.382	7	142.62	6	168.40	10		

The tabulated oscillator strengths for transitions of the arrays $2s^2 2p^3$–$2s2p^4$ and $2s2p^4$–$2p^5$ are the results of the multiconfiguration Dirac-Fock (MCDF) calculations of Cheng *et al.*[1] These relativistic calculations included a perturbative treatment of the Breit interaction and the Lamb shift. The results should be quite accurate, except in the case of weak lines. (A few very weak lines have been omitted from this tabulation.)

Reference

[1] K. T. Cheng, Y.-K. Kim, and J. P. Desclaux, At. Data Nucl. Data Tables **24**, 111 (1979).

Ti XVI: Allowed transitions

No.	Transition Array	Multiplet	λ (Å)	E_i (cm⁻¹)	E_k (cm⁻¹)	g_i	g_k	A_{ki} (10^8 s⁻¹)	f_{ik}	S (at. u.)	log gf	Accuracy	Source
1.	$2s^2 2p^3$–$2s2p^4$	$^4S°$ - ^4P	*164.74*	0	*607000*	4	12	110	0.14	0.30	−0.26	C	1
			169.740	0	589140	4	6	100	0.066	0.15	−0.58	C	1
			161.168	0	620470	4	4	120	0.0469	0.100	−0.73	C	1
			157.812	0	633660	4	2	132	0.0246	0.051	−1.007	C	1
2.		$^4S°$ - ^2D											
			[122.99]	0	813080	4	4	1.7	3.8(−4)[a]	6.2(−4)	−2.82	E	1
3.		$^4S°$ - ^2S											
			[106.39]	0	939920	4	2	4.1	3.5(−4)	4.9(−4)	−2.85	E	1
4.		$^4S°$ - ^2P											
			102.393	0	976650	4	4	12	0.0019	0.0026	−2.12	E	1
			[97.991]	0	1020500	4	2	1.5	1.1(−4)	1.4(−4)	−3.36	E	1
5.		$^2D°$ - ^4P											
			[218.14]	130720	589140	6	6	0.73	5.2(−4)	0.0022	−2.51	E	1
			[193.19]	116030	633660	4	2	0.43	1.2(−4)	3.1(−4)	−3.32	E	1
			[211.37]	116030	589140	4	6	0.96	9.6(−4)	0.0027	−2.42	E	1
6.		$^2D°$ - ^2D	*144.78*	*124840*	*815560*	10	10	250	0.078	0.37	−0.11	C−	1
			145.665	130720	817210	6	6	230	0.074	0.21	−0.35	C	1
			143.459	116030	813080	4	4	280	0.085	0.16	−0.47	C	1
			[146.55]	130720	813080	6	4	6.1	0.0013	0.0038	−2.11	D	1
			[142.62]	116030	817210	4	6	0.26	1.2(−4)	2.3(−4)	−3.32	E	1
7.		$^2D°$ - ^2S											
			121.382	116030	939920	4	2	240	0.026	0.042	−0.98	E	1
8.		$^2D°$ - ^2P	*115.42*	*124840*	*991270*	10	6	730	0.088	0.333	−0.057	C	1
			118.215	130720	976650	6	4	740	0.104	0.243	−0.205	C	1
			110.561	116030	1020500	4	2	336	0.0308	0.0448	−0.91	C	1
			116.198	116030	976650	4	4	145	0.0294	0.0450	−0.93	C	1
9.		$^2P°$ - ^4P											
			[270.35]	219250	589140	4	6	0.17	2.8(−4)	0.0010	−2.95	E	1
			[249.24]	219250	620470	4	4	0.63	5.9(−4)	0.0019	−2.63	E	1
			[229.38]	197700	633660	2	2	0.41	3.2(−4)	4.8(−4)	−3.19	E	1
10.		$^2P°$ - ^2D	*165.70*	*212070*	*815560*	6	10	40	0.027	0.090	−0.78	C−	1
			167.242	219250	817210	4	6	46.4	0.0292	0.064	−0.93	C	1
			162.503	197700	813080	2	4	26.1	0.0207	0.0221	−1.383	C	1
			[168.40]	219250	813080	4	4	4.2	0.0018	0.0040	−2.14	D	1

Ti XVI: Allowed transitions — Continued

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} (10^8 s^{-1})	f_{ik}	S (at. u.)	log *gf*	Accuracy	Source
11.		$^2P^\circ - {}^2S$	*137.39*	*212070*	939920	6	2	330	0.031	0.085	−0.73	C	1
			138.760	219250	939920	4	2	84	0.0121	0.0221	−1.315	C	1
			134.724	197700	939920	2	2	260	0.071	0.063	−0.85	C	1
12.		$^2P^\circ - {}^2P$	*128.34*	*212070*	*991270*	6	6	300	0.075	0.19	−0.35	C	1
			132.022	219250	976650	4	4	87	0.0228	0.0396	−1.040	C	1
			121.538	197700	1020500	2	2	56	0.0123	0.0098	−1.61	C	1
			124.805	219250	1020500	4	2	610	0.071	0.12	−0.55	C	1
			128.373	197700	976650	2	4	54	0.0269	0.0227	−1.269	C	1
13.	$2s2p^4-2p^5$	$^4P - {}^2P^\circ$											
			[105.43]	589140	1537660	6	4	8.7	9.7(−4)	0.0020	−2.24	E	1
			[109.03]	620470	1537660	4	4	3.3	5.8(−4)	8.3(−4)	−2.63	E	1
			[104.80]	633660	1587830	2	2	2.9	4.8(−4)	3.3(−4)	−3.02	E	1
			[110.62]	633660	1537660	2	4	1.1	3.9(−4)	2.8(−4)	−3.11	E	1
14.		$^2D - {}^2P^\circ$	*135.35*	*815560*	*1554380*	10	6	420	0.070	0.31	−0.16	C	1
			138.800	817210	1537660	6	4	350	0.067	0.18	−0.40	C	1
			129.075	813080	1587830	4	2	381	0.0476	0.081	−0.72	C	1
			138.020	813080	1537660	4	4	88	0.0251	0.0456	−1.000	C	1
15.		$^2S - {}^2P^\circ$	*162.74*	939920	*1554380*	2	6	41	0.049	0.052	−1.01	D−	1
			167.297	939920	1537660	2	4	55	0.0460	0.051	−1.036	C	1
			[154.34]	939920	1587830	2	2	1.8	6.6(−4)	6.7(−4)	−2.88	E	1
16.		$^2P - {}^2P^\circ$	*177.59*	*991270*	*1554380*	6	6	320	0.15	0.53	−0.04	C	1
			178.240	976650	1537660	4	4	252	0.120	0.282	−0.319	C	1
			176.267	1020500	1587830	2	2	245	0.114	0.132	−0.64	C	1
			163.610	976650	1587830	4	2	192	0.0386	0.083	−0.81	C	1
			[193.36]	1020500	1537660	2	4	22.7	0.0255	0.0325	−1.292	C	1

[a]The number in parentheses following the tabulated value indicates the power of ten by which this value has to be multiplied.

Ti XVI

Forbidden Transitions

List of tabulated lines

Wavelength (Å)	No.	Wavelength (Å)	No.	Wavelength (Å)	No.	Wavelength (Å)	No.
313.04	8	519.18	7	1129.2	4	2722	12
438.46	7	557.35	7	1224.1	4	3191	6
456.10	2	611.36	11	1241	12	4639	5
482.11	11	627.20	11	1493	4	6805	3
491.91	11	814.93	10	1993	14	7579	6
505.82	2	861.85	1	2245	6	24200	9
508.29	7	968.80	4	2280	13		

Line strengths tabulated for magnetic dipole and electric quadrupole transitions within the $2p^3$ configuration are the results of the multiconfiguration Dirac-Fock (MCDF) calculations of Cheng *et al.*[1] These relativistic calculations included a perturbative treatment of the Breit interaction and the Lamb shift. Allowance for configuration mixing was limited to the $n=2$ complex. Strengths of electric quadrupole transitions as defined in

Ref. 1 were multiplied by the factor 2/3 which is needed to bring these values into conformance with the definition of quadrupole strengths used in the NBS tables. The weakest lines are excluded from this compilation, as their strengths are considered to be very uncertain.

A-values for forbidden transitions within the $2s2p^4$ configuration, for transitions of the $2s^22p^3$–$2p^5$ array, and for the M1 component of the single transition within the $2p^5$ configuration were calculated by Bhatia *et al.*[2] using scaled Thomas-Fermi wavefunctions with allowance for configuration interaction and relativistic effects. We utilized their M1 and E2 line strength data, which were communicated to us by Bhatia,[3] and we converted these to A-values with wavelengths derived from experimental data. This approach normally yields transition probabilities that are more accurate than those based on calculated wavelengths (as published in Ref. 2). The weakest lines are excluded from the compilation. (This applies to all lines of the $2s^22p^3$–$2p^5$ array.)

The A-value quoted here for the E2 component of the transition within the $2p^5$ configuration was obtained by applying a Z-expansion formula published by Oboladze and Safronova.[4] Their value for the magnetic dipole contribution to this line is in very good agreement with the result of Ref. 2. It is not clear whether Oboladze and Safronova incorporated configuration interaction into their calculations. Thus the A-value of the E2 contribution should be considered rather uncertain.

References

[1]K. T. Cheng, Y.-K. Kim, and J. P. Desclaux, At. Data Nucl. Data Tables **24**, 111 (1979).
[2]A. K. Bhatia, U. Feldman, and G. A. Doschek, J. Appl. Phys. **51**, 1464 (1980).
[3]A. K. Bhatia, private communication (1986).
[4]N. S. Obladze and U. I. Safronova, Opt. Spectrosc. (USSR) **48**, 469 (1980).

Ti XVI: Forbidden transitions

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	Type of transition	A_{ki} (s^{-1})	S (at. u.)	Accuracy	Source
1.	$2p^3$–$2p^3$	$^4S°$ – $^2D°$										
			[861.85]	0	116030	4	4	M1	2000	0.19	D	1
2.		$^4S°$ – $^2P°$										
			[456.10]	0	219250	4	4	M1	7800	0.11	D	1
			[505.82]	0	197700	4	2	M1	4900	0.047	D−	1
3.		$^2D°$ – $^2D°$										
			[6805]	116030	130720	4	6	M1	28.1	1.97	C	1
			"	"	"	4	6	E2	5.0(−5)[a]	0.0026	E	1
4.		$^2D°$ – $^2P°$										
			[1493]	130720	197700	6	2	E2	0.52	0.0046	E	1
			1129.2	130720	219250	6	4	M1	2000	0.43	D	1
			"	"	"	6	4	E2	3.0	0.013	E	1
			1224.1	116030	197700	4	2	M1	1600	0.22	D	1
			"	"	"	4	2	E2	1.7	0.0057	E	1
			968.9	116030	219250	4	4	M1	5200	0.70	D	1
			"	"	"	4	4	E2	1.4	0.0028	E	1
5.		$^2P°$ – $^2P°$										
			4635.6	197700	219250	2	4	M1	72	1.06	C	1
			"	"	"	2	4	E2	2.2(−4)	0.0011	E	1
6.	$2s2p^4$–$2s2p^4$	^4P – ^4P										
			[3191]	589140	620470	6	4	M1	740	3.58	C	2,3
			[7579]	620470	633660	4	2	M1	101	3.27	C	2,3
			[2245]	589140	633660	6	2	E2	0.054	0.0037	E	2,3
7.		^4P – ^2D										
			[438.46]	589140	817210	6	6	M1	4700	0.088	D	2,3
			[519.18]	620470	813080	4	4	M1	1800	0.038	D	2,3
			[508.29]	620470	817210	4	6	M1	440	0.013	D	2,3
			[557.35]	633660	813080	2	4	M1	340	0.010	D−	2,3

Ti XVI: Forbidden transitions — Continued

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	Type of transition	A_{ki} (s^{-1})	S (at. u.)	Accu-racy	Source
8.		^{4}P - ^{2}S										
			[313.04]	620470	939920	4	2	M1	2.1(+4)	0.047	D	2,3
9.		^{2}D - ^{2}D										
			[24200]	813080	817210	4	6	M1	0.76	2.4	D	2,3
10.		^{2}D - ^{2}S										
			[814.93]	817210	939920	6	2	E2	20	0.0084	E	2,3
11.		^{2}D - ^{2}P										
			[491.91]	817210	1020500	6	2	E2	35	0.0012	D−	2,3
			[627.20]	817210	976650	6	4	M1	1000	0.037	D−	2,3
			[482.11]	813080	1020500	4	2	M1	2500	0.021	D−	2,3
			[611.36]	813080	976650	4	4	M1	2100	0.072	D−	2,3
12.		^{2}S - ^{2}P										
			[2722]	939920	976650	2	4	M1	53	0.16	D	2,3
			[1241]	939920	1020500	2	2	M1	2000	0.29	D	2,3
13.		^{2}P - ^{2}P										
			[2280]	976650	1020500	4	2	M1	1400	1.2	C	2,3
14.	$2p^5$-$2p^5$	^{2}P° - ^{2}P°										
			[1993]	1537660	1587830	4	2	M1	2270	1.33	C	2,3
			"	"	"	4	2	E2	0.11	0.0041	E	4

[a]The number in parentheses following the tabulated value indicates the power of ten by which this value has to be multiplied.

Ti XVII

C Isoelectronic Sequence

Ground State: $1s^2 2s^2 2p^2\ ^3P_0$

Ionization Energy: 1131 eV = 9120000 cm^{-1}

Allowed Transitions

List of tabulated lines

Wavelength (Å)	No.	Wavelength (Å)	No.	Wavelength (Å)	No.	Wavelength (Å)	No.
18.05	29	123.654	4	139.18	22	152.174	3
18.13	28,29	124.553	10	141.948	9	153.554	3
18.176	28	124.77	17	142.589	14	154.133	3
102	15	126.004	17	142.98	19	156.54	18
107	15	126.676	5	144.19	19	157.52	18
109.432	6	127.782	4	144.405	16	158.14	18
114.17	20	135.202	16	144.66	16	158.469	3
119.284	4	136.160	16	146.067	16	159.62	18
122.62	5	136.393	16	146.856	3	159.955	3

List of tabulated lines — Continued

Wavelength (Å)	No.	Wavelength (Å)	No.	Wavelength (Å)	No.	Wavelength (Å)	No.
163.049	27	183.11	8	210.55	21	230.93	21
167.74	13	185.11	8	213.62	23	234.63	23
169.36	18	186.863	24	224.16	7	270.43	25
171.06	18	188.312	2	227.57	7	295.94	11
172.380	2	190.71	2	227.93	12	305.00	25
181.67	2	191.16	2	228.21	7	328	1
182.072	2	207.73	21	228.93	26	359	1

The tabulated oscillator strengths for transitions of the arrays $2s^22p^2$–$2s2p^3$ and $2s2p^3$–$2p^4$ are the results of the multiconfiguration Dirac-Fock (MCDF) calculations of Cheng *et al.*[1] These relativistic calculations included a perturbative treatment of the Breit interaction and the Lamb shift. Allowance for configuration mixing was limited to the $n=2$ complex. The results should be quite accurate, except in the case of weak lines. (A few very weak lines have been omitted from this tabulation.)

Transition probabilities for lines of the $2s^22p^2$–$2s2p^3$ array were calculated by Froese Fischer and Saha[2] using the multiconfiguration Hartree-Fock (MCHF) method with Breit-Pauli corrections. Their basis included many configurations outside the $n=2$ complex, but relativistic effects were not treated to the same degree as in Ref. 1. Line strengths derived from these two sources are in reasonably good agreement, particularly for the stronger transitions.

Stratton *et al.*[3] measured the ratio of A-values for two lines out of the $2s2p^3\ ^3S^\circ_1$ level. Their result agrees fairly well with the theoretical data of Cheng *et al.*

Data for a few lines of the $2p^2$–$2p3d$ array were interpolated from the HX (Hartree-Fock with statistical allowance for exchange) f-values of Bromage and Fawcett[4] for the isoelectronic ions Ca XV and Fe XXI.

References

[1] K. T. Cheng, Y.-K. Kim, and J. P. Desclaux, At. Data Nucl. Data Tables **24**, 111 (1979).

[2] C. Froese Fischer and H. P. Saha, Phys. Scr. **32**, 181 (1985).

[3] B. C. Stratton, H. W. Moos, S. Suckewer, U. Feldman, J. F. Seely, and A. K. Bhatia, Phys. Rev. A **31**, 2534 (1985).

[4] G. E. Bromage and B. C. Fawcett, Mon. Not. R. Astron. Soc. **178**, 605 (1977).

Ti XVII: Allowed transitions

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} (10^8 s^{-1})	f_{ik}	S (at. u.)	log gf	Accuracy	Source
1.	$2s^22p^2$–$2s2p^3$	$^3P - {}^5S^\circ$											
			[359]			5	5	0.083	1.6(−4)[a]	9.5(−4)	−3.10	E	1
			[328]			3	5	0.060	1.6(−4)	5.2(−4)	−3.32	E	1
2.		$^3P - {}^3D^\circ$	*184.52*	*40866*	*582820*	9	15	60	0.051	0.28	−0.34	D	1
			188.312	55761	586795	5	7	52	0.0390	0.121	−0.71	C	1
			182.072	29664	578878	3	5	66	0.055	0.099	−0.78	C	1
			172.380	0	580114	1	3	64	0.086	0.049	−1.07	C	1
			[191.16]	55761	578878	5	5	0.88	4.8(−4)	0.0015	−2.62	E	1
			[181.67]	29664	580114	3	3	13	0.0063	0.011	−1.72	D	1
			[190.71]	55761	580114	5	3	0.15	5.0(−5)	1.6(−4)	−3.60	E	1
3.		$^3P - {}^3P^\circ$	*155.51*	*40866*	*683916*	9	9	150	0.054	0.25	−0.31	C−	1
			158.469	55761	686803	5	5	140	0.051	0.13	−0.59	C	1
			153.554	29664	680926	3	3	85	0.0300	0.0455	−1.046	C	1
			159.955	55761	680926	5	3	37	0.0085	0.022	−1.37	D	1
			154.133	29664	678454	3	1	163	0.0194	0.0295	−1.235	C	1
			152.174	29664	686803	3	5	10	0.0060	0.0090	−1.74	D	1
			146.856	0	680926	1	3	37.9	0.0368	0.0178	−1.434	C	1

Ti XVII: Allowed transitions — Continued

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} (10^8 s^{-1})	f_{ik}	S (at. u.)	log *gf*	Accu-racy	Source
4.		$^3P - {}^3S^\circ$	*125.39*	*40866*	838350	9	3	750	0.059	0.22	−0.27	C	1
			127.782	55761	838350	5	3	460	0.068	0.14	−0.47	C	1
			123.654	29664	838350	3	3	230	0.052	0.064	−0.81	C	1
			119.284	0	838350	1	3	80	0.051	0.020	−1.29	C	1
5.		$^3P - {}^1D^\circ$											
			126.676	55761	845180	5	5	30	0.0072	0.015	−1.44	E	1
			[122.62]	29664	845180	3	5	1.3	4.9(−4)	5.9(−4)	−2.83	E	1
6.		$^3P - {}^1P^\circ$											
			109.432	29664	943520	3	3	22	0.0039	0.0042	−1.93	E	1
7.		$^1D - {}^3D^\circ$											
			[224.16]	140693	586795	5	7	3.2	0.0034	0.013	−1.77	E	1
			[228.21]	140693	578878	5	5	0.26	2.0(−4)	7.5(−4)	−3.00	E	1
			[227.57]	140693	580114	5	3	0.62	2.9(−4)	0.0011	−2.84	E	1
8.		$^1D - {}^3P^\circ$											
			[183.11]	140693	686803	5	5	1.1	5.6(−4)	0.0017	−2.55	E	1
			[185.11]	140693	680926	5	3	1.9	6.0(−4)	0.0018	−2.52	E	1
9.		$^1D - {}^1D^\circ$	141.948	140693	845180	5	5	387	0.117	0.273	−0.233	C	1
10.		$^1D - {}^1P^\circ$	124.553	140693	943520	5	3	520	0.072	0.15	−0.44	C	1
11.		$^1S - {}^3D^\circ$											
			[295.94]	242204	580114	1	3	0.22	8.8(−4)	8.6(−4)	−3.06	E	1
12.		$^1S - {}^3P^\circ$											
			[227.93]	242204	680926	1	3	0.68	0.0016	0.0012	−2.80	E	1
13.		$^1S - {}^3S^\circ$	[167.74]	242204	838350	1	3	2.2	0.0028	0.0015	−2.55	E	1
14.		$^1S - {}^1P^\circ$	142.589	242204	943520	1	3	135	0.123	0.058	−0.91	C	1
15.	$2s2p^3$-$2p^4$	$^5S^\circ - {}^3P$											
			[107]			5	5	3.4	5.8(−4)	0.0010	−2.54	E	1
			[102]			5	3	1.1	1.0(−4)	1.7(−4)	−3.30	E	1
16.		$^3D^\circ - {}^3P$	*141.26*	*582820*	*1290730*	15	9	340	0.062	0.43	−0.03	C−	1
			146.067	586795	1271390	7	5	260	0.059	0.20	−0.38	C	1
			136.160	578878	1313300	5	3	195	0.0326	0.073	−0.79	C	1
			135.202	580114	1319750	3	1	293	0.0268	0.0358	−1.095	C	1
			144.405	578878	1271390	5	5	94	0.0295	0.070	−0.83	C	1
			136.393	580114	1313300	3	3	114	0.0317	0.0427	−1.022	C	1
			[144.66]	580114	1271390	3	5	15	0.0076	0.011	−1.64	D	1
17.		$^3D^\circ - {}^1D$											
			126.004	586795	1380330	7	5	21	0.0036	0.010	−1.60	E	1
			[124.77]	578878	1380330	5	5	3.5	8.1(−4)	0.0017	−2.39	E	1

Ti XVII: Allowed transitions — Continued

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} (10^8 s^{-1})	f_{ik}	S (at. u.)	log gf	Accuracy	Source
18.		$^3P^\circ - ^3P$	*164.80*	*683916*	*1290730*	9	9	96	0.039	0.19	−0.46	D	1
			[171.06]	686803	1271390	5	5	35.1	0.0154	0.0434	−1.114	C	1
			[158.14]	680926	1313300	3	3	1.4	5.4(−4)	8.4(−4)	−2.79	E	1
			[159.62]	686803	1313300	5	3	103	0.0236	0.062	−0.93	C	1
			[156.54]	680926	1319750	3	1	144	0.0176	0.0272	−1.277	C	1
			[169.36]	680926	1271390	3	5	27.5	0.0197	0.0330	−1.228	C	1
			[157.52]	678454	1313300	1	3	33.9	0.0378	0.0196	−1.423	C	1
19.		$^3P^\circ - ^1D$											
			[144.19]	686803	1380330	5	5	3.5	0.0011	0.0026	−2.26	E	1
			[142.98]	680926	1380330	3	5	3.3	0.0017	0.0024	−2.29	E	1
20.		$^3P^\circ - ^1S$											
			[114.17]	680926	1556830	3	1	12	7.9(−4)	8.9(−4)	−2.63	E	1
21.		$^3S^\circ - ^3P$	*221.05*	838350	*1290730*	3	9	71	0.16	0.34	−0.33	C	1
			[230.93]	838350	1271390	3	5	56	0.075	0.17	−0.65	C	1
			[210.55]	838350	1313300	3	3	87	0.058	0.12	−0.76	C	1
			[207.73]	838350	1319750	3	1	107	0.0231	0.0474	−1.159	C	1
22.		$^3S^\circ - ^1S$	[139.18]	838350	1556830	3	1	30	0.0029	0.0040	−2.06	E	1
23.		$^1D^\circ - ^3P$											
			[234.63]	845180	1271390	5	5	4.0	0.0033	0.013	−1.78	E	1
			[213.62]	845180	1313300	5	3	0.56	2.3(−4)	8.1(−4)	−2.94	E	1
24.		$^1D^\circ - ^1D$	186.863	845180	1380330	5	5	266	0.139	0.428	−0.158	C	1
25.		$^1P^\circ - ^3P$											
			[305.00]	943520	1271390	3	5	0.60	0.0014	0.0042	−2.38	E	1
			[270.43]	943520	1313300	3	3	2.6	0.0029	0.0077	−2.06	E	1
26.		$^1P^\circ - ^1D$	[228.93]	943520	1380330	3	5	34.3	0.0449	0.102	−0.87	C	1
27.		$^1P^\circ - ^1S$	163.049	943520	1556830	3	1	620	0.083	0.13	−0.60	C	1
28.	$2p^2$–$2p3d$	$^3P - ^3D^\circ$											
			18.176	55761	5557600	5	7	9.2(+4)	0.64	0.19	0.51	E	*interp.*
			[18.13]			1	3	8.1(+4)	1.2	0.072	0.08	D	*interp.*
29.		$^3P - ^3P^\circ$											
			[18.05]			3	3	4.5(+4)	0.22	0.039	−0.18	E	*interp.*
			[18.13]			5	3	2.4(+4)	0.072	0.021	−0.44	E	*interp.*

[a]The number in parentheses following the tabulated value indicates the power of ten by which this value has to be multiplied.

Ti XVII

Forbidden Transitions

List of tabulated lines

Wavelength (Å)	No.	Wavelength (Å)	No.	Wavelength (Å)	No.	Wavelength (Å)	No.
274.24	11	608.83	14	985.11	4	2385	17
283.2	6	625.39	13	991.95	8	3370.8	1
288.0	6	631.39	14	999.92	8	3834.4	1
375.52	10	635.24	13	1004.3	8	12630	7
385.40	9	659.85	13	1016.9	8	15500	17
389.53	15	900.67	2	1062.3	8	17010	12
407.8	5	917.94	18	1177.4	2	40440	12
410.63	19	926.57	8	1492	18	80880	7
470.50	3	937.30	8	1793.4	1		
566.57	20	950.84	16	2067	17		

Line strengths tabulated for magnetic dipole and electric quadrupole transitions within the $2p^2$ configuration are the results of the multiconfiguration Dirac-Fock (MCDF) calculations of Cheng *et al.*[1] These relativistic calculations included a perturbative treatment of the Breit interaction and the Lamb shift. Allowance for configuration mixing was limited to the $n=2$ complex. Strengths of electric quadrupole transitions as defined in Ref. 1 were multiplied by the factor $2/3$ which is needed to bring these values into conformance with the definition of quadrupole strengths used in the NBS tables. The weakest lines are excluded from this compilation, as their strengths are considered to be very uncertain.

Transition probabilities for these same lines were calculated by Froese Fischer and Saha[2] using the multiconfiguration Hartree-Fock (MCHF) method with Breit-Pauli corrections. Their basis included many configurations outside the $n=2$ complex, but relativistic effects were not treated to the same degree as in Ref. 1. Line strengths derived from these data are in good agreement with the data of Cheng *et al.*

A-values for forbidden transitions within the $2s2p^3$ and $2p^4$ configurations, and for transitions of the $2s^22p^2$–$2p^4$ array, were calculated by Bhatia *et al.*[3] using scaled Thomas-Fermi wavefunctions with allowance for configuration interaction and relativistic effects. We utilized their M1 and E2 line strength data, which were communicated to us by Bhatia,[4] and we converted these to A-values with wavelengths derived from experimental data. This approach normally yields transition probabilities that are more accurate than those based on calculated wavelengths. The weakest lines are excluded from the compilation. (This applies to all lines of the $2s^22p^2$–$2p^4$ array.)

References

[1] K. T. Cheng, Y.-K. Kim, and J. P. Desclaux, At. Data Nucl. Data Tables **24**, 111 (1979).
[2] C. Froese Fischer and H. P. Saha, Phys. Scr. **32**, 181 (1985).
[3] A. K. Bhatia, U. Feldman, and G. A. Doschek, J. Appl. Phys. **51**, 1464 (1980).
[4] A. K. Bhatia, private communication (1986).

Ti XVII: Forbidden transitions

No.	Transition Array	Multiplet	λ (Å)	E_i (cm⁻¹)	E_k (cm⁻¹)	g_i	g_k	Type of transition	A_{ki} (s⁻¹)	S (at. u.)	Accuracy	Source
1.	$2p^2$–$2p^2$	^{3}P - ^{3}P										
			3834.4	29664	55761	3	5	M1	215	2.25	C+	1
			"	"	"	3	5	E2	0.0014	0.0034	E	1
			3370.8	0	29664	1	3	M1	444	1.89	C+	1
			[1793.4]	0	55761	1	5	E2	0.034	0.0019	E	1

Ti XVII: Forbidden transitions — Continued

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	Type of transition	A_{ki} (s^{-1})	S (at. u.)	Accuracy	Source
2.		^{3}P - ^{1}D										
			[1177.4]	55761	140693	5	5	M1	2200	0.68	D	1
			"	"	"	5	5	E2	0.36	0.0024	E	1
			[900.67]	29664	140693	3	5	M1	1800	0.25	D	1
3.		^{3}P - ^{1}S										
			[470.50]	29664	242204	3	1	M1	2.6(+4)[a]	0.10	D	1
4.		^{1}D - ^{1}S	[985.11]	140693	242204	5	1	E2	12	0.0065	E	1
5.	$2s2p^3$–$2s2p^3$	^{5}S° - ^{3}D°										
			[407.8]			5	5	M1	1500	0.019	E	3,4
6.		^{5}S° - ^{3}P°										
			[283.2]			5	5	M1	1.5(+4)	0.063	D–	3,4
			[288.0]			5	3	M1	8700	0.023	D–	3,4
7.		^{3}D° - ^{3}D°										
			[80880]	578878	580114	5	3	M1	0.073	4.3	D	3,4
			[12630]	578878	586795	5	7	M1	8.0	4.2	D	3,4
8.		^{3}D° - ^{3}P°										
			[1062.3]	586795	680926	7	3	E2	3.0	0.0072	E	3,4
			[1004.3]	578878	678454	5	1	E2	8.2	0.0050	E	3,4
			[999.92]	586795	686803	7	5	M1	2300	0.43	D	3,4
			[1016.9]	580114	678454	3	1	M1	3100	0.12	D	3,4
			[926.57]	578878	686803	5	5	M1	1900	0.28	D	3,4
			[991.95]	580114	680926	3	3	M1	3000	0.33	D	3,4
			[937.30]	580114	686803	3	5	M1	450	0.069	D–	3,4
			"	"	"	3	5	E2	1.1	0.0024	E	4
9.		^{3}D° - ^{3}S°										
			[385.40]	578878	838350	5	3	M1	1900	0.012	E	3,4
10.		^{3}D° - ^{1}D°										
			[375.52]	578878	845180	5	5	M1	1100	0.011	D–	3,4
11.		^{3}D° - ^{1}P°										
			[274.24]	578878	943520	5	3	M1	1.2(+4)	0.027	D–	3,4
12.		^{3}P° - ^{3}P°										
			[17010]	680926	686803	3	5	M1	2.7	2.5	D	3,4
			[40440]	678454	680926	1	3	M1	0.26	1.9	D	3,4
13.		^{3}P° - ^{3}S°										
			[659.85]	686803	838350	5	3	M1	690	0.022	D–	3,4
			[635.24]	680926	838350	3	3	M1	530	0.015	D–	3,4
			[625.39]	678454	838350	1	3	M1	920	0.025	D–	3,4

Ti XVII: Forbidden transitions — Continued

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	Type of transition	A_{ki} (s^{-1})	S (at. u.)	Accuracy	Source
14.		$^3P^\circ - {^1D^\circ}$										
			[631.39]	686803	845180	5	5	M1	3200	0.15	D	3,4
			[608.83]	680926	845180	3	5	M1	1300	0.053	D−	3,4
15.		$^3P^\circ - {^1P^\circ}$										
			[389.53]	686803	943520	5	3	M1	1500	0.010	D−	3,4
16.		$^3S^\circ - {^1P^\circ}$	[950.84]	838350	943520	3	3	M1	4900	0.47	D	3,4
17.	$2p^4$–$2p^4$	$^3P - {^3P}$										
			[2385]	1271390	1313300	5	3	M1	1610	2.43	C	3,4
			"	"	"	5	3	E2	1.3	0.18	D	4
			[15500]	1313300	1319750	3	1	M1	14	1.9	C−	3,4
			[2067]	1271390	1319750	5	1	E2	0.085	0.019	D−	3,4
18.		$^3P - {^1D}$										
			[917.94]	1271390	1380330	5	5	M1	2400	0.35	D	3,4
			[1492]	1313300	1380330	3	5	M1	190	0.12	D−	3,4
19.		$^3P - {^1S}$										
			[410.63]	1313300	1556830	3	1	M1	3.5(+4)	0.090	D−	3,4
20.		$^1D - {^1S}$	[566.57]	1380330	1556830	5	1	E2	200	0.0069	E	3,4

[a]The number in parentheses following the tabulated value indicates the power of ten by which this value has to be multiplied.

Ti XVIII

B Isoelectronic Sequence

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

Ionization Energy: 1221 eV = 9850000 cm^{-1}

Allowed Transitions

List of tabulated lines

Wavelength (Å)	No.	Wavelength (Å)	No.	Wavelength (Å)	No.	Wavelength (Å)	No.
17.22	14	144.759	3	187.55	8	246	7
17.365	14	148.83	9	189.663	8	292.44	11
17.39	14	150.15	9	191.23	8	301.49	11
111	6	153.15	9	193.41	8	322	1
112	6	153.23	4	197.838	2	328	1
133.852	3	159.00	4	200.18	2	462	10
134	5	166.225	4	208.07	12		
137	5	179.902	2	216.59	12		

The tabulated oscillator strengths for transitions of the arrays $2s^22p$–$2s2p^2$ and $2s2p^2$–$2p^3$ are the results of the multiconfiguration Dirac-Fock (MCDF) calculations of Cheng *et al.*[1] These relativistic calculations included a perturbative treatment of the Breit interaction and the Lamb shift. The results should be quite accurate, except in the case of weak lines. (A few very weak lines have been omitted from this tabulation.)

According to several sources (see, e.g., introduction to Fe XXII), the two levels $2s2p^2\,{}^2\mathrm{P}_{1/2}$ and ${}^2\mathrm{S}_{1/2}$ "cross" at about V XIX or Cr XX. Transitions to these levels in this neighboring ion, Ti XVIII, have been omitted from this compilation, since the precise location of the level crossing, and thus the correct designations of the levels, are uncertain.

The Hartree-Fock results of Shamey[2] for the isoelectronic ions Ar XIV and Fe XXII, which allowed for limited configuration interaction, were interpolated to provide f-values for the $2p$–$3s$, $2p$–$3d$, and $2p$–$4d$ transitions.

References

[1] K. T. Cheng, Y.-K. Kim, and J. P. Desclaux, At. Data Nucl. Data Tables **24**, 111 (1979).

[2] L. J. Shamey, J. Opt. Soc. Am. **61**, 942 (1971).

Ti XVIII: Allowed transitions

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} (10^8 s^{-1})	f_{ik}	S (at. u.)	log *gf*	Accuracy	Source
1.	$2s^22p$–$2s2p^2$	${}^2\mathrm{P}^\circ$ – ${}^4\mathrm{P}$											
			[328]			4	6	0.14	3.5(−4)[a]	0.0015	−2.85	E	1
			[322]			2	2	0.19	3.0(−4)	6.4(−4)	−3.22	E	1
2.		${}^2\mathrm{P}^\circ$ – ${}^2\mathrm{D}$	*191.62*	*37530*	*559400*	6	10	52	0.0473	0.179	−0.55	C−	1
			197.838	56300	561760	4	6	45.6	0.0401	0.104	−0.79	C	1
			179.902	0	555860	2	4	63	0.061	0.072	−0.91	C	1
			[200.18]	56300	555860	4	4	2.0	0.0012	0.0032	−2.32	D	1
3.		${}^2\mathrm{P}^\circ$ – ${}^2\mathrm{P}$											
			144.759	56300	747100	4	4	320	0.099	0.19	−0.40	C	1
			133.852	0	747100	2	4	52	0.0277	0.0244	−1.256	C	1
4.	$2s2p^2$–$2p^3$	${}^4\mathrm{P}$ – ${}^4\mathrm{S}^\circ$	*161.50*			12	4	335	0.0437	0.279	−0.280	C	1
			166.225			6	4	154	0.0426	0.140	−0.59	C	1
			159.00			4	4	116	0.0441	0.092	−0.75	C	1
			153.23			2	4	67	0.0470	0.0474	−1.027	C	1
5.		${}^4\mathrm{P}$ – ${}^2\mathrm{D}^\circ$											
			[137]			6	6	4.6	0.0013	0.0035	−2.11	E	1
			[134]			4	4	3.7	0.0010	0.0018	−2.40	E	1
6.		${}^4\mathrm{P}$ – ${}^2\mathrm{P}^\circ$											
			[112]			4	4	1.2	2.3(−4)	3.4(−4)	−3.04	E	1
			[111]			2	2	0.87	1.6(−4)	1.2(−4)	−3.49	E	1
7.		${}^2\mathrm{D}$ – ${}^4\mathrm{S}^\circ$											
			[246]			4	4	0.12	1.1(−4)	3.6(−4)	−3.36	E	1
8.		${}^2\mathrm{D}$ – ${}^2\mathrm{D}^\circ$	*190.28*	*559400*	*1084950*	10	10	110	0.057	0.36	−0.24	C	1
			189.663	561760	1089050	6	6	96	0.052	0.19	−0.51	C	1
			191.23	555860	1078790	4	4	66	0.0362	0.091	−0.84	C	1
			[193.41]	561760	1078790	6	4	30.5	0.0114	0.0436	−1.165	C	1
			187.55	555860	1089050	4	6	16.4	0.0130	0.0321	−1.284	C	1

Ti XVIII: Allowed transitions — Continued

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} (10^8 s^{-1})	f_{ik}	S (at. u.)	log gf	Accuracy	Source
9.		^{2}D - ^{2}P°	*151.05*	*559400*	*1221440*	10	6	166	0.0340	0.169	−0.469	C	1
			150.15	561760	1227760	6	4	115	0.0259	0.077	−0.81	C	1
			153.15	555860	1208810	4	2	197	0.0346	0.070	−0.86	C	1
			148.83	555860	1227760	4	4	34.0	0.0113	0.0221	−1.345	C	1
10.		^{2}P - ^{4}S°											
			[462]			4	4	0.11	3.4(−4)	0.0021	−2.87	E	1
11.		^{2}P - ^{2}D°											
			[292.44]	747100	1089050	4	6	26	0.050	0.19	−0.70	C	1
			[301.49]	747100	1078790	4	4	0.81	0.0011	0.0044	−2.36	D	1
12.		^{2}P - ^{2}P°											
			208.07	747100	1227760	4	4	120	0.079	0.22	−0.50	C	1
			[216.59]	747100	1208810	4	2	23	0.0082	0.023	−1.48	D	1
13.	$2p$–$3s$	^{2}P° - ^{2}S											
						4	2		0.020		−1.10	E	*interp.*
						2	2		0.020		−1.40	E	*interp.*
14.	$2p$–$3d$	^{2}P° - ^{2}D	*17.32*	*37530*	*5812000*	6	10	8.6(+4)	0.64	0.22	0.59	D	*interp.*
			17.365	56300	5815000	4	6	8.6(+4)	0.58	0.13	0.37	D	*interp.*
			17.22	0	5807000	2	4	7.3(+4)	0.65	0.074	0.11	D	*interp.*
			[17.39]	56300	5807000	4	4	1.4(+4)	0.064	0.015	−0.59	D	*interp.*
15.	$2p$–$4d$	^{2}P° - ^{2}D											
						4	6		0.11		−0.36	D	*interp.*
						2	4		0.12		−0.62	E	*interp.*
						4	4		0.012		−1.32	D	*interp.*

[a]The number in parentheses following the tabulated value indicates the power of ten by which this value has to be multiplied.

Ti XVIII

Forbidden Transitions

The line strengths tabulated for the single magnetic dipole and single electric quadrupole transition within the $2s^22p$ ground state configuration are the results of the multiconfiguration Dirac-Fock (MCDF) calculations of Cheng *et al.*[1] These relativistic calculations include a perturbative treatment of the Breit interaction and the Lamb shift. Allowance for configuration mixing is limited to the $n=2$ complex. The strength of the electric quadrupole transition as defined in Ref. 1 was multiplied by the factor $2/3$ in order to bring this value into conformance with the definition of the quadrupole strength used in the NBS tables.

Transition probabilities for the same lines were calculated by Froese Fischer and Saha[2] using the multiconfiguration Hartree-Fock (MCHF) method with Breit-Pauli corrections. Their orbital basis includes many configurations outside the $n=2$ complex, but relativistic effects were not treated to the same degree as in Ref. 1. The line strengths for both the M1 and E2 transitions, derived from these data by interpolation between appropriately spaced ions of the B sequence, are in very good agreement with the data of Cheng *et al.*[1]

A-values for forbidden transitions within the $2s2p^2$ and $2p^3$ configurations, and for transitions of the $2s^22p$–$2p^3$ array, were calculated by Bhatia *et al.*[3] using scaled Thomas-Fermi wavefunctions with allowance for configuration interaction and relativistic effects. We utilized their M1 and E2 line strength data, which were communicated to us by Bhatia,[4] and converted these to A-values with wavelengths derived from experimental data. This approach should normally yield transition probabilities that are more accurate than those based on theoretically determined wavelengths. The weakest lines determined by Bhatia *et al.*—for example, all lines of the $2s^22p$–$2p^3$ array—were excluded from this compilation.

References

[1]K. T. Cheng, Y.-K. Kim, and J. P. Desclaux, At. Data Nucl. Data Tables **24**, 111 (1979).
[2]C. Froese Fischer and H. P. Saha, Phys. Rev. A **28**, 3169 (1983).
[3]A. K. Bhatia, U. Feldman, and G. H. Doschek, J. Appl. Phys. **51**, 1464 (1980).
[4]A. K. Bhatia, private communication (1986).

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No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	Type of transition	A_{ki} (s^{-1})	S (at. u.)	Accuracy	Source
1.	$2p$–$2p$	$^2P^\circ$ – $^2P^\circ$										
			1778.1	0	56240	2	4	M1	1600	1.33	B	1
			"	"	"	2	4	E2	0.071	0.0030	C	1
2.	$2s2p^2$–$2s2p^2$	^4P – ^4P										
			[3598.4]	333170	360960	4	6	M1	343	3.56	C	3,4
			"	"	"	4	6	E2	0.0019	0.0041	D	4
			[4312.2]	309980	333170	2	4	M1	276	3.28	C	3,4
3.		^2D – ^2D										
			[17123]	555860	561700	4	6	M1	2.10	2.35	C	3,4
4.		^2S – ^2P										
			[1362.6]	673680	747070	2	4	M1	1400	0.51	C–	3,4
			[1664.7]	673680	733750	2	2	M1	1900	0.64	C–	3,4
5.		^2P – ^2P										
			[7507.5]	733750	747070	2	4	M1	13	0.80	C–	3,4
6.	$2p^3$–$2p^3$	$^2D^\circ$ – $^2D^\circ$										
			[9901]	1078800	1088900	4	6	M1	10.2	2.20	C	3,4
7.		$^2D^\circ$ – $^2P^\circ$										
			[720.5]	1088900	1227700	6	4	M1	3600	0.20	D	3,4
			"	"	"	6	4	E2	26	0.012	D–	4
			[769.2]	1078800	1208800	4	2	M1	3000	0.10	D	3,4
			[671.6]	1078800	1227700	4	4	M1	7800	0.35	D	3,4
8.		$^2P^\circ$ – $^2P^\circ$										
			[5291.0]	1208800	1227700	2	4	M1	55	1.20	C	3,4

Ti XIX

Be Isoelectronic Sequence

Ground State: $1s^22s^2\ {}^1S_0$

Ionization Energy: 1346 eV = 10860000 cm^{-1}

Allowed Transitions

List of tabulated lines

Wavelength (Å)	No.	Wavelength (Å)	No.	Wavelength (Å)	No.	Wavelength (Å)	No.
15.57	11	16.55	24	16.93	28	169.58	2
15.67	11	16.56	29	16.96	32	175.33	4
15.68	11	16.57	24	17.03	19	189.46	3
15.70	10	16.58	12	17.08	19,25	193.54	3
15.74	10	16.61	29	17.14	30	194.37	7
15.75	10	16.64	29	17.18	31	199.88	3
15.83	9	16.69	27	17.20	19	206.11	3
15.86	8,10	16.71	27	17.28	21	212.22	3
16.02	16	16.72	29	17.33	21	218.51	3
16.18	15	16.74	27	17.36	21,35	304.98	6
16.30	14	16.77	27	17.42	21	328.30	1
16.31	14	16.79	27	17.45	21	412.00	5
16.41	24	16.80	34	17.50	22	464.69	5
16.43	24	16.81	33	17.51	21	537.29	5
16.46	24	16.84	27	17.77	20		
16.48	13	16.85	28	18.09	23		
16.51	24	16.92	26	163.14	4		

Oscillator strengths for transitions of the arrays $2s^2$–$2s2p$ and $2s2p$–$2p^2$ are taken from the multiconfiguration Dirac-Fock (MCDF) calculations of Cheng *et al.*[1] These relativistic calculations include the configuration interaction most relevant for the states of these configurations, as well as a perturbative treatment of the Breit interaction and the Lamb shift. The results should be quite accurate, except for the weakest intercombination lines. (The ${}^3P_1^\circ - {}^1S_0$ transition of the $2s2p$–$2p^2$ array has been omitted here, since the f-value is considerably smaller than those of the other lines of this array.)

A number of sources of reliable data, from other relativistic calculations, are available for the $2s$–$2p$ transitions. However, with the exception of some of the weaker lines, they all agree well with the results of Cheng *et al.*[1] The latter are quoted exclusively here since they provide data from a single set of comprehensive calculations, all done at a uniform and reasonably accurate level of approximation, for the valence shell $2s$–$2p$ transitions for all ions of the isoelectronic sequence.

The f-values for the $2s^2$–$2s3p$, $2s2p$–$2p3p$, $2s2p$–$2s3s$, $2p^2$–$2p3s$, $2s2p$–$2s3d$, and $2p^2$–$2p3d$ arrays of transitions are taken from the work of Fawcett,[2] who used Cowan's version of the relativistic Hartree-Fock method with intermediate coupling and configuration interaction. This work provides a comprehensive set of data for the entire isoelectronic sequence, calculated at a uniform level of approximation. Some of these transitions, for some ions of this sequence, have also been calculated by Bhatia *et al.*[3] using the program SUPERSTRUCTURE, which includes configuration interaction and intermediate coupling. Where they overlap, these two sets of calculations agree to within the uncertainties assigned here. Transitions involving the $J=1$ levels of $2p3p\ {}^3S$ and ${}^3P$ have been omitted because of erratic behavior of the f-values along the sequence.

The oscillator strength for the $2s^2\ {}^1S - 2s4p\ {}^1P^\circ$ transition is the result of the relativistic random phase approximation (RRPA) calculations of Lin and Johnson.[4] The f-value for the intercombination line of this array was interpolated from the results of Ref. 4 for neighboring Be-like ions.

A few multiplet f-values for transitions involving the outer electron alone, $2s3s$–$2s3p$ and $2s3p$–$2s3d$, have been interpolated along the isoelectronic sequence and assigned a low accuracy.

References

[1]K. T. Cheng, Y.-K. Kim, and J. P. Desclaux, At. Data Nucl. Data Tables **24**, 111 (1979).
[2]B. C. Fawcett, At. Data Nucl. Data Tables **30**, 1 (1984); **33**, 479 (1985).
[3]A. K. Bhatia, U. Feldman, and J. F. Seely, At. Data Nucl. Data Tables **35**, 449 (1986).
[4]C. D. Lin and W. R. Johnson, Phys. Rev. A **15**, 1046 (1977).

Ti XIX: Allowed transitions

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} (10^8 s^{-1})	f_{ik}	S (at. u.)	log gf	Accuracy	Source
1.	$2s^2$–$2s2p$	^1S - $^3P^\circ$											
			[328.30]	0	304600	1	3	0.14	6.6(−4)[a]	7.1(−4)	−3.18	D	1
2.		^1S - $^1P^\circ$	[169.58]	0	589692	1	3	135	0.175	0.0977	−0.757	B	1
3.	$2s2p$–$2p^2$	$^3P^\circ$ - ^3P	*203.88*	*326470*	*816950*	9	9	103	0.0641	0.387	−0.239	B	1
			[206.11]	347240	832410	5	5	69.4	0.0442	0.150	−0.656	B	1
			[199.88]	304600	804890	3	3	28.2	0.0169	0.0334	−1.295	B	1
			[218.51]	347240	804890	5	3	36.1	0.0155	0.0558	−1.111	B	1
			[212.22]	304600	775810	3	1	96.0	0.0216	0.0453	−1.188	B	1
			[189.46]	304600	832410	3	5	34.1	0.0306	0.0573	−1.037	B	1
			[193.54]	288190	804890	1	3	42.1	0.0709	0.0452	−1.149	B	1
4.		$^3P^\circ$ - ^1D											
			[175.33]	347240	917580	5	5	15	0.0068	0.020	−1.47	C	1
			[163.14]	304600	917580	3	5	1.2	7.7(−4)	0.0012	−2.64	D	1
5.		$^1P^\circ$ - ^3P											
			[412.00]	589692	832410	3	5	1.0	0.0043	0.017	−1.89	D	1
			[464.69]	589692	804890	3	3	0.020	6.6(−5)	3.0(−4)	−3.70	E	1
			[537.29]	589692	775810	3	1	0.13	1.9(−4)	0.0010	−3.24	E	1
6.		$^1P^\circ$ - ^1D	[304.98]	589692	917580	3	5	29.2	0.0678	0.204	−0.692	B	1
7.		$^1P^\circ$ - ^1S	[194.37]	589692	1104170	3	1	227	0.0428	0.0822	−0.891	B	1
8.	$2s^2$–$2s3p$	^1S - $^3P^\circ$											
			[15.86]	0	6303200	1	3	2.9(+4)	0.33	0.017	−0.48	C−	2
9.		^1S - $^1P^\circ$	[15.83]	0	[6319000]	1	3	3.2(+4)	0.36	0.019	−0.44	C−	2
10.	$2s2p$–$2p3p$	$^3P^\circ$ - ^3D											
			[15.74]	347240	6699700	5	7	2.7(+4)	0.14	0.036	−0.15	C−	2
			[15.75]	304600	[6654000]	3	5	2.4(+4)	0.15	0.023	−0.35	C−	2
			[15.70]	288190	[6656000]	1	3	7000	0.078	0.0040	−1.11	D	2
			[15.86]	347240	[6654000]	5	5	2000	0.0074	0.0019	−1.43	D	2
			[15.74]	304600	[6656000]	3	3	1.2(+4)	0.043	0.0067	−0.89	D	2
11.		$^3P^\circ$ - ^3P											
			[15.68]	347240	[6726000]	5	5	2.7(+4)	0.10	0.026	−0.30	C−	2
			[15.67]	304600	6685800	3	1	3.3(+4)	0.040	0.0062	−0.92	D	2
			[15.57]	304600	[6726000]	3	5	2800	0.017	0.0026	−1.29	D	2
12.		$^1P^\circ$ - ^1P	[16.58]	589692	[6620000]	3	3	1.4(+4)	0.057	0.0093	−0.77	D	2
13.		$^1P^\circ$ - ^3D											
			[16.48]	589692	[6656000]	3	3	1.1(+4)	0.043	0.0070	−0.89	D	2
14.		$^1P^\circ$ - ^3P											
			[16.30]	589692	[6726000]	3	5	5600	0.037	0.0060	−0.95	D	2
			[16.31]	589692	[6720000]	3	3	250	0.0010	1.6(−4)	−2.52	C−	2
15.		$^1P^\circ$ - ^1D	[16.18]	589692	6770900	3	5	3.8(+4)	0.25	0.040	−0.12	C−	2

Ti XIX: Allowed transitions — Continued

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} (10^8 s^{-1})	f_{ik}	S (at. u.)	log gf	Accuracy	Source
16.		$^1P^\circ - {}^1S$	[16.02]	589692	[6830000]	3	1	3.1(+4)	0.040	0.0063	−0.92	D	2
17.	$2s^2$–$2s4p$	$^1S - {}^3P^\circ$											
						1	3		0.016		−1.80	D	*interp.*
18.		$^1S - {}^1P^\circ$				1	3		0.16		−0.80	D	4
19.	$2s2p$–$2s3s$	$^3P^\circ - {}^3S$	*17.14*	*326470*	6160800	9	3	1.9(+4)	0.028	0.014	−0.61	D	2
			[17.20]	347240	6160800	5	3	1.1(+4)	0.028	0.0079	−0.85	D	2
			[17.08]	304600	6160800	3	3	6400	0.028	0.0047	−1.08	D	2
			[17.03]	288190	6160800	1	3	2100	0.028	0.0016	−1.55	D	2
20.		$^1P^\circ - {}^1S$	[17.77]	589692	[6216000]	3	1	6300	0.010	0.0018	−1.52	D	2
21.	$2p^2$–$2p3s$	$^3P - {}^3P^\circ$	*17.38*	*816950*	[*6571000*]	9	9	1.2(+4)	0.056	0.029	−0.30	D	2
			[17.36]	832410	[6593000]	5	5	8900	0.040	0.011	−0.70	D	2
			[17.42]	804890	[6545000]	3	3	2600	0.012	0.0021	−1.44	D	2
			[17.51]	832410	[6545000]	5	3	5400	0.015	0.0043	−1.12	D	2
			[17.45]	804890	[6535000]	3	1	1.2(+4)	0.018	0.0031	−1.27	D	2
			[17.28]	804890	[6593000]	3	5	4000	0.030	0.0051	−1.05	D	2
			[17.33]	775810	[6545000]	1	3	4200	0.057	0.0033	−1.24	D	2
22.		$^1D - {}^1P^\circ$	[17.50]	917580	[6633000]	5	3	1.1(+4)	0.030	0.0086	−0.82	D	2
23.		$^1S - {}^1P^\circ$	[18.09]	1104170	[6633000]	1	3	3900	0.058	0.0035	−1.24	D	2
24.	$2s2p$–$2s3d$	$^3P^\circ - {}^3D$	*16.48*	*326470*	*6393800*	9	15	1.1(+5)	0.72	0.35	0.81	C−	2
			[16.51]	347240	6402700	5	7	1.0(+5)	0.60	0.16	0.48	C−	2
			[16.43]	304600	6389200	3	5	8.2(+4)	0.55	0.089	0.22	C−	2
			[16.41]	288190	6380600	1	3	6.1(+4)	0.74	0.040	−0.13	C−	2
			[16.55]	347240	6389200	5	5	2.7(+4)	0.11	0.030	−0.26	C−	2
			[16.46]	304600	6380600	3	3	4.4(+4)	0.18	0.029	−0.27	C−	2
			[16.57]	347240	6380600	5	3	2900	0.0072	0.0020	−1.44	C−	2
25.		$^1P^\circ - {}^1D$	[17.08]	589692	6445900	3	5	8.3(+4)	0.61	0.10	0.26	C−	2
26.	$2p^2$–$2p3d$	$^3P - {}^3F^\circ$											
			[16.92]	832410	[6743000]	5	7	2.0(+4)	0.12	0.033	−0.22	C−	2
27.		$^3P - {}^3D^\circ$	*16.73*	*816950*	[*6794000*]	9	15	1.1(+5)	0.77	0.38	0.84	C−	2
			[16.74]	832410	6807600	5	7	1.2(+5)	0.72	0.20	0.56	C−	2
			[16.71]	804890	6789100	3	5	7.3(+4)	0.51	0.084	0.18	C−	2
			[16.69]	775810	[6769000]	1	3	1.02(+5)	1.28	0.070	0.107	C−	2
			[16.79]	832410	6789100	5	5	5200	0.022	0.0061	−0.96	D	2
			[16.77]	804890	[6769000]	3	3	2.6(+4)	0.11	0.018	−0.48	C−	2
			[16.84]	832410	[6769000]	5	3	340	8.8(−4)	2.4(−4)	−2.36	D	2
28.		$^3P - {}^1D^\circ$											
			[16.93]	832410	6738000	5	5	4200	0.018	0.0050	−1.05	C−	2
			[16.85]	804890	6738000	3	5	4.4(+4)	0.31	0.052	−0.03	D	2

Ti XIX: Allowed transitions — Continued

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} ($10^8 s^{-1}$)	f_{ik}	S (at. u.)	log gf	Accuracy	Source
29.		$^3P - ^3P°$	*16.67*	*816950*	[*6815000*]	9	9	8.2(+4)	0.342	0.169	0.488	C−	2
			[16.72]	832410	6813700	5	5	7.3(+4)	0.304	0.084	0.182	C−	2
			[16.64]	804890	6813700	3	3	5.3(+4)	0.22	0.036	−0.18	C−	2
			[16.72]	832410	6813700	5	3	3.3(+4)	0.082	0.023	−0.39	C−	2
			[16.61]	804890	[6826000]	3	1	8.0(+4)	0.11	0.018	−0.48	C−	2
			[16.64]	804890	6813700	3	5	6200	0.043	0.0071	−0.89	D	2
			[16.56]	775810	6813700	1	3	890	0.011	6.0(−4)	−1.96	D	2
30.		$^1D - ^3F°$											
			[17.14]	917580	[6752000]	5	5	6400	0.028	0.0079	−0.85	D	2
31.		$^1D - ^1D°$	[17.18]	917580	6738000	5	5	1.7(+4)	0.074	0.021	−0.43	C−	2
32.		$^1D - ^3P°$											
			[16.96]	917580	6813700	5	5	1.7(+4)	0.074	0.021	−0.43	C−	2
33.		$^1D - ^1P°$	[16.81]	917580	6866000	5	3	6300	0.016	0.0044	−1.10	D	2
34.		$^1D - ^1F°$	[16.80]	917580	6871700	5	7	1.81(+5)	1.07	0.296	0.73	C−	2
35.		$^1S - ^1P°$	[17.36]	1104170	6866000	1	3	9.5(+4)	1.29	0.074	0.111	C−	2
36.	$2s3s-2s3p$	$^3S - ^3P°$				3	9		0.15		−0.35	D	*interp.*
37.		$^1S - ^1P°$				1	3		0.062		−1.21	E	*interp.*
38.	$2s3p-2s3d$	$^3P° - ^3D$				9	15		0.033		−0.53	E	*interp.*
39.		$^1P° - ^1D$				3	5		0.058		−0.76	E	*interp.*

[a]The number in parentheses following the tabulated value indicates the power of ten by which this value has to be multiplied.

Ti XIX

Forbidden Transitions

Transition probabilities for magnetic dipole and electric quadrupole transitions within the $2s2p$ and $2p^2$ configurations and for lines of the $2s^2$–$2p^2$ transition array, as well as for magnetic quadrupole transitions of the arrays $2s^2$–$2s2p$ and $2s2p$–$2p^2$, were calculated by Glass[1] using relativistic intermediate-coupling wavefunctions. He makes extensive allowance for configuration interaction and has achieved better than 1% agreement between calculated and experimental transition energies.

Of his results for electric quadrupole transitions, we have tabulated data for only the strongest lines. The calculated A-values for the M2 transitions and for the remaining E2 transitions are extremely small, and are therefore not listed.

Reference

[1]R. Glass, Z. Phys. A **320**, 545 (1985).

Ti XIX: Forbidden transitions

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	Type of transition	A_{ki} (s^{-1})	S (at. u.)	Accuracy	Source
1.	$2s^2$–$2p^2$	^1S – ^3P										
			[120.13]	0	832410	1	5	E2	480	3.6(−5)[a]	E	1
			[124.24]	0	804890	1	3	M1	2200	4.7(−4)	E	1
2.	$2s2p$–$2s2p$	$^3P^o$ – $^3P^o$										
			2344.6	304600	347240	3	5	M1	1040	2.49	C+	1
			[6092.2]	288190	304600	1	3	M1	78.1	1.96	C+	1
3.		$^3P^o$ – $^1P^o$										
			[412.45]	347240	589692	5	3	M1	2900	0.023	D−	1
			[350.76]	304600	589692	3	3	M1	2800	0.013	D−	1
			"	"	"	3	3	E2	9.9	9.4(−5)	E	1
			[331.67]	288190	589692	1	3	M1	4500	0.018	D−	1
4.	$2p^2$–$2p^2$	^3P – ^3P										
			[3632.7]	804890	832410	3	5	M1	277	2.46	C	1
			[3437.8]	775810	804890	1	3	M1	419	1.89	C	1
5.		^3P – ^1D										
			[1174.1]	832410	917580	5	5	M1	2500	0.72	D+	1
			[887.4]	804890	917580	3	5	M1	2100	0.27	D	1
6.		^3P – ^1S										
			[334.14]	804890	1104170	3	1	M1	3.8(+4)	0.053	D	1

[a]The number in parentheses following the tabulated value indicates the power of ten by which this value has to be multiplied.

Ti XX

Li Isoelectronic Sequence

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

Ionization Energy: 1425.4 eV = 11497000 cm^{-1}

Allowed Transitions

List of tabulated lines

Wavelength (Å)	No.	Wavelength (Å)	No.	Wavelength (Å)	No.	Wavelength (Å)	No.
2.621	4	9.591	23	11.958	15	24.2	27
2.629	1	9.733	9,21	15.211	6	24.8	35
2.6295	3	9.788	21	15.253	6	24.9	35
2.631	1	10.046	19	15.907	13	25.1	44
2.6319	2	10.109	19	16.049	13	26.2	26
2.632	3	10.278	8	16.067	13	26.870	33
2.6355	2	10.620	17	22.9	28	27.000	33
9.246	11	10.690	17	23.5	37	27.001	33
9.434	10	11.452	7	23.6	37	27.3	42
9.534	23	11.872	15	23.8	46	27.4	42

List of tabulated lines — Continued

Wavelength (Å)	No.	Wavelength (Å)	No.	Wavelength (Å)	No.	Wavelength (Å)	No.
30.614	25	45.650	29	48.3	65	99.197	52
31.411	31	45.996	29	53.2	56	99.246	52
31.586	31	46.030	29	53.8	56	101.8	59
31.591	31	47.123	38	54.1	63	101.9	59
32.056	40	47.270	38	64.691	54	259.30	5
32.124	40	47.8	58	64.700	54	309.15	5
44.070	24	48.1	58	65.8	61		

Transition probabilities for the strongest inner-shell transitions to doubly excited $n = 2$ states are taken from the multiconfiguration Dirac-Fock (MCDF) calculations of Hata and Grant.[1] Their results are in good agreement with the Z-expansion perturbation calculations of Vainshtein and Šafronova,[2] who included relativistic corrections at the level of the Pauli approximation.

Oscillator strengths for lines of the principal ($2s$–$2p$) resonance multiplet are the results of the MCDF calculations of Cheng *et al.*,[3] which include a perturbative treatment of the Breit interaction and the Lamb shift. The results of the MCDF calculations of Armstrong *et al.*[4] were interpolated to provide f-values for the $2p$–$3d$ transitions.

The f-value for the $3d$–$4f$ transition was taken from a study of systematic trends along isoelectronic sequences by Smith and Wiese.[5] The tabulated data for many additional transitions were taken from the theoretical analysis of Martin and Wiese,[6] which was based on a generalized study of systematic trends for several spectral series of the lithium isoelectronic sequence.

Results of the relativistic Hartree-Fock calculations of Kim and Desclaux[7] for several ions of the Li sequence were incorporated into the data of Ref. 6 for the $2s$–$3p$ transitions. For all other transitions for which the results of Ref. 6 are quoted here, no relativistic calculations were available. However, the relativistic calculations of Younger and Weiss[8] for the hydrogen isoelectronic sequence provide a means of assessing the magnitude of relativistic corrections since the Li sequence is very similar in structure to the H sequence. For those transitions for which relativistic effects were estimated to be significant (specifically, whenever the ratio of the weighted relativistic hydrogenic f-values $g_i f_{ik}$ of any two lines within a multiplet was found to deviate from the corresponding LS-coupling linestrength ratio by more than 5% for the appropriate value of the nuclear charge Z), the f-values were excluded from the compilation. A more detailed discussion of this comparison is given in Ref. 6.

Although the $2p$–$3s$ multiplet did not satisfy the criterion described in the paragraph above, we have nevertheless quoted the multiplet f-value obtained by Onello[9] using a Z-expansion technique based on a variational calculation for O VI that allowed for large-scale configuration interaction. The resulting multiplet oscillator strengths for Fe XXIV and Ni XXVI are in very good agreement with data derived from the results of calculations that included relativistic effects.[10,11] We thus felt that the results of Ref. 9 should be sufficiently accurate for inclusion in this compilation.

Biemont[12] has calculated f-values in the single-configuration Hartree-Fock approximation for numerous multiplets. His results have been used here to supplement the data taken from the above mentioned sources. Only transitions in which the principal quantum number of the lower state is less than 5 have been tabulated here.

Transition probability data are available for numerous transitions involving doubly excited states with the spectator electron occupying the $n = 3$ shell, or higher.[13,14] These have not been tabulated, however, since they belong to, or are very close to belonging to, the unresolved satellites of the helium-like ion.

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Ti xx: Allowed transitions

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} ($10^8\ s^{-1}$)	f_{ik}	S (at. u.)	log gf	Accuracy	Source
1.	$1s^22s-1s(^2S)2s2p(^3P^\circ)$	$^2S - {}^2P^\circ$	*2.628*			2	6	2.4(+5)[a]	0.075	0.0013	−0.82	D	1
			[2.629]			2	4	4.9(+4)	0.010	1.8(−4)	−1.69	D	1
			[2.631]			2	2	6.1(+5)	0.063	0.0011	−0.90	C	1
2.	$1s^22p-1s2p^2$	$^2P^\circ - {}^2D$											
			2.6355	385650	38329000	4	6	1.2(+6)	0.19	0.0065	−0.13	C	1
			2.6319	323470	38318000	2	4	1.5(+6)	0.31	0.0054	−0.21	C	1
3.		$^2P^\circ - {}^2P$											
			2.6295	385650	38416000	4	4	3.2(+6)	0.33	0.011	0.12	C	1
			[2.632]			2	2	2.7(+6)	0.28	0.0048	−0.25	C	1
4.		$^2P^\circ - {}^2S$											
			[8.621]			4	2	1.1(+6)	0.61	0.070	0.39	C	1
5.	$2s-2p$	$^2S - {}^2P^\circ$	*274.03*	0	*364920*	2	6	21.3	0.0721	0.130	−0.841	B+	3
			259.30	0	385650	2	4	25.2	0.0509	0.0869	−0.992	B+	3
			309.15	0	323470	2	2	14.8	0.0212	0.0432	−1.373	B+	3
6.	$2s-3p$	$^2S - {}^2P^\circ$	*15.225*	0	*6568200*	2	6	3.53(+4)	0.368	0.0369	−0.133	B	6
			15.211	0	6574200	2	4	3.50(+4)	0.243	0.0243	−0.313	B	6
			15.253	0	6556100	2	2	3.58(+4)	0.125	0.0126	−0.602	B	6
7.	$2s-4p$	$^2S - {}^2P^\circ$	11.452	0	8732100	2	6	1.7(+4)	0.099	0.0075	−0.70	C+	6
8.	$2s-5p$	$^2S - {}^2P^\circ$	10.278	0	9729500	2	6	8400	0.040	0.0027	−1.10	C+	6
9.	$2s-6p$	$^2S - {}^2P^\circ$	9.733	0	10270000	2	6	4950	0.0211	0.00135	−1.375	C+	6
10.	$2s-7p$	$^2S - {}^2P^\circ$	9.434	0	10600000	2	6	3100	0.0124	7.70(−4)	−1.606	C+	6
11.	$2s-8p$	$^2S - {}^2P^\circ$	9.246	0	10820000	2	6	2000	0.0077	4.7(−4)	−1.81	D	12
12.	$2p-3s$	$^2P^\circ - {}^2S$	*16.399*	*364920*	6463000	6	2	1.3(+4)	0.018	0.0058	−0.97	D	9
13.	$2p-3d$	$^2P^\circ - {}^2D$	*16.002*	*364920*	*6614000*	6	10	1.05(+5)	0.674	0.213	0.607	B	*interp.*
			16.049	385650	6616600	4	6	1.05(+5)	0.610	0.129	0.387	B	*interp.*
			15.907	323470	6610000	2	4	8.84(+4)	0.671	0.0703	0.128	B	*interp.*
			16.067	385650	6610000	4	4	1.8(+4)	0.068	0.014	−0.57	B	*interp.*
14.	$2p-4s$	$^2P^\circ - {}^2S$				6	2		0.0037		−1.65	D+	6
15.	$2p-4d$	$^2P^\circ - {}^2D$	*11.929*	*364920*	*8747700*	6	10	3.4(+4)	0.12	0.028	−0.14	B	6
			11.958	385650	8748300	4	6	3.4(+4)	0.11	0.017	−0.36	B	*ls*
			11.872	323470	8746700	2	4	2.8(+4)	0.12	0.0093	−0.62	B	*ls*
			11.958	385650	8746700	4	4	5600	0.012	0.0019	−1.32	C+	*ls*
16.	$2p-5s$	$^2P^\circ - {}^2S$				6	2		0.0017		−1.99	D+	6
17.	$2p-5d$	$^2P^\circ - {}^2D$	*10.667*	*364920*	*9740000*	6	10	1.59(+4)	0.0451	0.00950	−0.568	C+	6
			10.690	385650	9740200	4	6	1.58(+4)	0.0405	0.00570	−0.791	C+	*ls*
			10.620	323470	9739700	2	4	1.34(+4)	0.0453	0.00317	−1.043	C+	*ls*
			10.690	385650	9739700	4	4	2600	0.0045	6.3(−4)	−1.75	D	*ls*

Ti xx: Allowed transitions — Continued

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} ($10^8 s^{-1}$)	f_{ik}	S (at. u.)	log *gf*	Accuracy	Source
18.	$2p$–$6s$	$^2P^\circ$ - ^2S				6	2		8.5(−4)		−2.29	D	6
19.	$2p$–$6d$	$^2P^\circ$ - ^2D	*10.088*	*364920*	*10277800*	6	10	8650	0.0220	0.00438	−0.879	C+	6
			10.109	385650	10277900	4	6	8600	0.0198	0.00263	−1.102	C+	*ls*
			10.046	323470	10277700	2	4	7290	0.0221	0.00146	−1.355	C+	*ls*
			10.109	385650	10277700	4	4	1400	0.0022	2.9(−4)	−2.06	D	*ls*
20.	$2p$–$7s$	$^2P^\circ$ - ^2S				6	2		4.9(−4)		−2.53	D	6
21.	$2p$–$7d$	$^2P^\circ$ - ^2D	*9.766*	*364920*	*10600000*	6	10	5290	0.0126	0.00243	−1.121	C+	6
			9.788	385650	10610000	4	6	5260	0.0113	0.00146	−1.344	C+	*ls*
			9.733	323470	10590000	2	4	4450	0.0126	8.10(−4)	−1.597	C+	*ls*
			9.788	385650	10590000	4	4	860	0.0012	1.6(−4)	−2.30	D	*ls*
22.	$2p$–$8s$	$^2P^\circ$ - ^2S				6	2		2.8(−4)		−2.77	D	12
23.	$2p$–$8d$	$^2P^\circ$ - ^2D	*9.560*	*364920*	*10820000*	6	10	3500	0.0079	0.0015	−1.32	D	12
			9.591	385650	10820000	4	6	3400	0.0071	9.0(−4)	−1.55	D	*ls*
			9.534	323470	10810000	2	4	2900	0.0080	5.0(−4)	−1.80	D	*ls*
			9.591	385650	10810000	4	4	570	7.9(−4)	1.0(−4)	−2.50	E	*ls*
24.	$3s$–$4p$	^2S - $^2P^\circ$	[44.070]	6463000	8732100	2	6	4800	0.42	0.12	−0.08	C	6
25.	$3s$–$5p$	^2S - $^2P^\circ$	[30.614]	6463000	9729500	2	6	2540	0.107	0.0216	−0.67	C	6
26.	$3s$–$6p$	^2S - $^2P^\circ$	[26.2]	6463000	10270000	2	6	1500	0.047	0.0081	−1.03	C	6
27.	$3s$–$7p$	^2S - $^2P^\circ$	[24.2]	6463000	10600000	2	6	940	0.0248	0.00395	−1.305	C	6
28.	$3s$–$8p$	^2S - $^2P^\circ$	[22.9]	6463000	10820000	2	6	650	0.0154	0.00232	−1.51	C	12
29.	$3p$–$4d$	$^2P^\circ$ - ^2D	*45.882*	*6568200*	*8747700*	6	10	1.1(+4)	0.59	0.53	0.55	B	6
			[45.996]	6574200	8748300	4	6	1.1(+4)	0.53	0.32	0.32	B	*ls*
			[45.650]	6556100	8746700	2	4	9600	0.60	0.18	0.08	B	*ls*
			[46.030]	6574200	8746700	4	4	1800	0.058	0.035	−0.64	C+	*ls*
30.	$3p$–$5s$	$^2P^\circ$ - ^2S				6	2		0.0090		−1.27	D+	6
31.	$3p$–$5d$	$^2P^\circ$ - ^2D	*31.528*	*6568200*	*9740000*	6	10	5520	0.137	0.0853	−0.085	C+	6
			[31.586]	6574200	9740200	4	6	5490	0.123	0.0512	−0.308	C+	*ls*
			[31.411]	6556100	9739700	2	4	4640	0.137	0.0284	−0.561	C+	*ls*
			[31.591]	6574200	9739700	4	4	920	0.014	0.0057	−1.26	D	*ls*
32.	$3p$–$6s$	$^2P^\circ$ - ^2S				6	2		0.0038		−1.64	C−	6
33.	$3p$–$6d$	$^2P^\circ$ - ^2D	*26.957*	*6568200*	*10277800*	6	10	3070	0.0557	0.0297	−0.476	C+	6
			[27.000]	6574200	10277900	4	6	3050	0.0501	0.0178	−0.698	C+	*ls*
			[26.870]	6556100	10277700	2	4	2580	0.0560	0.00990	−0.951	C+	*ls*
			[27.001]	6574200	10277700	4	4	510	0.0056	0.0020	−1.65	D	*ls*
34.	$3p$–$7s$	$^2P^\circ$ - ^2S				6	2		0.0019		−1.94	C−	6

Ti XX: Allowed transitions — Continued

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} (10^8 s^{-1})	f_{ik}	S (at. u.)	log gf	Accuracy	Source
35.	$3p$–$7d$	$^2P^\circ$ - ^2D	*24.8*	*6568200*	*10600000*	6	10	1880	0.0289	0.0142	−0.761	C+	6
			[24.8]	6574200	10610000	4	6	1890	0.0261	0.00852	−0.981	C+	*ls*
			[24.8]	6556100	10590000	2	4	1570	0.0290	0.00473	−1.237	C+	*ls*
			[24.9]	6574200	10590000	4	4	310	0.0029	9.5(−4)	−1.94	D	*ls*
36.	$3p$–$8s$	$^2P^\circ$ - ^2S				6	2		0.0011		−2.18	D	12
37.	$3p$–$8d$	$^2P^\circ$ - ^2D	*23.5*	*6568200*	*10820000*	6	10	1250	0.0173	0.0080	−0.98	C	12
			[23.5]	6574200	10820000	4	6	1200	0.016	0.0048	−1.21	C	*ls*
			[23.5]	6556100	10810000	2	4	1100	0.017	0.0027	−1.46	C	*ls*
			[23.6]	6574200	10810000	4	4	200	0.0017	5.3(−4)	−2.17	D	*ls*
38.	$3d$–$4p$	^2D - $^2P^\circ$	*47.212*	*6614000*	8732100	10	6	620	0.0125	0.0194	−0.90	C	12
			[47.270]	6616600	8732100	6	4	560	0.0124	0.0116	−1.128	C	*ls*
			[47.123]	6610000	8732100	4	2	630	0.010	0.0065	−1.38	C	*ls*
			[47.123]	6610000	8732100	4	4	63	0.0021	0.0013	−2.08	D	*ls*
39.	$3d$–$4f$	^2D - $^2F^\circ$				10	14		1.00		1.000	B	5
40.	$3d$–$5p$	^2D - $^2P^\circ$	*32.098*	*6614000*	9729500	10	6	270	0.0025	0.0026	−1.60	D	12
			[32.124]	6616600	9729500	6	4	240	0.0025	0.0016	−1.82	D	*ls*
			[32.056]	6610000	9729500	4	2	270	0.0021	8.7(−4)	−2.08	D	*ls*
			[32.056]	6610000	9729500	4	4	26	4.0(−4)	1.7(−4)	−2.79	E	*ls*
41.	$3d$–$5f$	^2D - $^2F^\circ$				10	14		0.157		0.196	C	12
42.	$3d$–$6p$	^2D - $^2P^\circ$	*27.3*	*6614000*	10270000	10	6	140	9.4(−4)	8.4(−4)	−2.03	D	12
			[27.4]	6616600	10270000	6	4	120	9.2(−4)	5.0(−4)	−2.26	D	*ls*
			[27.3]	6610000	10270000	4	2	140	7.8(−4)	2.8(−4)	−2.51	D	*ls*
			[27.3]	6610000	10270000	4	4	14	1.6(−4)	5.6(−5)	−3.21	E	*ls*
43.	$3d$–$6f$	^2D - $^2F^\circ$				10	14		0.054		−0.27	C	12
44.	$3d$–$7p$	^2D - $^2P^\circ$	[25.1]	*6614000*	10600000	10	6	83	4.7(−4)	3.9(−4)	−2.33	D	12
45.	$3d$–$7f$	^2D - $^2F^\circ$				10	14		0.0256		−0.59	C	12
46.	$3d$–$8p$	^2D - $^2P^\circ$	[23.8]	*6614000*	10820000	10	6	53	2.7(−4)	2.1(−4)	−2.57	D	12
47.	$3d$–$8f$	^2D - $^2F^\circ$				10	14		0.0144		−0.84	C	12
48.	$4s$–$5p$	^2S - $^2P^\circ$				2	6		0.467		−0.030	C	6
49.	$4s$–$6p$	^2S - $^2P^\circ$				2	6		0.127		−0.60	C	6
50.	$4s$–$7p$	^2S - $^2P^\circ$				2	6		0.055		−0.96	C	6
51.	$4s$–$8p$	^2S - $^2P^\circ$				2	6		0.0296		−1.228	C	12
52.	$4p$–$5d$	$^2P^\circ$ - ^2D	*99.216*	8732100	*9740000*	6	10	2360	0.581	1.14	0.542	C+	6
			[99.197]	8732100	9740200	4	6	2370	0.524	0.684	0.321	C+	*ls*
			[99.246]	8732100	9739700	2	4	1970	0.582	0.380	0.066	C+	*ls*
			[99.246]	8732100	9739700	4	4	390	0.058	0.076	−0.63	D	*ls*
53.	$4p$–$6s$	$^2P^\circ$ - ^2S				6	2		0.0147		−1.055	C−	6

Ti xx: Allowed transitions — Continued

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} ($10^8 s^{-1}$)	f_{ik}	S (at. u.)	log gf	Accuracy	Source
54.	4p-6d	$^2P^\circ - ^2D$	*64.696*	8732100	*10277800*	6	10	1350	0.141	0.180	−0.073	C+	6
			[64.691]	8732100	10277900	4	6	1350	0.127	0.108	−0.295	C+	*ls*
			[64.700]	8732100	10277700	2	4	1120	0.141	0.0600	−0.550	C+	*ls*
			[64.700]	8732100	10277700	4	4	220	0.014	0.012	−1.25	D	*ls*
55.	4p-7s	$^2P^\circ - ^2S$				6	2		0.0060		−1.44	C−	6
56.	4p-7d	$^2P^\circ - ^2D$	*53.5*	8732100	*10600000*	6	10	860	0.0615	0.0650	−0.433	C+	6
			[53.2]	8732100	10610000	4	6	875	0.0557	0.0390	−0.652	C+	*ls*
			[53.8]	8732100	10590000	2	4	706	0.0613	0.0217	−0.912	C+	*ls*
			[53.8]	8732100	10590000	4	4	140	0.0061	0.0043	−1.61	D	*ls*
57.	4p-8s	$^2P^\circ - ^2S$				6	2		0.0032		−1.72	D	12
58.	4p-8d	$^2P^\circ - ^2D$	*47.8*	8732100	*10820000*	6	10	580	0.0330	0.0312	−0.70	C	12
			[47.8]	8732100	10820000	4	6	580	0.0297	0.0187	−0.93	C	*ls*
			[48.1]	8732100	10810000	2	4	473	0.0328	0.0104	−1.183	C	*ls*
			[48.1]	8732100	10810000	4	4	96	0.0033	0.0021	−1.88	D	*ls*
59.	4d-5p	$^2D - ^2P^\circ$	*101.9*	*8747700*	9729500	10	6	334	0.0312	0.105	−0.51	C	12
			[101.9]	8748300	9729500	6	4	300	0.031	0.063	−0.73	C	*ls*
			[101.8]	8746700	9729500	4	2	336	0.0261	0.0350	−0.98	C	*ls*
			[101.8]	8746700	9729500	4	4	34	0.0052	0.0070	−1.68	D	*ls*
60.	4d-5f	$^2D - ^2F^\circ$				10	14		0.889		0.949	B	12
61.	4d-6p	$^2D - ^2P^\circ$	[65.8]	*8747700*	10270000	10	6	170	0.0065	0.014	−1.19	D	12
62.	4d-6f	$^2D - ^2F^\circ$				10	14		0.186		0.270	C	12
63.	4d-7p	$^2D - ^2P^\circ$	[54.1]	*8747700*	10600000	10	6	95	0.0025	0.0045	−1.60	D	12
64.	4d-7f	$^2D - ^2F^\circ$				10	14		0.072		−0.14	C	12
65.	4d-8p	$^2D - ^2P^\circ$	[48.3]	*8747700*	10820000	10	6	62	0.0013	0.0021	−1.89	D	12
66.	4d-8f	$^2D - ^2F^\circ$				10	14		0.0366		−0.437	C	12
67.	4f-5d	$^2F^\circ - ^2D$				14	10		0.0089		−0.90	D	12
68.	4f-6d	$^2F^\circ - ^2D$				14	10		0.0016		−1.65	D	12

[a]The number in parentheses following the tabulated value indicates the power of ten by which this value has to be multiplied.

Ti xx

Forbidden Transitions

The single magnetic dipole transition within the $1s^22p$ configuration has the line strength of 1.33 in the absence of relativistic effects in the wavefunctions.[1] It is estimated that these effects are negligible, since comprehensive relativistic calculations by Cheng *et al.*[2] for the analogous transition in the $1s^22s^22p$ configuration of the boron sequence show that such relativistic corrections are negligible until much more highly charged ions.

The listed transition probability data are also expected to be quite accurate since the energy levels are derived from experimental data.

An electric quadrupole transition at the same wavelength is estimated to be of negligible strength, as calculated by Bhatia[3] for this transition in the case of Mn XXIII. (He obtains a ratio of about 10^{-3} for the ratio of E2 to M1 line strengths).

References

[1]W. L. Wiese, M. W. Smith, and B. M. Miles, "Atomic Transition Probabilities", Vol. II, NSRDS-NBS 22, U.S. Govt. Print. Office, Washington, DC 1969.

[2]K. T. Cheng, Y.-K. Kim, and J. P. Desclaux, At. Data Nucl. Data Tables **24**, 111 (1979).

[3]A. K. Bhatia, private communication (1986).

Ti XX: Forbidden transitions

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	Type of transition	A_{ki} (s^{-1})	S (at. u.)	Accu-racy	Source
1.	$2p$–$2p$	$^2P^\circ$ – $^2P^\circ$										
			[1609.11]	323549	385695	2	4	M1	2150	1.33	B	*interp.*

Ti XXI

He Isoelectronic Sequence

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

Ionization Energy: 6249.0 eV = 50401000 cm^{-1}

Allowed Transitions

List of tabulated lines

Wavelength (Å)	No.	Wavelength (Å)	No.	Wavelength (Å)	No.	Wavelength (Å)	No.
2.0633	17	2.513	7,10	10.866	31	42.876	45
2.0637	16	2.514	7	11.059	32	88.984	55
2.1108	15	2.520	9	14.198	21	89.904	56
2.1117	14	2.527	5	14.520	22	91.836	58
2.2211	13	2.539	6	14.736	27	92.678	59
2.2237	12	2.6102	2	15.019	28	260.3	19
2.497	11	2.6227	1	28.243	41	390.5	18
2.505	4,8	9.4982	25	28.599	42	495.8	18
2.507	3	9.6791	26	28.791	48	523.0	18
2.508	7	9.6947	35	29.126	49	566.3	20
2.510	7	9.8584	36	40.982	39		
2.511	3	10.607	23	41.558	40		
2.512	3,7	10.821	24	42.351	44		

Oscillator strengths for transitions of the $1s^2$–$1s2p$ array are taken from the results of Drake,[1] who incorporated accurate nonrelativistic matrix elements and Dirac hydrogenic matrix elements into a Z-expansion technique in order to provide f-values which would accurately reflect correlation effects for low-Z ions and relativistic effects for high-Z ions of the helium isoelectronic sequence. The f-values for the $1s^2\ ^1S$ – $1snp\ ^3P^\circ$ ($n = 3$–5) transitions were interpolated from results of the relativistic random phase approximation (RRPA) calculations of Johnson and Lin.[2] Data for other s–p and p–s transitions were interpolated from the RRPA results of Lin *et al.*,[3] with the exception of the $2s$–$2p$ transitions, where we tabulate the actual published RRPA A-values of these same authors.[4]

The charge expansion results of Laughlin[5] are given for various p–d and d–p transitions, as well as transitions between $4d$ and $4f$ levels. For those multiplets involving no change in principal quantum number ($3p$–$3d$, $4p$–$4d$, $4d$–$4f$) the f-values should be considered rather uncertain, since they are sensitive to energy differences. Oscillator strengths for the $2p$–$3d$ transitions, and for $1s3p\ ^3P^\circ$ – $1s3d\ ^3D$, were interpolated from the variational calculations of Weiss.[6] Both of these calculations indicate that, unlike the triplets, the nd ^{1}D energy levels ($n = 3,4$) lie below the np ^{1}P° levels, and the $4f$ ^{1}F° lies below the $4d$ ^{1}D.

Brown and Cortez[7] have provided f-values for numerous d–f and f–d transitions for the isoelectronic sequence by fitting Z-expansion formulas to the results of variational calculations for the low-Z ions. Their results for transitions between the lower-lying D and F° terms are tabulated here.

Transition probabilities for the stronger transitions involving the doubly excited $n = 2$ states are taken from the papers by Bitter *et al.*,[8] which reports theoretical results from both the Z-expansion method and SUPERSTRUCTURE, and Vainshtein and Safronova,[9] which is based on the Z-expansion method. These sets of data agree well for the stronger transitions, and we report here the average of the two when both are available. Numerous data are also available for transitions involving doubly excited states where the spectator electron has principal quantum number $n = 3$ or higher.[8,10] However, these data are not tabulated here since most of the transitions are very close to belonging to the unresolved satellites of the H-like ions, if they do not in fact do so.

References

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[3] C. D. Lin, W. R. Johnson, and A. Dalgarno, Astrophys. J. **217**, 1011 (1977).
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[8] M. Bitter, S. von Goeler, S. Cohen, K. W. Hill, S. Sesnic, F. Tenney, J. Timberlake, U. I. Safronova, L. A. Vainshtein, J. Dubau, M. Loulergue, F. Bely-Dubau, and L. Steenman-Clark, Phys. Rev. A **29**, 661 (1984).
[9] L. A. Vainshtein and U. I. Safronova, At. Data Nucl. Data Tables **21**, 49 (1978).
[10] L. A. Vainshtein and U. I. Safronova, At. Data Nucl. Data Tables **25**, 311 (1980).

Ti XXI: Allowed transitions

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} (10^8 s^{-1})	f_{ik}	S (at. u.)	log gf	Accuracy	Source
1.	$1s^2$–$1s2p$	^{1}S – ^{3}P°											
			[2.6227]	0	[38129200]	1	3	1.12(+5)[a]	0.0346	2.99(−4)	−1.461	B	1
2.		^{1}S – ^{1}P°	[2.6102]	0	[38311600]	1	3	2.40(+6)	0.735	0.00632	−0.134	B	1
3.	$1s2s$–$2s2p$	^{3}S – ^{3}P°	*2.509*	[37927500]	[*77790000*]	3	9	1.4(+6)	0.40	0.0098	0.07	C	8,9
			[2.507]	[37927500]	[77820000]	3	5	1.4(+6)	0.22	0.0054	−0.18	C	8,9
			[2.511]	[37927500]	[77750000]	3	3	1.4(+6)	0.13	0.0033	−0.40	C	8,9
			[2.512]	[37927500]	[77740000]	3	1	1.4(+6)	0.044	0.0011	−0.88	C	8,9
4.		^{1}S – ^{1}P°	[2.505]	[38135000]	[78060000]	1	3	1.4(+6)	0.40	0.0033	−0.40	C	8,9
5.	$1s2p$–$2s^2$	^{3}P° – ^{1}S											
			[2.527]	[38129200]	[77700000]	3	1	1.2(+5)	0.0038	9.6(−5)	−1.94	D	8,9
6.		^{1}P° – ^{1}S	[2.539]	[38311600]	[77700000]	3	1	4.1(+5)	0.013	3.3(−4)	−1.40	D	8,9
7.	$1s2p$–$2p^2$	^{3}P° – ^{3}P	*2.511*	[*38158300*]	[*77980000*]	9	9	2.7(+6)	0.26	0.019	0.36	D+	8,9
			[2.512]	[38183600]	[78000000]	5	5	1.8(+6)	0.17	0.0070	−0.07	C	8,9
			[2.510]	[38129200]	[77970000]	3	3	6.9(+5)	0.065	0.0016	−0.71	D	9
			[2.514]	[38183600]	[77970000]	5	3	1.2(+6)	0.068	0.0028	−0.47	C	9
			[2.513]	[38129200]	[77920000]	3	1	2.7(+6)	0.085	0.0021	−0.59	C	8,9
			[2.508]	[38129200]	[78000000]	3	5	7.9(+5)	0.12	0.0031	−0.43	D	8,9
			[2.510]	[38118700]	[77970000]	1	3	9.6(+5)	0.27	0.0022	−0.57	D	9
8.		^{3}P° – ^{1}D											
			[2.505]	[38183600]	[78100000]	5	5	3.5(+5)	0.033	0.0014	−0.78	D	8,9
9.		^{1}P° – ^{3}P											
			[2.520]	[38311600]	[78000000]	3	5	2.6(+5)	0.041	0.0010	−0.91	D	8,9

Ti XXI: Allowed transitions — Continued

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} (10^8 s^{-1})	f_{ik}	S (at. u.)	log gf	Accuracy	Source
10.		$^1P^\circ - {}^1D$	[2.513]	[38311600]	[78100000]	3	5	2.4(+6)	0.38	0.0094	0.06	C	8,9
11.		$^1P^\circ - {}^1S$	[2.497]	[38311600]	[78360000]	3	1	2.4(+6)	0.075	0.0018	−0.65	C	8,9
12.	$1s^2$–$1s3p$	$^1S - {}^3P^\circ$											
			[2.2237]	0	[44970800]	1	3	3.8(+4)	0.0084	6.1(−5)	−2.08	E	*interp.*
13.		$^1S - {}^1P^\circ$	[2.2211]	0	[45021900]	1	3	6.35(+5)	0.141	0.00103	−0.851	C+	*interp.*
14.	$1s^2$–$1s4p$	$^1S - {}^3P^\circ$											
			[2.1117]	0	[47355200]	1	3	1.5(+4)	0.0031	2.2(−5)	−2.51	E	*interp.*
15.		$^1S - {}^1P^\circ$	[2.1108]	0	[47376200]	1	3	2.60(+5)	0.0522	3.63(−4)	−1.282	C+	*interp.*
16.	$1s^2$–$1s5p$	$^1S - {}^3P^\circ$											
			[2.0637]	0	[48455800]	1	3	8400	0.0016	1.1(−5)	−2.80	E	*interp.*
17.		$^1S - {}^1P^\circ$	[2.0633]	0	[48466500]	1	3	1.32(+5)	0.0252	1.71(−4)	−1.599	C+	*interp.*
18.	$1s2s$–$1s2p$	$^3S - {}^3P^\circ$	*433.3*	[37927500]	*[38158300]*	3	9	5.09	0.0430	0.184	−0.889	B	4
			[390.5]	[37927500]	[38183600]	3	5	7.07	0.0269	0.104	−1.093	B	4
			[495.8]	[37927500]	[38129200]	3	3	3.31	0.0122	0.0597	−1.437	B	4
			[523.0]	[37927500]	[38118700]	3	1	2.93	0.00401	0.0207	−1.920	B	4
19.		$^3S - {}^1P^\circ$											
			[260.3]	[37927500]	[38311600]	3	3	1.02	0.00104	0.00266	−2.507	B	4
20.		$^1S - {}^1P^\circ$	[566.3]	[38135000]	[38311600]	1	3	2.28	0.0329	0.0613	−1.483	B	4
21.	$1s2s$–$1s3p$	$^3S - {}^3P^\circ$											
			[14.198]	[37927500]	[44970800]	3	3	4.10(+4)	0.124	0.0174	−0.429	C	*interp.*
22.		$^1S - {}^1P^\circ$	[14.520]	[38135000]	[45021900]	1	3	3.93(+4)	0.373	0.0178	−0.428	C	*interp.*
23.	$1s2s$–$1s4p$	$^3S - {}^3P^\circ$											
			[10.607]	[37927500]	[47355200]	3	3	1.8(+4)	0.030	0.0031	−1.05	C+	*interp.*
24.		$^1S - {}^1P^\circ$	[10.821]	[38135000]	[47376200]	1	3	1.7(+4)	0.090	0.0032	−1.05	C+	*interp.*
25.	$1s2s$–$1s5p$	$^3S - {}^3P^\circ$											
			[9.4982]	[37927500]	[48455800]	3	3	8900	0.012	0.0011	−1.44	C+	*interp.*
26.		$^1S - {}^1P^\circ$	[9.6791]	[38135000]	[48466500]	1	3	8800	0.037	0.0012	−1.43	C+	*interp.*
27.	$1s2p$–$1s3s$	$^3P^\circ - {}^3S$											
			[14.736]	[38129200]	[44915100]	3	3	4600	0.015	0.0022	−1.35	C−	*interp.*
28.		$^1P^\circ - {}^1S$	[15.019]	[38311600]	[44969900]	3	1	1.3(+4)	0.015	0.0022	−1.35	C+	*interp.*
29.	$1s2p$–$1s3d$	$^3P^\circ - {}^3D$				9	15		0.68		0.79	C+	*interp.*
30.		$^1P^\circ - {}^1D$				3	5		0.70		0.32	C+	*interp.*

Ti XXI: Allowed transitions — Continued

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} (10^8 s^{-1})	f_{ik}	S (at. u.)	log gf	Accuracy	Source
31.	$1s2p-1s4s$	$^3P^\circ - {}^3S$											
			[10.866]	[38129200]	[47332000]	3	3	1800	0.0032	3.4(−4)	−2.02	D	*interp.*
32.		$^1P^\circ - {}^1S$	[11.059]	[38311600]	[47354200]	3	1	5200	0.0032	3.5(−4)	−2.02	C	*interp.*
33.	$1s2p-1s4d$	$^3P^\circ - {}^3D$				9	15		0.12		0.03	C	5
34.		$^1P^\circ - {}^1D$				3	5		0.12		−0.44	C	5
35.	$1s2p-1s5s$	$^3P^\circ - {}^3S$											
			[9.6947]	[38129200]	[48444100]	3	3	920	0.0013	1.2(−4)	−2.41	D	*interp.*
36.		$^1P^\circ - {}^1S$	[9.8584]	[38311600]	[48455200]	3	1	2700	0.0013	1.3(−4)	−2.41	C	*interp.*
37.	$1s3s-1s3p$	$^3S - {}^3P^\circ$											
						3	3		0.019		−1.24	E	*interp.*
38.		$^1S - {}^1P^\circ$				1	3		0.058		−1.24	D	*interp.*
39.	$1s3s-1s4p$	$^3S - {}^3P^\circ$											
			[40.982]	[44915100]	[47355200]	3	3	5400	0.137	0.055	−0.386	C	*interp.*
40.		$^1S - {}^1P^\circ$	[41.558]	[44969900]	[47376200]	1	3	5300	0.410	0.056	−0.387	C	*interp.*
41.	$1s3s-1s5p$	$^3S - {}^3P^\circ$											
			[28.243]	[44915100]	[48455800]	3	3	2900	0.035	0.0098	−0.98	C	*interp.*
42.		$^1S - {}^1P^\circ$	[28.599]	[44969900]	[48466500]	1	3	2880	0.106	0.0100	−0.975	C+	*interp.*
43.	$1s3p-1s3d$	$^3P^\circ - {}^3D$				9	15		0.013		−0.93	D	*interp.*
44.	$1s3p-1s4s$	$^3P^\circ - {}^3S$											
			[42.351]	[44970800]	[47332000]	3	3	1300	0.034	0.014	−0.99	C−	*interp.*
45.		$^1P^\circ - {}^1S$	[42.876]	[45021900]	[47354200]	3	1	3800	0.035	0.015	−0.98	C	*interp.*
46.	$1s3p-1s4d$	$^3P^\circ - {}^3D$				9	15		0.60		0.73	C	5
47.		$^1P^\circ - {}^1D$				3	5		0.62		0.27	C	5
48.	$1s3p-1s5s$	$^3P^\circ - {}^3S$											
			[28.791]	[44970800]	[48444100]	3	3	620	0.0077	0.0022	−1.64	D	*interp.*
49.		$^1P^\circ - {}^1S$	[29.126]	[45021900]	[48455200]	3	1	1800	0.0077	0.0022	−1.64	C	*interp.*
50.	$1s3d-1s3p$	$^1D - {}^1P^\circ$				5	3		0.0024		−1.92	E	5
51.	$1s3d-1s4p$	$^3D - {}^3P^\circ$				15	9		0.012		−0.74	C	5
52.		$^1D - {}^1P^\circ$				5	3		0.011		−1.26	C	5
53.	$1s4s-1s4p$	$^3S - {}^3P^\circ$											
						3	3		0.027		−1.09	E	*interp.*

Ti XXI: Allowed transitions — Continued

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	A_{ki} ($10^8 s^{-1}$)	f_{ik}	S (at. u.)	log gf	Accu-racy	Source
54.		$^1S - {}^1P^\circ$				1	3		0.081		−1.09	E	*interp.*
55.	$1s4s-1s5p$	$^3S - {}^3P^\circ$											
			[88.984]	[47332000]	[48455800]	3	3	1280	0.152	0.134	−0.341	C	*interp.*
56.		$^1S - {}^1P^\circ$	[89.904]	[47354200]	[48466500]	1	3	1300	0.46	0.14	−0.34	D	*interp.*
57.	$1s4p-1s4d$	$^3P^\circ - {}^3D$				9	15		0.023		−0.68	D	5
58.	$1s4p-1s5s$	$^3P^\circ - {}^3S$											
			[91.836]	[47355200]	[48444100]	3	3	440	0.056	0.051	−0.77	D	*interp.*
59.		$^1P^\circ - {}^1S$	[92.678]	[47376200]	[48455200]	3	1	1300	0.056	0.051	−0.77	C	*interp.*
60.	$1s4d-1s4p$	$^1D - {}^1P^\circ$				5	3		0.0037		−1.73	E	5
61.	$1s4d-1s4f$	$^3D - {}^3F^\circ$				15	21		9.3(−4)		−1.86	E	5
62.	$1s4d-1s5f$	$^3D - {}^3F^\circ$				15	21		0.89		1.13	B	7
63.		$^1D - {}^1F^\circ$				5	7		0.89		0.65	B	7
64.	$1s4f-1s4d$	$^1F^\circ - {}^1D$				7	5		4.9(−4)		−2.46	E	5
65.	$1s4f-1s5d$	$^3F^\circ - {}^3D$				21	15		0.0089		−0.73	C	7
66.		$^1F^\circ - {}^1D$				7	5		0.0089		−1.21	C	7
67.	$1s5s-1s5p$	$^3S - {}^3P^\circ$											
						3	3		0.034		−0.99	E	*interp.*
68.		$^1S - {}^1P^\circ$				1	3		0.10		−1.00	E	*interp.*

[a] The number in parentheses following the tabulated value indicates the power of ten by which this value has to be multiplied.

Ti XXI

Forbidden Transitions

The results of multiconfiguration Dirac-Fock calculations by Hata and Grant[1] have been selected for this tabulation. Their work includes both a very detailed consideration of configuration interaction—with configurational wavefunction sets containing as many as 51 interacting states—as well as a fully relativistic treatment based on the Dirac Hamiltonian. Their calculated wavelengths are in very close agreement with experiment, and the agreement between the experimental lifetime data[2-4] and the theoretical result is excellent, with differences not exceeding five percent. A comprehensive comparison table containing all experimental data[2-6] on these He-like ions of Fe-group elements is given in Table 1 and demonstrates the excellent agreement between experimental and theoretical data throughout.

The probabilities of the M1 transitions $1s^2\ {}^1S_0 - 1s3s\ {}^3S_1$ and $1s^2\ {}^1S_0 - 1s4s\ {}^3S_1$ have been calculated by Kundu and Mukherjee[7] with a nonrelativistic time-dependent coupled Hartree-Fock approximation. Since they agree, for the $1s^2\ {}^1S_0 - 1s2s\ {}^3S_1$ M1 line, within 14% with the result of Hata and Grant[1], an accuracy estimate of ± 25% appears to be reasonable.

TABLE 1. Comparison of calculated[1] and observed[2-6] lifetimes (in ns) for the $2s\ ^3S_1$ state (M1 decay) and the $2p\ ^3P_2$ state (M2 + E1 decay) for several He-like ions

Ion	$2s\ ^3S_1$ state Theory	Experiment	$2p\ ^3P_2^o$ state Theory[a]	Experiment
Ti XXI	26.0	25.8±1.3[b]	0.42	0.44±0.03[c]; 0.404±0.040[d]
V XXII	16.5	16.9±0.7[e]	0.307	
Cr XXIII	10.7		0.225	0.215±0.035[d]
Fe XXV	4.72	4.8±0.6[e]	0.124	0.11±0.02[e]; 0.121±0.015[f]

[a]The lifetime for this state is the reciprocal of the sum of the transition rates $2p\ ^3P_2^o \rightarrow 1s\ ^1S_0$ (M2) and $2p\ ^3P_2^o \rightarrow 2s\ ^3S_1$ (E1), i.e., $\tau = [A(M2)+A(E1)]^{-1}$. The transition probability for the E1 transition $2s\ ^3S_1 - 2p\ ^3P_2^o$ is taken from the MCDF calculations of Hata and Grant.[8]
[a]Ref. 2.
[b]Ref. 3.
[c]Ref. 4.
[d]Ref. 5.
[e]Ref. 6.

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Ti XXI: Forbidden transitions

No.	Transition Array	Multiplet	λ (Å)	E_i (cm^{-1})	E_k (cm^{-1})	g_i	g_k	Type of transition	A_{ki} (s^{-1})	S (at. u.)	Accuracy	Source
1.	$1s^2$–$1s2s$	$^1S - ^3S$	[2.6369]	0	[37923330]	1	3	M1	3.85(+7)[a]	7.85(−5)	B	1
2.	$1s^2$–$1s2p$	$^1S - ^3P^o$										
			[2.6192]	0	[38180210]	1	5	M2	1.69(+9)	0.157	B	1
3.	$1s^2$–$1s3s$	$^1S - ^3S$	[2.2266]	0	[44911530]	1	3	M1	1.50(+7)	1.84(−5)	C	2
4.	$1s^2$–$1s4s$	$^1S - ^3S$	[2.1129]	0	[47328420]	1	3	M1	6.76(+6)	7.09(−6)	C	2

[a]The number in parentheses following the tabulated value indicates the power of ten by which this value has to be multiplied.

Ti XXII

H Isoelectronic Sequence

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

Ionization Energy: 6625.87 eV = 53440800 cm^{-1}

Allowed Transitions

Electric dipole transition probability data for this hydrogen-like ion can be obtained directly, in a non-relativistic approximation, from the data for neutral hydrogen.[1] The oscillator strength is independent of Z along the entire isoelectronic sequence and is therefore identical to the value for the hydrogen atom. Line strengths scale as Z^{-2} and transition probabilities scale as Z^4, i.e.,

$$S_Z = Z^{-2} S_H, \qquad A_Z = Z^4 A_H.$$

For higher nuclear charges in this sequence, relativistic corrections will cause these values to deviate increasingly from the non-relativistic ones. The first effect of relativity will be to alter the transition energies, or wavelengths, from the non-relativistic, even though the line strength itself is still well approximated by the non-relativistic value. In this case, experimental energies should be used in the standard conversion formulas, given in the general introduction to this volume, to calculate the most accurate values of f and A. It should be noted that the relativistic removal of the j-degeneracy introduces dipole transitions which do not occur in the non-relativistic theory, e.g., $2s_{1/2} - 2p_{3/2}$.

For very high Z, it is necessary to use the four-component Dirac spinors rather than two-component Schroedinger functions in theoretical calculations, and this introduces relativistic corrections to the line strengths themselves. Several recent systematic studies of the problem[2,3] indicate that these corrections are not large for stages of ionization in the range 20–30. Corrections for $Z = 30$ are usually no larger than 5–10% and generally substantially less than 5%. If an accuracy greater than this is required, the reader is referred to these papers[2,3] for a more detailed error analysis.

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