A UNITED STATES DEPARTMENT OF COMMERCE PUBLICATION

NSRDS—NBS 34

NATIONAL STANDARD REFERENCE DATA SYSTEM

Ionization Potentials and Ionization Limits Derived From the Analyses of Optical Spectra

U.S. DEPARTMENT OF COMMERCE
National Bu[reau of]
Stand[ards]

UNITED STATES DEPARTMENT OF COMMERCE • MAURICE H. STANS, *Secretary*
NATIONAL BUREAU OF STANDARDS • LEWIS M. BRANSCOMB, *Director*

Ionization Potentials and Ionization Limits Derived from the Analyses of Optical Spectra

Charlotte E. Moore

Office of Standard Reference Data
National Bureau of Standards
Washington, D.C. 20234

NSRDS-NBS 34

Nat. Stand. Ref. Data Ser., Nat. Bur. Stand. (U.S.), 34, 22 pages (Sept. 1970)
CODEN: NSRDA

Issued September 1970

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C., 20402 (Order by SD Catalog No. C 13.48:34) - Price 75 cents

Library of Congress Catalog Card Number: 76–607107

FOREWORD

The National Standard Reference Data System provides effective access to the quantitative data of physical science, critically evaluated and compiled for convenience, and readily accessible through a variety of distribution channels. The System was established in 1963 by action of the President's Office of Science and Technology and the Federal Council for Science and Technology, with responsibility to administer it assigned to the National Bureau of Standards.

The System now comprises a complex of data centers and other activities, carried on in academic institutions and other laboratories both in and out of government. The independent operational status of existing critical data projects is maintained and encouraged. Data centers that are components of the NSRDS produce compilations of critically evaluated data, critical reviews of the state of quantitative knowledge in specialized areas, and computations of useful functions derived from standard reference data. In addition, the centers and projects establish criteria for evaluation and compilation of data and make recommendations on needed improvements in experimental techniques. They are normally closely associated with active research in the relevant field.

The technical scope of the NSRDS is indicated by the principal categories of data compilation projects now active or being planned: nuclear properties, atomic and molecular properties, solid state properties, thermodynamic and transport properties, chemical kinetics, and colloid and surface properties.

The NSRDS receives advice and planning assistance from the National Research Council of the National Academy of Sciences-National Academy of Engineering. An overall Review Committee considers the program as a whole and makes recommendations on policy, long-term planning, and international collaboration. Advisory Panels, each concerned with a single technical area, meet regularly to examine major portions of the program, assign relative priorities, and identify specific key problems in need of further attention. For selected specific topics, the Advisory Panels sponsor subpanels which make detailed studies of users' needs, the present state of knowledge, and existing data resources as a basis for recommending one or more data compilation activities. This assembly of advisory services contributes greatly to the guidance of NSRDS activities.

The NSRDS–NBS series of publications is intended primarily to include evaluated reference data and critical reviews of long-term interest to the scientific and technical community.

LEWIS M. BRANSCOMB, *Director*

Contents

Ionization Potentials and Ionization Limits Derived from the Analyses of Optical Spectra

Charlotte E. Moore

A current table of ionization potentials expressed in electron volts and a detailed table giving the limits from which they have been derived are presented. For each spectrum the ground term is given, with the limit as the ground state. The energy levels of terms of the lowest configuration determined from ground state zero, are also included for selected spectra. The literature references used for each spectrum are indicated by number and listed in a bibliography with some 200 entries.

The latest recommended conversion factor (cm^{-1} to eV) 0.000123981 corresponding to 1 eV= 8065.73 cm^{-1} has been used throughout.

Key words: Atomic spectra, ground terms; ground terms, atomic spectra; ionization limits; ionization potentials.

The data in the Volumes on "Atomic Energy Levels" (AEL) [135], [136], [137], include the ionization limits known for individual spectra. The latest table of ionization potentials calculated from these limits was published as Table 34 in Volume III (1958). Much work has been done since then and there has been a steady demand for a revision of this Table.

A fairly comprehensive general bibliography has recently been published [194] which lists for each spectrum the literature references on analyses of atomic spectra dating from the entries in the respective Volume of "AEL" (1949), (1952), (1958), well into 1968. The present compendium is based largely on the references in this Bibliography, with some, but probably not all, later material.

The reliability of the data recorded in the literature is often difficult to appraise. In cases where long series are known in the various spectra, the ionization potentials are well determined. With these as key points, good values can be derived by extrapolation or interpolation along isoelectronic sequences, or by comparison along the rows in the Periodic Chart for spectra of similar stages of ionization. Frequently, however, authors give values of ionization potentials without stating the conversion factor used and without describing clearly how the quoted value was obtained.

For this reason, the present paper includes not only the ionization potentials in eV, but also, the limits in cm^{-1} from which these have been derived. Table 1 gives the ionization potentials in eV for each spectrum.

The conversion factor taken from [195] was used for Table 1, since it is the value currently recommended by the National Academy of Sciences-National Research Council. However, recent measurements [200] suggest that this value may be in error by about 30 parts per million. Therefore, it should be understood that all of the significant figures included in Table 1 may not be meaningful in an absolute sense. This applies particularly to entries with magnitudes greater than 100 eV.

All limits have been multiplied by the factor 0.000123981 to obtain the entries in Table 1, i.e., 1 eV=8065.73 cm^{-1}. The factor used in "AEL" was 0.00012395 and has been superseded. As a result, in the present table there are systematic differences from the 1958 Table, caused by the change in the conversion factor, as well as the differences caused by improved values of the limits.

Italics denote ionization potentials derived from limits that are bracketed in Table 2.

In compiling Table 1 the author has attempted to indicate roughly the various degrees of accuracy of the limits. Those based on well-established series deserve the greatest weight. When the ionization potential is given to three places, it is felt that the third place is meaningful. The two- and one-place entries are less well defined, but it is hoped that they have some significance. The limits of error assigned by the various investigators provide a general criterion, but these are given for comparatively few spectra. Users should, therefore, consult the limits given in Table 2 and the references in order to evaluate the data for individual spectra.

Table 2 contains the basic data for each spectrum. As in Table 1, the successive stages of ionization are indicated at the heading of each column: I, denoting first spectra (neutral atoms); II, second spectra (singly ionized atoms), etc. The elements are arranged in order of increasing atomic number, Z. The ground state is indicated for each spectrum, together with the ionization limit in cm^{-1}. In every case this limit refers to the ground state of the ion in the next higher stage of ionization. The limits of error are quoted from the original authors. Although not specifically defined, these afford a general guide as to the reliability of the limit.

Although all limits are based on data derived from the analyses of optical spectra, they are determined in various ways, since reliable series are

TABLE I. *Ionization potentials**

Z	Element	Spectrum I	II	III	IV	V	VI	VII	VIII	IX	X
1	H	13.598									
2	He	24.587	54.416								
3	Li	5.392	75.638	122.451							
4	Be	9.322	18.211	153.893	217.713						
5	B	8.298	25.154	37.930	259.368	340.217					
6	C	11.260	24.383	47.887	64.492	392.077	489.981				
7	N	14.534	29.601	47.448	77.472	97.888	552.057	667.029			
8	O	13.618	35.116	54.934	77.412	113.896	138.116	739.315	871.387		
9	F	17.422	34.970	62.707	87.138	114.240	157.161	185.182	953.886	1103.089	
10	Ne	21.564	40.962	63.45	97.11	126.21	157.93	207.27	239.09	1195.797	1362.164
11	Na	5.139	47.286	71.64	98.91	138.39	172.15	208.47	264.18	299.87	1465.091
12	Mg	7.646	15.035	80.143	109.24	141.26	186.50	224.94	265.90	327.95	367.53
13	Al	5.986	18.828	28.447	119.99	153.71	190.47	241.43	284.59	330.21	398.57
14	Si	8.151	16.345	33.492	45.141	166.77	205.05	246.52	303.17	351.10	401.43
15	P	10.486	19.725	30.18	51.37	65.023	220.43	263.22	309.41	371.73	424.50
16	S	10.360	23.33	34.83	47.30	*72.68*	88.049	280.93	328.23	379.10	447.09
17	Cl	12.967	23.81	39.61	53.46	67.8	*97.03*	114.193	348.28	400.05	455.62
18	Ar	15.759	27.629	40.74	59.81	75.02	91.007	124.319	143.456	422.44	478.68
19	K	4.341	31.625	45.72	60.91	*82.66*	*100.0*	117.56	154.86	175.814	503.44
20	Ca	6.113	11.871	50.908	67.10	84.41	*108.78*	127.7	147.24	188.54	211.270
21	Sc	6.54	12.80	24.76	73.47	91.66	111.1	*138.0*	158.7	180.02	225.32
22	Ti	6.82	13.58	27.491	43.266	99.22	119.36	140.8	168.5	*193.2*	215.91
23	V	6.74	14.65	29.310	46.707	*65.23*	128.12	150.17	173.7	*205.8*	*230.5*
24	Cr	6.766	16.50	30.96	*49.1*	*69.3*	90.56	161.1	*184.7*	*209.3*	*244.4*
25	Mn	7.435	15.640	33.667	*51.2*	*72.4*	*95*	119.27	*196.46*	*221.8*	*243.3*
26	Fe	7.870	16.18	30.651	*54.8*	*75.0*	*99*	*125*	151.06	235.04	262.1
27	Co	7.86	17.06	33.50	*51.3*	*79.5*	*102*	*129*	*157*	186.13	276
28	Ni	7.635	18.168	35.17	*54.9*	*75.5*	*108*	*133*	*162*	*193*	224.5
29	Cu	7.726	20.292	36.83	55.2	*79.9*	*103*	*139*	*166*	*199*	*232*
30	Zn	9.394	17.964	39.722	*59.4*	*82.6*	*108*	*134*	*174*	*203*	*238*
31	Ga	5.999	20.51	30.71	64						
32	Ge	7.899	15.934	34.22	45.71	93.5					
33	As	9.81	18.633	28.351	50.13	62.63	127.6				
34	Se	9.752	21.19	30.820	42.944	*68.3*	81.70	155.4			
35	Br	11.814	21.8	36	*47.3*	*59.7*	*88.6*	*103.0*	192.8		
36	Kr	13.999	24.359	36.95	*52.5*	*64.7*	*78.5*	*111.0*	*126*	230.9	
37	Rb	4.177	27.28	40	*52.6*	*71.0*	*84.4*	*99.2*	*136*	*150*	277.1
38	Sr	5.695	11.030	*43.6*	57	*71.6*	*90.8*	*106*	*122.3*	*162*	*177*
39	Y	6.38	12.24	20.52	*61.8*	*77.0*	*93.0*	*116*	*129*	*146.2*	*191*
40	Zr	6.84	13.13	22.99	34.34	81.5					
41	Nb	6.88	14.32	25.04	38.3	50.55	102.6	125			
42	Mo	7.099	16.15	27.16	46.4	61.2	68	126.8	153		

TABLE I. *Ionization potentials** — Continued

Spectrum — Continued											Z
XI	XII	XIII	XIV	XV	XVI	XVII	XVIII	XIX	XX	XXI	
											1
											2
											3
											4
											5
											6
											7
											8
											9
											10
1648.659											11
1761.802	1962.613										12
442.07	2085.983	2304.080									13
476.06	523.50	2437.676	2673.108								14
479.57	560.41	611.85	2816.943	3069.762							15
504.78	564.65	651.63	707.14	3223.836	3494.099						16
529.26	591.97	656.69	749.74	809.39	3658.425	3946.193					17
538.95	618.24	686.09	755.73	854.75	*918*	4120.778	4426.114				18
564.13	629.09	714.02	787.13	861.77	*968*	*1034*	4610.955	4933.931			19
591.25	656.39	726.03	816.61	895.12	*974*	*1087*	*1157*	5129.045	5469.738		20
249.832	685.89	755.47	829.79	926.00							21
265.23	291.497	787.33	861.33	940.36							22
255.04	308.25	336.267	895.58	974.02							23
270.8	*298.0*	355	384.30	1010.64							24
286.0	*314.4*	*343.6*	404	435.3	1136.2						25
290.4	*330.8*	*361.0*	*392.2*	457	489.5	1266.1					26
305	*336*	*379*	*411*	*444*	512	546.8	1403.0				27
321.2	*352*	*384*	*430*	*464*	*499*	*571*	607.2	1547			28
266	*368.8*	*401*	*435*	*484*	*520*	*557*	*633*	671	1698		29
274	*310.8*	*419.7*	*454*	*490*	*542*	*579*	*619*	*698*	738	1856	30
											31
											32
											33
											34
											35
											36
											37
324.1											38
206	374.0										39
											40
											41
											42

TABLE I. *Ionization potentials** — Continued

Z	Element	Spectrum I	II	III	IV	V	VI	VII	VIII	IX	X
43	Tc	7.28	15.26	29.54							
44	Ru	7.37	16.76	28.47							
45	Rh	7.46	18.08	31.06							
46	Pd	8.34	19.43	32.93							
47	Ag	7.576	21.49	34.83							
48	Cd	8.993	16.908	37.48							
49	In	5.786	18.869	28.03	54						
50	Sn	7.344	14.632	30.502	40.734	72.28					
51	Sb	8.641	16.53	25.3	44.2	56	108				
52	Te	9.009	18.6	27.96	37.41	58.75	70.7	137			
53	I	10.451	19.131	33							
54	Xe	12.130	21.21	32.1							
55	Cs	3.894	25.1								
56	Ba	5.212	10.004								
57	La	5.577	11.06	19.175							
58	Ce	5.47	10.85	20.20	36.72						
59	Pr	5.42	10.55	21.62	38.95	57.45					
60	Nd	5.49	10.72								
61	Pm	5.55	10.90								
62	Sm	5.63	11.07								
63	Eu	5.67	11.25								
64	Gd	6.14	12.1								
65	Tb	5.85	11.52								
66	Dy	5.93	11.67								
67	Ho	6.02	11.80								
68	Er	6.10	11.93								
69	Tm	6.18	12.05	23.71							
70	Yb	6.254	12.17	25.2							
71	Lu	5.426	13.9								
72	Hf	7.0	14.9	23.3	33.3						
73	Ta	7.89									
74	W	7.98									
75	Re	7.88									
76	Os	8.7									
77	Ir	9.1									
78	Pt	9.0	18.563								
79	Au	9.225	20.5								
80	Hg	10.437	18.756	34.2							
81	Tl	6.108	20.428	29.83							
82	Pb	7.416	15.032	31.937	42.32	68.8					
83	Bi	7.289	16.69	25.56	45.3	56.0	88.3				

TABLE I. *Ionization potentials** — Continued

Z	Element	Spectrum I	II	III	IV	V	
84	Po	8.42					
86	At						
86	Rn	10.748					
87	Fr						
88	Ra	5.279	10.147				
89	Ac	6.9	12.1				
90	Th		11.5	20.0	28.8		
91	Pa						
92	U						
93	Np						
94	Pu	5.8					
95	Am	6.0					

*1cm^{-1}=0.000123981 eV.

known for only a limited number of spectra. For the H I and He I isoelectronic sequences, the theoretical values quoted here are well determined. Edlén, [44], [45], [46], [47], has made a detailed study of formulae for extrapolating ionization limits along sequences of the lighter elements. His values are extensively quoted in Table 2.

Catalán and his associates, [22 to 27], have interpolated values for spectra of neighboring elements in the same stage of ionization. These have been used for spectra in which series are not known. Russell, [166], Sugar and Reader, [156], [181] and others, have described similar general relationships between spectra, that can be used to derive fairly reliable limits.

In Table 2 all ionization limits were recorded that were derived from observed series, from extrapolation or interpolation as described above (Edlén, Catalán, etc.), or from theoretical calculations such as those of the H I and He I series. When all available data from these sources had been entered, if gaps still remained for spectra of a given element in successive stages of ionization, the intervening limits were entered in brackets, as for Ti VIII and Ti IX. These limits, in brackets, represent calculated values interpolated or extrapolated from observed data, and reported in two general tables of ionization potentials in which different methods have been used. For scattered spectra of the elements S V through Zn XIX, the table of Lotz, [116], has been quoted. For larger atomic numbers, the entries in brackets are from the table of Finkelnburg and Humbach, [65]. No attempt has been made, however, to quote *all* such calculated values.

The need for higher ionization limits within a given spectrum increases as laboratory research on absorption series in the vacuum ultraviolet, on series produced with synchrotron radiation as a source, and the like, advances. At the request of workers in these fields, all components of the ground term, and in selected cases, all levels from the ground configuration, are entered in Table 2. All levels above the ground state are relative to the ground state zero. For example, in the format of "AEL," the lowest levels of O I are as follows:

Desig.	AEL	Table 2
$2p^4\ {}^3P_2$	0.000	109837.02 = Limit
${}^3P_1$	158.265	158.265
${}^3P_0$	226.977	226.977
${}^1D_2$	15867.862	15867.862
${}^1S_0$	33792.583	33792.583

In compiling Table 2, the energy levels of *only* the ground term have been included for complex spectra, particularly with increasing *Z*. It is well known that in rare-earth spectra low configurations and low terms overlap in many cases. Consequently, many more low energy levels may be known than those of the ground term. Users are urged to recognize this limitation of the Table and to consult the literature references for further details concerning the low levels that have been reported for individual spectra.

As in "AEL" estimated values of energy levels are given in brackets. Similarly, "*x*" denotes that the energy level is not connected by observation with the others.

In Table 2, under the term designations for each spectrum, the numbers in italics at the lower left, refer to Table 3. This table is a Bibliography which contains the literature references used for each spectrum to obtain the limits and terms quoted in Table 2.

The importance of stating, clearly, how a limit or an ionization potential has been derived cannot be overemphasized. It is hoped that the present tables will enable each user to judge the quality of the available data used to compile Table 1.

Although the foregoing results are limited to optical spectra, it should be recognized that experimental values of ionization energies have, also, been published. A surface ionization method has been used to obtain ionization potentials for first spectra of rare earths, [196 to 198]. In general, the agreement is satisfactory between the values obtained by the different methods.

Estimates of ionization potentials of third spectra of the lanthanons have been calculated recently "by applying the Born-Haber cycle to the group 3A oxides and arsenides." [199].

After the work on the present publication had been started, the author learned that extensive revisions of the data on the spectra of lighter elements were being prepared by B. Edlén, J. O. Ekberg, and L. Å. Svensson, in Lund. They have most generously furnished much valuable material, in advance of publication, for inclusion here. The author is deeply indebted to these colleagues whose expert judgment and advice greatly enhance the value of the present publication. She is equally grateful to all others who have so willingly contributed their unpublished material.

Washington, D.C.
April 22, 1970

Table 3. Bibliography

References

1. Albertson, W., Astroph. J. **84,** No. 1, 26–72 (1936).
2. Albertson, W., Phys. Rev. **52,** 644–647 (1937).
3. Alexander, E., Feldman, U., and Fraenkel, B. S., J. Opt. Soc. Am. **55,** No. 6, 650–653 (1965).
4. Alexander, E., Feldman, U., Fraenkel, B. S., and Hoory, S., J. Opt. Soc. Am. **56,** No. 5, 651–652 (1966).
5. Andersson, E., and Johannesson, G. A., unpublished material (1969).
6. Andrew, K. L., and Meissner, K. W., J. Opt. Soc. Am. **49,** No. 2, 146–161 (1959).
7. Bauche, J., Blaise, J., and Fred, M., J. Opt. Soc. Am. **54,** No. 4, 565 (A) (1964).
8. Blaise, J., Fred, M., Gerstenkorn, S., and Judd, B. R., Compt. Rend. **255,** 2403–2405 (1962).
9. Bockasten, K., Ark. Fys. (Stockholm) **10,** No. 40, 567–582 (1956).
10. Bockasten, K., unpublished material (1963).
11. Bockasten, K., J. Opt. Soc. Am. **54,** No. 8, 1065 (L) (1964).
12. Bockasten, K., unpublished material (1969), based on unpublished data communicated by Wu, C. M., and Crooker, A. M.
13. Bockasten, K., and Edlén, B., private communication (1970).
14. Bockasten, K., Hallin, R., and Hughes, T. P., Proc. Phys. Soc. (London) **81,** Part 3, No. 521, 522–530 (1963).
15. Bockasten, K., and Johansson, K. B., Ark. Fys. (Stockholm) **38,** No. 31, 563–584 (1968).
16. Börgström, A., Ark. Fys. (Stockholm) **38,** No. 12, 243–260 (1968).
17. Bowen, I. S., Astroph. J. **121,** No. 2, 306–311 (1955); **132,** No. 1, 1–17 (1960).
18. Bromander, J., unpublished material (Uppsala 1969), from data by Glad, S.; See Ark. Fys. (Stockholm) **7,** No. 2, 7 to 32 (1954).
19. Bromander, J., and Johansson, B., J. Opt. Soc. Am. **57,** No. 9, 1158–1159 (L) (1967).
20. Bryant, B. W., J. Opt. Soc. Am. **55,** No. 7, 771–779 (1965), with revision by J. Sugar (1970).

20a. Camus, P. et Tomkins, F. S., J. de Phys. **30,** No. 7, 545–550 (1969).

20b. Camus, P. et Tomkins, F. S., Première Réunion Ann. de l'Assoc. Européenne de Spectroscopie Atomique, Abstract 67, Paris-Orsay (1969).

21. Catalán, M. A., Meggers, W. F., and Garcia-Riquelme, O., J. Res. Nat. Bur. Stand. (U.S.), **68A** (Phys. and Chem.) No. 1, 9–59 (Jan.-Feb. 1964).
22. Catalán, M. A. y Rico, F. R., An. Real Soc. Esp. Fis. y Quim. (Madrid) [A] **48,** Nos. 11, 12, 328–338 (1952).
23. Catalán, M. A. y Rico, F., letter (Dec. 1956).
24. Catalán, M. A. y Rico, F., An. Real Soc. Esp. Fis. y Quim. (Madrid) [A] **53,** Nos. 3. 4, 85–94 (1957).
25. Catalán, M. A. y Rico, F. R., An. Real Soc. Esp. Fis. y Quim. (Madrid) [A] **54,** Nos. 9, 10, 289–300 (1958).
26. Catalán, M. A. y Rico, F., An. Real Soc. Esp. Fis. y Quim. (Madrid) [A] **54,** Nos. 9, 10, 301–308 (1958).
27. Catalán, M. A. y Velasco, R., An. Real Soc. Esp. Fis. y Ouim. (Madrid) [A] **48,** Nos. 9, 10, 247–266 (1952).
28. Chaghtai, M. S.-U.-Z., J. Opt. Soc. Am. **59,** No. 8, 969–970 (1969).
29. Charles, G. W., J. Opt. Soc. Am. **56,** No. 10, 1292–1297 (1966).
30. Cohen, L., Feldman, U., and Kastner, S. O., J. Opt. Soc. Am. **58,** No. 3, 331–334 (1968).
31. Conway, J. G., and Worden, E. F., J. Opt. Soc. Am. **58,** No. 11, 1564 (A) (1968).
32. Cowan, R. D., Astroph. J. **147,** No. 1, 377–379 (L) (1967).
33. Cowan, R. D., J. Opt. Soc. Am. **58,** No. 7, 924–933 (1968), and Edlén, B., unpublished material (1970).
34. Cowan, R. D., and Peacock, N. J., Astroph. J. **142,** No. 1, 390–396 (L) (1965).
35. Crooker, A. M., private communication (December 1955).
36. Crooker, A. M., unpublished analysis (1962).
37. Crooker, A. M., and Dick, K. A., Canadian J. Phys. **46,** No. 10, 1241–1251 (1968).
38. Crooker, A. M., and Joshi, Y. N., J. Opt. Soc. Am. **54,** No. 4, 553–554 (L) (1964).
39. Deutschman, W. A., and House, L. L., Astroph. J. **144,** No. 1, 435–437 (L) (1966).
40. Deutschman, W. A., and House, L. L., Astroph. J. **149,** No. 2, Part 1, 451–452 (1967).
41. Dick, K. A., Canadian J. Phys. **46,** No. 11, 1291–1302 (1968).
42. Edlén, B., Mon. Not. Roy. Astron. Soc. **114,** No. 6, 700–703 (1954).
43. Edlén, B., Trans. Intern. Astron. Union **9,** 218–226 (1955).
44. Edlén, B., "Atomic Spectra," Hand. der Phys., Encycl. of Phys. **27,** 172 (1964).
45. Edlén, B., "Atomic Spectra," Hand. der Phys., Encycl. of Phys. **27,** 196 (1964).
46. Edlén, B., "Atomic Spectra," Hand. der Phys., Encycl. of Phys. **27,** 198 (1964).
47. Edlén, B., "Atomic Spectra," Hand. der Phys., Encycl. of Phys. **27,** 200 (1964).

TABLE 2. *Ionization limits and lowest terms*

Z	Element	Spectrum I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
1	H	$1s$ $^2S_{0\frac{1}{2}}$ 109678.764 *68*											
2	He	$1s^2$ $^1S_0$ 198310.76 ±0.01 *119, 169a*	$1s$ $^2S_{0\frac{1}{2}}$ 438908.85 *68*										
3	Li	$2s$ $^2S_{0\frac{1}{2}}$ 43487.150 ±0.005 *90*	$1s^2$ $^1S_0$ 610079.0 ±0.1 *49, 81, 145*	$1s$ $^2S_{0\frac{1}{2}}$ 987660.1 *49, 68*									
4	Be	$2s^2$ $^1S_0$ 75192.07 *93*	$2s$ $^2S_{0\frac{1}{2}}$ 146882.86 *92*	$1s^2$ $^1S_0$ 1241259.4 *145*	$1s$ $^2S_{0\frac{1}{2}}$ 1756018.7 *68*								
5	B	$2p$ $^2P^\circ_{0\frac{1}{2}}$ 66928.10 ±0.1 $^2P^\circ_{1\frac{1}{2}}$ 15.254 *48, 142*	$2s^2$ $^1S_0$ 202887.4 ±0.8 *141*	$2s$ $^2S_{0\frac{1}{2}}$ 305931.1 ±0.6 *140*	$1s^2$ $^1S_0$ 2092001.4 *49, 145*	$1s$ $^2S_{0\frac{1}{2}}$ 2744105.1 *49, 68*							
6	C	$2p^2$ $^3P_0$ 90820.42 ±0.1 $^3P_1$ 16.40 $^3P_2$ 43.40 $^1D_2$ 10192.63 $^1S_0$ 21648.01 *94*	$2p$ $^2P^\circ_{0\frac{1}{2}}$ 196664.7 $^2P^\circ_{1\frac{1}{2}}$ 63.42 *18, 48*	$2s^2$ $^1S_0$ 386241.0 ±2 *13, 141*	$2s$ $^2S_{0\frac{1}{2}}$ 520178.4 ±1.5 *9, 49, 140*	$1s^2$ $^1S_0$ 3162395 *49* ±30	$1s$ $^2S_{0\frac{1}{2}}$ 3952061.4 *49, 68*						
7	N	$2p^3$ $^4S^\circ_{1\frac{1}{2}}$ 117225.4 $^2D^\circ_{2\frac{1}{2}}$ 19224.464 $^2D^\circ_{1\frac{1}{2}}$ 19233.177 $^2P^\circ_{0\frac{1}{2}}$ 28838.920 $^2P^\circ_{1\frac{1}{2}}$ 28839.306 *55, 123*	$2p^2$ $^3P_0$ 238750.5 ±1.3 $^3P_1$ 48.7 $^3P_2$ 130.8 $^1D_2$ 15316.2 $^1S_0$ 32688.8 *53*	$2p$ $^2P^\circ_{0\frac{1}{2}}$ 382704 $^2P^\circ_{1\frac{1}{2}}$ 174.36 *48, 53, 78*	$2s^2$ $^1S_0$ 624866 ±3 *77, 141*	$2s$ $^2S_{0\frac{1}{2}}$ 789537.2 ±3.0 *76*	$1s^2$ $^1S_0$ 4452758 *49, 145*	$1s$ $^2S_{0\frac{1}{2}}$ 5380089 *68*					
8	O	$2p^4$ $^3P_2$ 109837.02 ±0.06 $^3P_1$ 158.265 $^3P_0$ 226.977 $^1D_2$ 15867.862 $^1S_0$ 33792.583 *17, 54, 57*	$2p^3$ $^4S^\circ_{1\frac{1}{2}}$ 283240 $^2D^\circ_{2\frac{1}{2}}$ 26810.7 $^2D^\circ_{1\frac{1}{2}}$ 26830.5 $^2P^\circ_{1\frac{1}{2}}$ 40466.9 $^2P^\circ_{0\frac{1}{2}}$ 40468.4 *17, 46, 135*	$2p^2$ $^3P_0$ 443086 $^3P_1$ 113.9 $^3P_2$ 306.9 $^1D_2$ 20274 $^1S_0$ 43186 *10, 17*	$2p$ $^2P^\circ_{0\frac{1}{2}}$ 624383.8 ±2.0 $^2P^\circ_{1\frac{1}{2}}$ 385.9 *19, 48*	$2s^2$ $^1S_0$ 918657 ±4 *15*	$2s$ $^2S_{0\frac{1}{2}}$ 1114008 *14, 49* ±10	$1s^2$ $^1S_0$ 5963135 *145*	$1s$ $^2S_{0\frac{1}{2}}$ 7028393 *68*				
9	F	$2p^5$ $^2P^\circ_{1\frac{1}{2}}$ 140524.5 ±0.4 $^2P^\circ_{0\frac{1}{2}}$ 404.1 *48, 115*	$2p^4$ $^3P_2$ 282058.6 ±1.5 $^3P_1$ 341.0 $^3P_0$ 489.9 $^1D_2$ 20873.4 $^1S_0$ 44918.1 *143*	$2p^3$ $^4S^\circ_{1\frac{1}{2}}$ 505777 ±5 $^2D^\circ_{2\frac{1}{2}}$ 34084 $^2D^\circ_{1\frac{1}{2}}$ 34120 $^2P^\circ_{1\frac{1}{2}}$, $^2P^\circ_{0\frac{1}{2}}$ } 51558 *135, 144*	$2p^2$ $^3P_0$ 702830 $^3P_1$ 225.2 $^3P_2$ 612.2 $^1D_2$ 25234.4 $^1S_0$ 53537 *17, 46, 135*	$2p$ $^2P^\circ_{0\frac{1}{2}}$ 921430 $^2P^\circ_{1\frac{1}{2}}$ 744.5 *46, 48*	$2s^2$ $^1S_0$ 1267622 *49*	$2s$ $^2S_{0\frac{1}{2}}$ 1493629 *49*	$1s^2$ $^1S_0$ 7693810 *145*	$1s$ $^2S_{0\frac{1}{2}}$ 8897240 *68*			
10	Ne	$2p^6$ $^1S_0$ 173929.70 *133*	$2p^5$ $^2P^\circ_{1\frac{1}{2}}$ 330391.0 $^2P^\circ_{0\frac{1}{2}}$ 780.45 *48, 146*	$2p^4$ $^3P_2$ 511800 $^3P_1$ 642.9 $^3P_0$ 920.4 $^1D_2$ 25840.8 $^1S_0$ 55750 *17, 46, 146*	$2p^3$ $^4S^\circ_{1\frac{1}{2}}$ 783300 $^2D^\circ_{2\frac{1}{2}}$ [41217] $^2D^\circ_{1\frac{1}{2}}$ 41262 $^2P^\circ_{0\frac{1}{2}}$ 62417 $^2P^\circ_{1\frac{1}{2}}$ 62423 *17, 46*	$2p^2$ $^3P_0$ 1018000 $^3P_1$ 414 $^3P_2$ 1112 $^1D_2$ 30293 $^1S_0$ 63899 *17, 46*	$2p$ $^2P^\circ_{0\frac{1}{2}}$ 1273800 $^2P^\circ_{1\frac{1}{2}}$ 1310 *14, 46, 48*	$2s^2$ $^1S_0$ 1671792 *49*	$2s$ $^2S_{0\frac{1}{2}}$ 1928462 *49*	$1s^2$ $^1S_0$ 9645005 *49, 145*	$1s$ $^2S_{0\frac{1}{2}}$ 10986876 *49, 68*		
11	Na	$3s$ $^2S_{0\frac{1}{2}}$ 41449.44 ±0.03 *162*	$2p^6$ $^1S_0$ 381395 ±1 *12*	$2p^5$ $^2P^\circ_{1\frac{1}{2}}$ 577800 $^2P^\circ_{0\frac{1}{2}}$ 1366 *46, 48*	$2p^4$ $^3P_2$ 797800 $^3P_1$ 1105.5 $^3P_0$ 1576 $^1D_2$ 30839.4 $^1S_0$ 66492 *17, 44, 46, 135*	$2p^3$ $^4S^\circ_{1\frac{1}{2}}$ 1116200 $^2D^\circ_{2\frac{1}{2}}$ 48337 $^2D^\circ_{1\frac{1}{2}}$ 48362 $^2P^\circ_{0\frac{1}{2}}$ 73221 $^2P^\circ_{1\frac{1}{2}}$ 73260 *44, 46, 135*	$2p^2$ $^3P_0$ 1388500 $^3P_1$ 698 $^3P_2$ 1858 $^1D_2$ [35518] $^1S_0$ [74434] *17, 46, 135*	$2p$ $^2P^\circ_{0\frac{1}{2}}$ 1681500 $^2P^\circ_{1\frac{1}{2}}$ 2139 *46, 48*	$2s^2$ $^1S_0$ 2130800 *46*	$2s$ $^2S_{0\frac{1}{2}}$ 2418700 *46*	$1s^2$ $^1S_0$ 11817061 *129*	$1s$ $^2S_{0\frac{1}{2}}$ 13297676 *68*	

TABLE 2. *Ionization limits and lowest terms*—continued

Spectrum (I–VI)

Z	Element	I	II	III	IV	V	VI
12	Mg	$3s^2$ $^1S_0$ 61671.02 ±0.02 *159*	$3s$ $^2S_{0\frac{1}{2}}$ 121267.61 ±0.05 *161*	$2p^6$ $^1S_0$ 646410 ±20 *5*	$2p^5$ $^2P^\circ_{1\frac{1}{2}}$ 881100 $^2P^\circ_{0\frac{1}{2}}$ 2227 *46, 48*	$2p^4$ $^3P_2$ 1139400 $^3P_1$ 1780 $^3P_0$ 2519 $^1D_2$ 35890 $^1S_0$ 77254 *44, 46, 135*	$2p^3$ $^4S^\circ_{1\frac{1}{2}}$ 1504300 $^2D^\circ_{2\frac{1}{2}}$ 55245 $^2D^\circ_{1\frac{1}{2}}$ 55266 $^2P^\circ_{0\frac{1}{2}}$ 83805 $^2P^\circ_{1\frac{1}{2}}$ 83927 *44, 46, 135*
13	Al	$3p$ $^2P^\circ_{0\frac{1}{2}}$ 48278.37 ±0.02 $^2P^\circ_{1\frac{1}{2}}$ 112.061 *56*	$3s^2$ $^1S_0$ 151860.4 ±0.5 *135*	$3s$ $^2S_{0\frac{1}{2}}$ 229445.71 ±0.2 *87*	$2p^6$ $^1S_0$ 967800 *46*	$2p^5$ $^2P^\circ_{1\frac{1}{2}}$ 1239800 $^2P^\circ_{0\frac{1}{2}}$ 3442 *46, 48*	$2p^4$ $^3P_2$ 1536300 $^3P_1$ 2736 $^3P_0$ 3831 $^1D_2$ 41140 $^1S_0$ 88210 *44, 46, 135*
14	Si	$3p^2$ $^3P_0$ 65747.5 ±0.6 $^3P_1$ 77.115 $^3P_2$ 223.157 $^1D_2$ 6298.850 $^1S_0$ 15394.370 *150*	$3p$ $^2P^\circ_{0\frac{1}{2}}$ 131838.4 ±0.1 $^2P^\circ_{1\frac{1}{2}}$ 287.32 *172*	$3s^2$ $^1S_0$ 270139.3 ±0.4 *186*	$3s$ $^2S_{0\frac{1}{2}}$ 364093.1 ±0.6 *185*	$2p^6$ $^1S_0$ 1345100 *46*	$2p^5$ $^2P^\circ_{1\frac{1}{2}}$ 1653900 $^2P^\circ_{0\frac{1}{2}}$ 5097 *46, 48*
15	P	$3p^3$ $^4S^\circ_{1\frac{1}{2}}$ 84580 $^2D^\circ_{1\frac{1}{2}}$ 11360.8 $^2D^\circ_{2\frac{1}{2}}$ 11376.4 $^2P^\circ_{0\frac{1}{2}}$ 18722.65 $^2P^\circ_{1\frac{1}{2}}$ 18747.95 *118*	$3p^2$ $^3P_0$ 159100 $^3P_1$ 164.8 $^3P_2$ 469.0 $^1D_2$ 8882.6 $^1S_0$ 21576.2 *118*	$3p$ $^2P^\circ_{0\frac{1}{2}}$ 243400 $^2P^\circ_{1\frac{1}{2}}$ 559.6 *47, 135*	$3s^2$ $^1S_0$ 414312.4 *135*	$3s$ $^2S_{0\frac{1}{2}}$ 524460 *45*	$2p^6$ $^1S_0$ 1777900 *46*
16	S	$3p^4$ $^3P_2$ 83558.0 $^3P_1$ 396.09 $^3P_0$ 573.65 $^1D_2$ 9238.58 $^1S_0$ 22179.99 *88, 98*	$3p^3$ $^4S^\circ_{1\frac{1}{2}}$ 188200 $^2D^\circ_{1\frac{1}{2}}$ 14853.0 $^2D^\circ_{2\frac{1}{2}}$ 14884.8 $^2P^\circ_{0\frac{1}{2}}$ 24524.9 $^2P^\circ_{1\frac{1}{2}}$ 24571.6 *17, 47*	$3p^2$ $^3P_0$ 280900 $^3P_1$ 297.2 $^3P_2$ 832.5 $^1D_2$ 11320.8 $^1S_0$ 27159.1 *17, 47, 135*	$3p$ $^2P^\circ_{0\frac{1}{2}}$ 381541.4 $^2P^\circ_{1\frac{1}{2}}$ 950.2 *135*	$3s^2$ $^1S_0$ [586200] *116*	$3s$ $^2S_{0\frac{1}{2}}$ 710184 *45*
17	Cl	$3p^5$ $^2P^\circ_{1\frac{1}{2}}$ 104591.0 ±0.3 $^2P^\circ_{0\frac{1}{2}}$ 882.36 *151*	$3p^4$ $^3P_2$ 192070 $^3P_1$ 696.1 $^3P_0$ 996.4 $^1D_2$ 11653.5 $^1S_0$ 27877.8 *47, 98*	$3p^3$ $^4S^\circ_{1\frac{1}{2}}$ 319500 $^2D^\circ_{1\frac{1}{2}}$ 18053.0 $^2D^\circ_{2\frac{1}{2}}$ 18118.6 $^2P^\circ_{0\frac{1}{2}}$ 29812.8 $^2P^\circ_{1\frac{1}{2}}$ 29905.6 *17, 47*	$3p^2$ $^3P_0$ 431226 $^3P_1$ 491 $^3P_2$ 1341 $^1D_2$ 13767 $_1S_0$ 32547 *17, 135*	$3p$ $^2P^\circ_{0\frac{1}{2}}$ 547000 $^2P^\circ_{1\frac{1}{2}}$ 1492 *135*	$3s^2$ $^1S_0$ [782600] *116*
18	Ar	$3p^6$ $^1S_0$ 127109.9 ±0.1 *135, 191*	$3p^5$ $^2P^\circ_{1\frac{1}{2}}$ 222848.2 $^2P^\circ_{0\frac{1}{2}}$ 1431.41 *130*	$3p^4$ $^3P_2$ 328600 $^3P_1$ 1112.1 $^3P_0$ 1570.2 $^1D_2$ 14010.0 $^1S_0$ 33265.7 *17, 47, 135*	$3p^3$ $^4S^\circ_{1\frac{1}{2}}$ 482400 $^2D^\circ_{1\frac{1}{2}}$ 21090.7 $^2D^\circ_{2\frac{1}{2}}$ 21219.5 $^2P^\circ_{0\frac{1}{2}}$ 34856.2 $^2P^\circ_{1\frac{1}{2}}$ 35033.1 *17, 135*	$3p^2$ $^3P_0$ 605100 $^3P_1$ 765 $^3P_2$ 2030 $^1D_2$ 16300 $^1S_0$ 37913 *17, 135*	$3p$ $^2P^\circ_{0\frac{1}{2}}$ 734040 $^2P^\circ_{1\frac{1}{2}}$ 2208 *52*
19	K	$4s$ $^2S_{0\frac{1}{2}}$ 35009.77 ±0.02 *162*	$3p^6$ $^1S_0$ 255076 *134*	$3p^5$ $^2P^\circ_{1\frac{1}{2}}$ 368800 $^2P^\circ_{0\frac{1}{2}}$ 2166 *52, 182*	$3p^4$ $^3P_2$ 491300 $^3P_1$ 1673 $^3P_0$ 2325 $^1D_2$ 16384.0 $^1S_0$ 38546.2 *17, 135, 182*	$3p^3$ $^4S^\circ_{1\frac{1}{2}}$ [666700] $^2D^\circ_{1\frac{1}{2}}$ 24012.7 $^2D^\circ_{2\frac{1}{2}}$ 24249.5 $^2P^\circ_{0\frac{1}{2}}$ 39758 $^2P^\circ_{1\frac{1}{2}}$ 40077 *17, 116*	$3p^2$ $^3P_0$ [806600] $^3P_1$ 1132 $^3P_2$ 2924 $^1D_2$ 18978 *52, 116, 135*
20	Ca	$4s^2$ $^1S_0$ 49305.72 *160*	$4s$ $^2S_{0\frac{1}{2}}$ 95751.87 ±0.03 *50*	$3p^6$ $^1S_0$ 410614.1 *16*	$3p^5$ $^2P^\circ_{1\frac{1}{2}}$ 541200 $^2P^\circ_{0\frac{1}{2}}$ 3118.0 *16, 52*	$3p^4$ $^3P_2$ 680800 $^3P_1$ 2406 $^3P_0$ 3276 $^1D_2$ 18830.1 *17, 135, 182*	$3p^3$ $^4S^\circ_{1\frac{1}{2}}$ [877400] $^2D^\circ_{1\frac{1}{2}}$ 26851 $^2D^\circ_{2\frac{1}{2}}$ 27267 *52, 116*

Spectrum (VII–XII)

Z	Element	VII	VIII	IX	X	XI	XII
12	Mg	$2p^2$ $^3P_0$ 1814300 $^3P_1$ 1127 $^3P_2$ 2939 $^1D_2$ [41003] $^1S_0$ [85191] *17, 46, 135*	$2p$ $^2P^\circ_{0\frac{1}{2}}$ 2144700 $^2P^\circ_{1\frac{1}{2}}$ 3302.2 *46, 48*	$2s^2$ $^1S_0$ 2645200 *46*	$2s$ $^2S_{0\frac{1}{2}}$ 2964400 *46*	$1s^2$ $^1S_0$ 14210261 *129*	$1s$ $^2S_{0\frac{1}{2}}$ 15829951 *49, 68*
13	Al	$2p^3$ $^4S^\circ_{1\frac{1}{2}}$ 1947300 $^2D^\circ_{1\frac{1}{2}}$ 62080 $^2D^\circ_{2\frac{1}{2}}$ 62140 $^2P^\circ_{0\frac{1}{2}}$ 94380 $^2P^\circ_{1\frac{1}{2}}$ 94650 *44, 46, 135*	$2p^2$ $^3P_0$ 2295400 $^3P_1$ 1740 $^3P_2$ 4440 *46, 135*	$2p$ $^2P^\circ_{0\frac{1}{2}}$ 2663400 $^2P^\circ_{1\frac{1}{2}}$ 4890 *46, 48*	$2s^2$ $^1S_0$ 3214800 *46*	$2s$ $^2S_{0\frac{1}{2}}$ 3565600 *46*	$1s^2$ $^1S_0$ 16825022 *129*
14	Si	$2p^4$ $^3P_2$ 1988400 $^3P_1$ 4030 $^3P_0$ 5570 $^1D_2$ 46550 $^1S_0$ 99330 *44, 46, 135*	$2p^3$ $^4S^\circ_{1\frac{1}{2}}$ 2445300 $^2D^\circ_{1\frac{1}{2}}$ 67140+x $^2D^\circ_{2\frac{1}{2}}$ 67420+x $^2P^\circ_{0\frac{1}{2}}$ 103320+x $^2P^\circ_{1\frac{1}{2}}$ 103900+x *46, 135*	$2p^2$ $^3P_0$ 2831900 $^3P_1$ 2590 $^3P_2$ 6460 *46, 135*	$2p$ $^2P^\circ_{0\frac{1}{2}}$ 3237800 $^2P^\circ_{1\frac{1}{2}}$ 6988.7 *46, 48*	$2s^2$ $^1S_0$ 3839800 *46*	$2s$ $^2S_{0\frac{1}{2}}$ 4222400 *46*
15	P	$2p^5$ $^2P^\circ_{1\frac{1}{2}}$ 2123100 $^2P^\circ_{0\frac{1}{2}}$ 7268 *46, 48, 135*	$2p^4$ $^3P_2$ 2495600 $^3P_1$ 5757 $^3P_0$ 7826 $^1D_2$ 52450+x $^1S_0$ 110970+x *46, 135*	$2p^3$ $^4S^\circ_{1\frac{1}{2}}$ 2998300 $^2D^\circ_{1\frac{1}{2}}$ 73167 $^2D^\circ_{2\frac{1}{2}}$ 73730 $^2P^\circ_{0\frac{1}{2}}$ 113457 $^2P^\circ_{1\frac{1}{2}}$ 114430 *46, 135*	$2p^2$ $^3P_0$ 3423900 $^3P_1$ [3705] $^3P_2$ [9050] $^1D_2$ 59330 $^1S_0$ 119430 *42, 46, 135*	$2p$ $^2P^\circ_{0\frac{1}{2}}$ 3868100 $^2P^\circ_{1\frac{1}{2}}$ 9700 *46, 135*	$2s^2$ $^1S_0$ 4520100 *46*
16	S	$2p^6$ $^1S_0$ 2265900 *46*	$2p^5$ $^2P^\circ_{1\frac{1}{2}}$ 2647400 $^2P^\circ_{0\frac{1}{2}}$ 10087 *46, 48*	$2p^4$ $^3P_2$ 3057700 $^3P_1$ 7970 $^3P_0$ 10630 $^1D_2$ 58000+x $^1S_0$ 122300+x *46, 135*	$2p^3$ $^4S^\circ_{1\frac{1}{2}}$ 3606100 $^2D^\circ_{1\frac{1}{2}}$ 77670+x $^2D^\circ_{2\frac{1}{2}}$ 78800+x $^2P^\circ_{0\frac{1}{2}}$ [122230]+x $^2P^\circ_{1\frac{1}{2}}$ 124080+x *40, 46, 135*	$2p^2$ $^3P_0$ 4071400 $^3P_1$ 5200 $^3P_2$ 12400 *40, 46*	$2p$ $^2P^\circ_{0\frac{1}{2}}$ 4554300 $^2P^\circ_{1\frac{1}{2}}$ 13135.3 *46, 48*
17	Cl	$3s$ $^2S_{0\frac{1}{2}}$ 921051 *45*	$2p^6$ $^1S_0$ 2809100 *46*	$2p^5$ $^2P^\circ_{1\frac{1}{2}}$ 3226700 $^2P^\circ_{0\frac{1}{2}}$ 13641 *46, 48*	$2p^4$ $^3P_2$ 3674900 $^3P_1$ 10880 $^3P_0$ 14140 $^1D_2$ 61000+x $^1S_0$ 130310+x *39, 46, 135*	$2p^3$ $^4S^\circ_{1\frac{1}{2}}$ 4268900 $^2D^\circ_{1\frac{1}{2}}$ 91960+x $^2D^\circ_{2\frac{1}{2}}$ [94000]+x $^2P^\circ_{0\frac{1}{2}}$ 141150+x $^2P^\circ_{1\frac{1}{2}}$ 144200+x *40, 46*	$2p^2$ $^3P_0$ 4774700 $^3P_1$ 7200 $^3P_2$ 16600 *40, 46*
18	Ar	$3s^2$ $^1S_0$ 1002730 *52*	$3s$ $^2S_{0\frac{1}{2}}$ 1157080 *52*	$2p^6$ $^1S_0$ 3407300 *46*	$2p^5$ $^2P^\circ_{1\frac{1}{2}}$ 3860900 $^2P^\circ_{0\frac{1}{2}}$ 18067 *46, 48*	$2p^4$ $^3P_2$ 4347000 $^3P_1$ 14390 $^3P_0$ 18230 *39, 46*	$2p^3$ $^4S^\circ_{1\frac{1}{2}}$ 4986600 *40, 46*
19	K	$3p$ $^2P^\circ_{0\frac{1}{2}}$ 948200 $^2P^\circ_{1\frac{1}{2}}$ 3133 *52*	$3s^2$ $^1S_0$ 1249100 *52*	$3s$ $^2S_{0\frac{1}{2}}$ 1418070 *52*	$2p^6$ $^1S_0$ 4060600 *46*	$2p^5$ $^2P^\circ_{1\frac{1}{2}}$ 4550100 $^2P^\circ_{0\frac{1}{2}}$ 23475 *46, 48*	$2p^4$ $^3P_2$ 5074100 $^3P_1$ 18970 $^3P_0$ 23250 *40, 46, 59*
20	Ca	$3p^2$ $^3P_0$ 1030000 $^3P_1$ 1628 $^3P_2$ 4075 $^1D_2$ 21864 *52, 135*	$3p$ $^2P^\circ_{0\frac{1}{2}}$ 1187600 $^2P^\circ_{1\frac{1}{2}}$ 4304 *52*	$3s^2$ $^1S_0$ 1520700 *52*	$3s$ $^2S_{0\frac{1}{2}}$ 1704050 52	$2p^6$ $^1S_0$ 4768900 *46*	$2p^5$ $^2P^\circ_{1\frac{1}{2}}$ 5294300 $^2P^\circ_{0\frac{1}{2}}$ 30044 *46, 48*

Spectrum (XIII–XXI)

Z	Element	XIII	XIV	XV	XVI	XVII	XVIII	XIX	XX	XXI
12	Mg									
13	Al	$1s$ $^2S_{0\frac{1}{2}}$ 18584138 *68*								
14	Si	$1s^2$ $^1S_0$ 19661693 *129*	$1s$ $^2S_{0\frac{1}{2}}$ 21560630 *49, 68*							
15	P	$2s$ $^2S_{0\frac{1}{2}}$ 4935000 *46*	$1s^2$ $^1S_0$ 22720766 *129*	$1s$ $^2S_{0\frac{1}{2}}$ 24759942 *68*						
16	S	$2s^2$ $^1S_0$ 5255900 *46*	$2s$ $^2S_{0\frac{1}{2}}$ 5703600 *46*	$1s^2$ $^1S_0$ 26002663 *129*	$1s$ $^2S_{0\frac{1}{2}}$ 28182535 *49, 68*					
17	Cl	$2p$ $^2P^\circ_{0\frac{1}{2}}$ 5296700 $^2P^\circ_{1\frac{1}{2}}$ *46*	$2s^2$ $^1S_0$ 6047200 *46*	$2s$ $^2S_{0\frac{1}{2}}$ 6528300 *46*	$1s^2$ $^1S_0$ 29507950 *129*	$1s$ $^2S_{0\frac{1}{2}}$ 31829012 *49, 68*				
18	Ar	$2p^2$ $^3P_0$ 5533800 $^3P_1$ 9900 $^3P_2$ 21900 *40, 46*	$2p$ $^2P^\circ_{0\frac{1}{2}}$ 6095500 $^2P^\circ_{1\frac{1}{2}}$ 22657 *42, 46, 48*	$2s^2$ $^1S_0$ 6894200 *46*	$2s$ $^2S_{0\frac{1}{2}}$ [7404400] *116*	$1s^2$ $^1S_0$ 33237173 *129*	$1s$ $^2S_{0\frac{1}{2}}$ 35699936 *68*			
19	K	$2p^3$ $^4S^\circ_{1\frac{1}{2}}$ 5759100 *46*	$2p^2$ $^3P_0$ 6348800 $^3P_1$ $^3P_2$ *46*	$2p$ $^2P^\circ_{0\frac{1}{2}}$ 6950800 $^2P^\circ_{1\frac{1}{2}}$ *46*	$2s^2$ $^1S_0$ [7807600] *116*	$2s$ $^2S_{0\frac{1}{2}}$ [8340000] *116*	$1s^2$ $^1S_0$ 37190818 *129*	$1s$ $^2S_{0\frac{1}{2}}$ 39795865 *49, 68*		
20	Ca	$2p^4$ $^3P_2$ 5856000 $^3P_1$ 24460 $^3P_0$ 28860 *46, 59, 89*	$2p^3$ $^4S^\circ_{1\frac{1}{2}}$ 6586600 *46*	$2p^2$ $^3P_0$ 7219800 $^3P_1$ 17558 $^3P_2$ 35922 *46, 89*	$2p$ $^2P^\circ_{0\frac{1}{2}}$ [7856000] $^2P^\circ_{1\frac{1}{2}}$ *116*	$2s^2$ $^1S_0$ [8767000] *116*	$2s$ $^2S_{0\frac{1}{2}}$ [9332000] *116*	$1s^2$ $^1S_0$ 41369608 *129*	$1s$ $^2S_{0\frac{1}{2}}$ 44117547 *49, 68*	

Z	Element	Spectrum																				
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI	XVII	XVIII	XIX	XX	XXI
21	Sc	$3d\ 4s^2$ $^2D_{1\frac12}$ 52750 $^2D_{2\frac12}$ 168.34 *27, 135*	$3d\ 4s$ $^3D_1$ 103240 $^3D_2$ 67.68 $^3D_3$ 177.63 $^1D_2$ 2540.97 *135, 166*	$3d$ $^2D_{1\frac12}$ 199700 $^2D_{2\frac12}$ 197.5 *25, 135*	$3p^6$ $^1S_0$ 592600 *52*	$3p^5$ $^2P^\circ_{1\frac12}$ 739300 $^2P^\circ_{0\frac12}$ 4318 *52, 182*	$3p^4$ $^3P_2$ 896000 $^3P_1$ 3348 $^3P_0$ 4458 $^1D_2$ 21398 *135, 182*	$3p^3$ $^4S^\circ_{1\frac12}$ [1113100] $^2D^\circ_{1\frac12}$ 29565 $^2D^\circ_{2\frac12}$ 30247 *52, 116*	$3p^2$ $^3P_0$ 1280000 $^3P_1$ 2272 $^3P_2$ 5505 $^1D_2$ 25035 *52, 60, 135*	$3p$ $^2P^\circ_{0\frac12}$ 1452000 $^2P^\circ_{1\frac12}$ 5761 *52*	$3s^2$ $^1S_0$ 1817400 52	$3s$ $^2S_{0\frac12}$ 2015080 *52*	$2p^6$ $^1S_0$ 5532200 *46*	$2p^5$ $^2P^\circ_{1\frac12}$ 6093400 $^2P^\circ_{0\frac12}$ 37900 *46, 59*	$2p^4$ $^3P_2$ 6692900 $^3P_1$ $^3P_0$ *46*	$2p^3$ $^4S^\circ_{1\frac12}$ 7468900 *46*						
22	Ti	$3d^2\ 4s^2$ $^3F_2$ 55010 $^3F_3$ 170.132 $^3F_4$ 386.874 *27, 73*	$3d^2\ 4s$ $^4F_{1\frac12}$ 109506 $^4F_{2\frac12}$ 93.94 $^4F_{3\frac12}$ 225.47 $^4F_{4\frac12}$ 393.22 *135, 166*	$3d^2$ $^3F_2$ 221735 $^3F_3$ 184.9 $^3F_4$ 420.4 $^1D_2$ 8473.5 $^3P_0$ 10538.4 $^3P_1$ 10603.6 $^3P_2$ 10721.2 *51*	$3d$ $^2D_{1\frac12}$ 348973 $^2D_{2\frac12}$ 382.1 *51*	$3p^6$ $^1S_0$ 800300 *52*	$3p^5$ $^2P^\circ_{1\frac12}$ 962700 $^2P^\circ_{0\frac12}$ 5829 *52, 182*	$3p^4$ $^3P_2$ 1136000 $^3P_1$ 4530 $^3P_0$ 5884 $^1D_2$ 24130 *135, 182*	$3p^3$ $^4S^\circ_{1\frac12}$ 1359000 $^2D^\circ_{1\frac12}$ 32168 $^2D^\circ_{2\frac12}$ 33239 *33, 52*	$3p^2$ $^3P_0$ [1558000] $^3P_1$ 3125 $^3P_2$ 7291 $^1D_2$ 28557 *52, 116, 183*	$3p$ $^2P^\circ_{0\frac12}$ 1741500 $^2P^\circ_{1\frac12}$ 7542 *52*	$3s^2$ $^1S_0$ 2139300 *52*	$3s$ $^2S_{0\frac12}$ 2351140 *52*	$2p^6$ $^1S_0$ 6350400 *46*	$2p^5$ $^2P^\circ_{1\frac12}$ 6947300 $^2P^\circ_{0\frac12}$ 47190 *46, 59*	$2p^4$ $^3P_2$ 7584700 $^3P_1$ $^3P_0$ *46*						
23	V	$3d^3\ 4s^2$ $^4F_{1\frac12}$ 54400 $^4F_{2\frac12}$ 137.38 $^4F_{3\frac12}$ 323.42 $^4F_{4\frac12}$ 553.02 *27, 135*	$3d^4$ $^5D_0$ 118200 $^5D_1$ 36.05 $^5D_2$ 106.63 $^5D_3$ 208.89 $^5D_4$ 339.21 *135, 188*	$3d^3$ $^4F_{1\frac12}$ 236 $^4F_{2\frac12}$ 145.5 $^4F_{3\frac12}$ 341.5 $^4F_{4\frac12}$ 583.8 *83*	$3d^2$ $^3F_2$ 376730 ±40 $^3F_3$ 325.4 $^3F_4$ 734.7 $^1D_2$ 10959.3 *85*	$3d$ $^2D_{1\frac12}$ [526100] $^2D_{2\frac12}$ 620 *85, 116, 135*	$3p^6$ $^1S_0$ 1033400 *52*	$3p^5$ $^2P^\circ_{1\frac12}$ 1211200 $^2P^\circ_{0\frac12}$ 7660 *52, 135*	$3p^4$ $^3P_2$ 1401000 $^3P_1$ 6000 $^3P_0$ 7580 $^1D_2$ 27120 *135*	$3p^3$ $^4S^\circ_{1\frac12}$ [1659900] *116*	$3p^2$ $^3P_0$ [1859200] $^3P_1$ 4310 $^3P_2$ 9540 *60, 116*	$3p$ $^2P^\circ_{0\frac12}$ 2057100 $^2P^\circ_{1\frac12}$ 9692 *52*	$3s^2$ $^1S_0$ 2486300 *52*	$3s$ $^2S_{0\frac12}$ 2712250 *52*	$2p^6$ $^1S_0$ 7223500 *46*	$2p^5$ $^2P^\circ_{1\frac12}$ 7856200 $^2P^\circ_{0\frac12}$ *30, 46*						
24	Cr	$3d^5\ 4s$ $^7S_3$ 54570 *103*	$3d^5$ $^6S_{2\frac12}$ 133060 *102*	$3d^4$ $^5D_0$ 249700 $^5D_1$ 59.9 $^5D_2$ 181.9 $^5D_3$ 355.8 $^5D_4$ 575.0 *136*	$3d^3$ $^4F_{1\frac12}$ [396000] $^4F_{2\frac12}$ 244 $^4F_{3\frac12}$ 561 $^4F_{4\frac12}$ 956 *116, 136*	$3d^2$ $^3F_2$ [559000] $^3F_3$ 513 $^3F_4$ 1146 $^1D_2$ 13200 *116, 136*	$3d$ $^2D_{1\frac12}$ 730400 $^2D_{2\frac12}$ 920 *3*	$3p^6$ $^1S_0$ 1299700 *136*	$3p^5$ $^2P^\circ_{1\frac12}$ [1490000] $^2P^\circ_{0\frac12}$ 9900 *116, 136*	$3p^4$ $^3P_2$ [1688000] $^3P_1$ 7860 $^3P_0$ 9600 *116, 136*	$3p^3$ $^4S^\circ_{1\frac12}$ [1971000] *116*	$3p^2$ $^3P_0$ [2184000] $^3P_1$ $^3P_2$ *116*	$3p$ $^2P^\circ_{0\frac12}$ [2403600] $^2P^\circ_{1\frac12}$ 12200 *60, 116*	$3s^2$ $^1S_0$ 2862000 *136*	$3s$ $^2S_{0\frac12}$ 3099630 *136*	$2p^6$ $^1S_0$ 8151600 *46*						
25	Mn	$3d^5\ 4s^2$ $^6S_{2\frac12}$ 59970 *21*	$3d^5\ 4s$ $^7S_3$ 126145.0 ±0.6 *86*	$3d^5$ $^6S_{2\frac12}$ 271550 *69*	$3d^4$ $^5D_0$ [413000] $^5D_1$ 98.4 $^5D_2$ 286.8 $^5D_3$ 552.7 $^5D_4$ 885.4 *116, 138*	$3d^3$ $^4F_{1\frac12}$ [584000] $^4F_{2\frac12}$ 349 $^4F_{3\frac12}$ 827 $^4F_{4\frac12}$ 1406 *116, 136*	$3d^2$ $^3F_2$ [766000] $^3F_3$ 746 $^3F_4$ 1669 $^1D_2$ 15337 *17, 116, 136*	$3d$ $^2D_{1\frac12}$ 962001 $^2D_{2\frac12}$ 1355 *136*	$3p^6$ $^1S_0$ [1584600] *116*	$3p^5$ $^2P^\circ_{1\frac12}$ [1789000] $^2P^\circ_{0\frac12}$ 12530 *116, 136*	$3p^4$ $^3P_2$ [2003000] $^3P_1$ 10000 $^3P_0$ 11700 *116, 136*	$3p^3$ $^4S^\circ_{1\frac12}$ [2307000] *116*	$3p^2$ $^3P_0$ [2535900] $^3P_1$ $^3P_2$ *116*	$3p$ $^2P^\circ_{0\frac12}$ [2771400] $^2P^\circ_{1\frac12}$ 16400 *62, 116*	$3s^2$ $^1S_0$ 3260000 *136*	$3s$ $^2S_{0\frac12}$ 3511210 *136*	$2p^6$ $^1S_0$ 9164300 *136*					
26	Fe	$3d^6\ 4s^2$ $^5D_4$ 63480 $^5D_3$ 415.932 $^5D_2$ 704.003 $^5D_1$ 888.132 $^5D_0$ 978.076 *27, 43*	$3d^6\ 4s$ $^6D_{4\frac12}$ 130524 $^6D_{3\frac12}$ 384.77 $^6D_{2\frac12}$ 667.64 $^6D_{1\frac12}$ 862.63 $^6D_{0\frac12}$ 977.03 *136, 166*	$3d^6$ $^5D_4$ 247221 $^5D_3$ 436.2 $^5D_2$ 738.9 $^5D_1$ 932.4 $^5D_0$ 1027.3 *74, 136*	$3d^5$ $^6S_{2\frac12}$ [442000] *116*	$3d^4$ $^5D_0$ [604900] $^5D_1$ 145 $^5D_2$ 419 $^5D_3$ 804 $^5D_4$ 1285 *116, 136*	$3d^3$ $^4F_{1\frac12}$ [798500] $^4F_{2\frac12}$ 510.9 $^4F_{3\frac12}$ 1189 $^4F_{4\frac12}$ 2002 *17, 116*	$3d^2$ $^3F_2$ [1008000] $^3F_3$ 1051 $^3F_4$ 2327 *17, 116*	$3d$ $^2D_{1\frac12}$ 1218400 $^2D_{2\frac12}$ 1850 *3, 32, 34*	$3p^6$ $^1S_0$ 1895800 *3*	$3p^5$ $^2P^\circ_{1\frac12}$ 2114000 $^2P^\circ_{0\frac12}$ 15682.9 *89, 136*	$3p^4$ $^3P_2$ 2342000 $^3P_1$ 12667.9 $^3P_0$ 14440 *89, 136*	$3p^3$ $^4S^\circ_{1\frac12}$ [2668000] *116*	$3p^2$ $^3P_0$ [2912000] $^3P_1$ 9302.6 $^3P_2$ 18561.1 *89, 116*	$3p$ $^2P^\circ_{0\frac12}$ [3163000] $^2P^\circ_{1\frac12}$ 18850.6 *89, 116*	$3s^2$ $^1S_0$ 3684000 *136*	$3s$ $^2S_{0\frac12}$ 3947840 *136*	$2p^6$ $^1S_0$ 10211700 *136*				
27	Co	$3d^7\ 4s^2$ $^4F_{4\frac12}$ 63430 $^4F_{3\frac12}$ 816.00 $^4F_{2\frac12}$ 1406.84 $^4F_{1\frac12}$ 1809.33 *27, 136*	$3d^8$ $^3F_4$ 137572 $^3F_3$ 950.45 $^3F_2$ 1597.20 *166, 187*	$3d^7$ $^4F_{4\frac12}$ 270200 $^4F_{3\frac12}$ 841.2 $^4F_{2\frac12}$ 1451.3 $^4F_{1\frac12}$ 1866.8 *171*	$3d^6$ $^5D_4$ [413800] $^5D_3$ $^5D_2$ $^5D_1$ $^5D_0$ *116*	$3d^5$ $^6S_{2\frac12}$ [641200] *116*	$3d^4$ $^5D_0$ [823000] $^5D_1$ 208 $^5D_2$ 586 $^5D_3$ 1129 $^5D_4$ 1789 *116, 136*	$3d^3$ $^4F_{1\frac12}$ [1040000] $^4F_{2\frac12}$ 698 $^4F_{3\frac12}$ 1610 $^4F_{4\frac12}$ 2723 *116, 136*	$3d^2$ $^3F_2$ [1266000] $^3F_3$ 1430 $^3F_4$ 3140 *4, 116*	$3d$ $^2D_{1\frac12}$ 1501300 $^2D_{2\frac12}$ 2440 *3, 75*	$3p^6$ $^1S_0$ 2230000 *3*	$3p^5$ $^2P^\circ_{1\frac12}$ 2462000 $^2P^\circ_{0\frac12}$ 19420 *75, 136*	$3p^4$ $^3P_2$ [2710000] $^3P_1$ $^3P_0$ *116*	$3p^3$ $^4S^\circ_{1\frac12}$ [3057000] *116*	$3p^2$ $^3P_0$ [3315000] $^3P_1$ [11834] $^3P_2$ *116, 136*	$3p$ $^2P^\circ_{0\frac12}$ [3581000] $^2P^\circ_{1\frac12}$ *116*	$3s^2$ $^1S_0$ 4133000 *136*	$3s$ $^2S_{0\frac12}$ 4410480 *136*	$2p^6$ $^1S_0$ 11316400 *136*			
28	Ni	$3d^8\ 4s^2$ $^3F_4$ 61579 $^3F_3$ 1332.153 $^3F_2$ 2216.519 *136*	$3d^9$ $^2D_{2\frac12}$ 146541.56 $^2D_{1\frac12}$ 1506.94 *174*	$3d^8$ $^3F_4$ 283700 $^3F_3$ 1360.7 $^3F_2$ 2269.6 *27, 170*	$3d^7$ $^4F_{4\frac12}$ [442800] $^4F_{3\frac12}$ 1188.4 $^4F_{2\frac12}$ 2040.9 $^4F_{1\frac12}$ 2618.8 *116, 148*	$3d^6$ $^5D_4$ [609000] $^5D_3$ $^5D_2$ $^5D_1$ $^5D_0$ *116*	$3d^5$ $^6S_{2\frac12}$ [871000] *116*	$3d^4$ $^5D_0$ [1073000] $^5D_1$ 275 $^5D_2$ 802 $^5D_3$ 1520 $^5D_4$ 2379 *116, 136*	$3d^3$ $^4F_{1\frac12}$ [1307000] $^4F_{2\frac12}$ $^4F_{3\frac12}$ $^4F_{4\frac12}$ *116*	$3d^2$ $^3F_2$ [1557000] $^3F_3$ 1890 $^3F_4$ 4110 *58, 116*	$3d$ $^2D_{1\frac12}$ 1811000 $^2D_{2\frac12}$ 3150 *3, 67*	$3p^6$ $^1S_0$ 2591000 *3*	$3p^5$ $^2P^\circ_{1\frac12}$ [2839000] $^2P^\circ_{0\frac12}$ 23627.3 *89, 116*	$3p^4$ $^3P_2$ [3097000] $^3P_1$ 19541.8 $^3P_0$ [20200] *89, 116, 136*	$3p^3$ $^4S^\circ_{1\frac12}$ [3468000] *116*	$3p^2$ $^3P_0$ [3742500] $^3P_1$ 14917.5 $^3P_2$ 27376.5 *89, 116*	$3p$ $^2P^\circ_{0\frac12}$ [4025000] $^2P^\circ_{1\frac12}$ 27761.4 *89, 116*	$3s^2$ $^1S_0$ [4606000] *116*	$3s$ $^2S_{0\frac12}$ 4897400 *136*	$2p^6$ $^1S_0$ 12477000 *63*		
29	Cu	$4s$ $^2S_{0\frac12}$ 62317.2 *136*	$3d^{10}$ $^1S_0$ 163669.2 ±0.5 *163*	$3d^9$ $^2D_{2\frac12}$ 297100 $^2D_{1\frac12}$ 2071.8 *136*	$3d^8$ $^3F_4$ 445124 ±1600 $^3F_3$ 1862.5 $^3F_2$ 3078.5 *169*	$3d^7$ $^4F_{4\frac12}$ [644500] $^4F_{3\frac12}$ $^4F_{2\frac12}$ $^4F_{1\frac12}$ *116*	$3d^6$ $^5D_4$ [831000] $^5D_3$ $^5D_2$ $^5D_1$ $^5D_0$ *116*	$3d^5$ $^6S_{2\frac12}$ [1121000] *116*	$3d^4$ $^5D_0$ [1339000] $^5D_1$ $^5D_2$ $^5D_3$ $^5D_4$ *116*	$3d^3$ $^4F_{1\frac12}$ [1605000] $^4F_{2\frac12}$ $^4F_{3\frac12}$ $^4F_{4\frac12}$ *116*	$3d^2$ $^3F_2$ [1871000] $^3F_3$ 2485 $^3F_4$ 5465 *58, 116*	$3d$ $^2D_{1\frac12}$ 2146000 $^2D_{2\frac12}$ *3*	$3p^6$ $^1S_0$ [2975000] *116*	$3p^5$ $^2P^\circ_{1\frac12}$ [3234000] $^2P^\circ_{0\frac12}$ *116*	$3p^4$ $^3P_2$ [3509000] $^3P_1$ $^3P_0$ *116*	$3p^3$ $^4S^\circ_{1\frac12}$ [3904000] *116*	$3p^2$ $^3P_0$ [4194000] $^3P_1$ $^3P_2$ *116*	$3p$ $^2P^\circ_{0\frac12}$ [4493000] $^2P^\circ_{1\frac12}$ *116*	$3s^2$ $^1S_0$ [5106000] *116*	$3s$ $^2S_{0\frac12}$ 5410000 *136*	$2p^6$ $^1S_0$ 13695000 *63*	

387-063 O - 70 (Face p. 6) No. 2

Z	Element	Spectrum I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI	XVII	XVIII	XIX	XX	XXI
30	Zn	$4s^2$ $^1S_0$ 75768.10 *95*	$4s$ $^2S_{0\frac{1}{2}}$ 144892.6 ±2 *122*	$3d^{10}$ $^1S_0$ 320390 ±1 *41*	$3d^9$ $^2D_{2\frac{1}{2}}$ [479100] $^2D_{1\frac{1}{2}}$ 2758.8 *37, 116*	$3d^8$ $^3F_4$ [666000] $^3F_3$ $^3F_2$ *116*	$3d^7$ $^4F_{4\frac{1}{2}}$ [871000] $^4F_{3\frac{1}{2}}$ $^4F_{2\frac{1}{2}}$ $^4F_{1\frac{1}{2}}$ *116*	$3d^6$ $^5D_4$ [1081000] $^5D_3$ $^5D_2$ $^5D_1$ $^5D_0$ *116*	$3d^5$ $^6S_{2\frac{1}{2}}$ [1403000] *116*	$3d^4$ $^5D_0$ [1637000] $^5D_1$ $^5D_2$ $^5D_3$ $^5D_4$ *116*	$3d^3$ $^4F_{1\frac{1}{2}}$ [1920000] $^4F_{2\frac{1}{2}}$ $^4F_{3\frac{1}{2}}$ $^4F_{4\frac{1}{2}}$ *116*	$3d^2$ $^3F_2$ [2210000] $^3F_3$ 3030 $^3F_4$ 6735 *58, 116*	$3d$ $^2D_{1\frac{1}{2}}$ [2507000] $^2D_{2\frac{1}{2}}$ *116*	$3p^6$ $^1S_0$ [3385000] *116*	$3p^5$ $^2P^{\circ}_{1\frac{1}{2}}$ [3662000] $^2P^{\circ}_{0\frac{1}{2}}$ *116*	$3p^4$ $^3P_2$ [3952000] $^3P_1$ $^3P_0$ *116*	$3p^3$ $^4S^{\circ}_{1\frac{1}{2}}$ [4372000] *116*	$3p^2$ $^3P_0$ [4670000] $^3P_1$ $^3P_2$ *116*	$3p$ $^2P^{\circ}_{0\frac{1}{2}}$ [4993000] $^2P^{\circ}_{1\frac{1}{2}}$ *116*	$3s^2$ $^1S_0$ [5630000] *116*	$3s$ $^2S_{0\frac{1}{2}}$ 5952000 *64*	$2p^6$ $^1S_0$ 14969000 *63*
31	Ga	$4p$ $^2P^{\circ}_{0\frac{1}{2}}$ 48387.63 $^2P^{\circ}_{1\frac{1}{2}}$ 826.19 *96*	$4s^2$ $^1S_0$ 165458 *136*	$4s$ $^2S_{0\frac{1}{2}}$ 247700 *136*	$3d^{10}$ $^1S_0$ 517600 *136*																	
32	Ge	$4p^2$ $^3P_0$ 63715 ±10 $^3P_1$ 557.1341 $^3P_2$ 1409.9609 $^1D_2$ 7125.2989 $^1S_0$ 16367.3332 *6, 97*	$4p$ $^2P^{\circ}_{0\frac{1}{2}}$ 128521.3 ±0.2 $^2P^{\circ}_{1\frac{1}{2}}$ 1767.356 *97, 100*	$4s^2$ $^1S_0$ 276036 *136*	$4s$ $^2S_{0\frac{1}{2}}$ 368701 *136*	$3d^{10}$ $^1S_0$ 753800 *136*																
33	As	$4p^3$ $^4S^{\circ}_{1\frac{1}{2}}$ 79165 *136*	$4p^2$ $^3P_0$ 150290 $^3P_1$ 1061 $^3P_2$ 2538 $^1D_2$ 10097 $^1S_0$ 22602 *35*	$4p$ $^2P^{\circ}_{0\frac{1}{2}}$ 228670 $^2P^{\circ}_{1\frac{1}{2}}$ 2940 *35, 136*	$4s^2$ $^1S_0$ 404369 *136*	$4s$ $^2S_{0\frac{1}{2}}$ 505136 *136*	$3d^{10}$ $^1S_0$ 1028800 *136*															
34	Se	$4p^4$ $^3P_2$ 78658.22 $^3P_1$ 1989.49 $^3P_0$ 2534.35 $^1D_2$ 9576.08 $^1S_0$ 22446.03 *136*	$4p^3$ $^4S^{\circ}_{1\frac{1}{2}}$ 170900 *26*	$4p^2$ $^3P_0$ 248583 $^3P_1$ 1741 $^3P_2$ 3937 $^1D_2$ 13032 *36, 136*	$4p$ $^2P^{\circ}_{0\frac{1}{2}}$ 346375 $^2P^{\circ}_{1\frac{1}{2}}$ 4376 *36, 136*	$4s^2$ $^1S_0$ [551000] *65*	$4s$ $^2S_{0\frac{1}{2}}$ 658994 *136*	$3d^{10}$ $^1S_0$ 1253300 *136*														
35	Br	$4p^5$ $^2P^{\circ}_{1\frac{1}{2}}$ 95284.8 ±0.5 $^2P^{\circ}_{0\frac{1}{2}}$ 3685.24 *184*	$4p^4$ $^3P_2$ 175870 $^3P_1$ 3136.4 $^3P_0$ 3837.5 $^1D_2$ 12089.1 $^1S_0$ 27867.1 *152, 184*	$4p^3$ $^4S^{\circ}_{1\frac{1}{2}}$ 289529 *136*	$4p^2$ $^3P_0$ [381600] $^3P_1$ 3247 $^3P_2$ 6237 $^1D_2$ 18115 *65, 136*	$4p$ $^2P^{\circ}_{0\frac{1}{2}}$ [481600] $^2P^{\circ}_{1\frac{1}{2}}$ 6090 *65, 136*	$4s^2$ $^1S_0$ [714800] *65*	$4s$ $^2S_{0\frac{1}{2}}$ [831000] *65*	$3d^{10}$ $^1S_0$ 1554700 *136*													
36	Kr	$4p^6$ $^1S_0$ 112914.5 *136, 147*	$4p^5$ $^2P^{\circ}_{1\frac{1}{2}}$ 196474.8 $^2P^{\circ}_{0\frac{1}{2}}$ 5371.00 *132, 136*	$4p^4$ $^3P_2$ 298020 $^3P_1$ 4548 $^3P_0$ 5313 $^1D_2$ 14644 $^1S_0$ 33079 *136*	$4p^3$ $^4S^{\circ}_{1\frac{1}{2}}$ [423600] *65*	$4p^2$ $^3P_0$ [522000] $^3P_1$ $^3P_2$ *65*	$4p$ $^2P^{\circ}_{0\frac{1}{2}}$ [633300] $^2P^{\circ}_{1\frac{1}{2}}$ 8108 *61, 65*	$4s^2$ $^1S_0$ [895500] *65*	$4s$ $^2S_{0\frac{1}{2}}$ [1016500] *65*	$3d^{10}$ $^1S_0$ 1862400 *106*												
37	Rb	$5s$ $^2S_{0\frac{1}{2}}$ 33690.81 ±0.01 *91*	$4p^6$ $^1S_0$ 220048 ±30 *155a*	$4p^5$ $^2P^{\circ}_{1\frac{1}{2}}$ 320000 $^2P^{\circ}_{0\frac{1}{2}}$ 7380 *136*	$4p^4$ $^3P_2$ [424400] $^3P_1$ $^3P_0$ *65*	$4p^3$ $^4S^{\circ}_{1\frac{1}{2}}$ [572800] *65*	$4p^2$ $^3P_0$ [680900] $^3P_1$ $^3P_2$ *65*	$4p$ $^2P^{\circ}_{0\frac{1}{2}}$ [800300] $^2P^{\circ}_{1\frac{1}{2}}$ *65*	$4s^2$ $^1S_0$ [1098000] *65*	$4s$ $^2S_{0\frac{1}{2}}$ [1210000] *65*	$3d^{10}$ $^1S_0$ 2235100 *136*											
38	Sr	$5s^2$ $^1S_0$ 45932.0 ±0.2 *70*	$5s$ $^2S_{0\frac{1}{2}}$ 88964.0 *136*	$4p^6$ $^1S_0$ [351800] *65*	$4p^5$ $^2P^{\circ}_{1\frac{1}{2}}$ 460000 $^2P^{\circ}_{0\frac{1}{2}}$ 9731 *136*	$4p^4$ $^3P_2$ [577700] $^3P_1$ $^3P_0$ *65*	$4p^3$ $^4S^{\circ}_{1\frac{1}{2}}$ [732600] *65*	$4p^2$ $^3P_0$ [855200] $^3P_1$ $^3P_2$ *65*	$4p$ $^2P^{\circ}_{0\frac{1}{2}}$ [986700] $^2P^{\circ}_{1\frac{1}{2}}$ *65*	$4s^2$ $^1S_0$ [1307000] *65*	$4s$ $^2S_{0\frac{1}{2}}$ [1428000] *65*	$3d^{10}$ $^1S_0$ 2613800 *136*										
39	Y	$4d\ 5s^2$ $^2D_{1\frac{1}{2}}$ 51447 $^2D_{2\frac{1}{2}}$ 530.36 *22, 136*	$5s^2$ $^1S_0$ 98690 *22*	$5s$ $^2S_{0\frac{1}{2}}$ 165500 *24, 104*	$4p^6$ $^1S_0$ [498600] *65*	$4p^5$ $^2P^{\circ}_{1\frac{1}{2}}$ [621200] $^2P^{\circ}_{0\frac{1}{2}}$ 12459.9 *65, 155*	$4p^4$ $^3P_2$ [750300] $^3P_1$ $^3P_0$ *65*	$4p^3$ $^4S^{\circ}_{1\frac{1}{2}}$ [935900] *65*	$4p^2$ $^3P_0$ [1041000] $^3P_1$ $^3P_2$ *65*	$4p$ $^2P^{\circ}_{0\frac{1}{2}}$ [1179500] $^2P^{\circ}_{1\frac{1}{2}}$ *65*	$4s^2$ $^1S_0$ [1541000] *65*	$4s$ $^2S_{0\frac{1}{2}}$ [1662000] *65*	$3d^{10}$ $^1S_0$ 3016800 *136*									
40	Zr	$4d^2\ 5s^2$ $^3F_2$ 55145 $^3F_3$ 570.41 $^3F_4$ 1240.84 *22, 136*	$4d^2\ 5s$ $^4F_{1\frac{1}{2}}$ 105900 $^4F_{2\frac{1}{2}}$ 314.67 $^4F_{3\frac{1}{2}}$ 763.44 $^4F_{4\frac{1}{2}}$ 1322.91 *23, 136*	$4d^2$ $^3F_2$ 185400 $^3F_3$ 680.5 $^3F_4$ 1485.7 *24, 104*	$4d$ $^2D_{1\frac{1}{2}}$ 276970 $^2D_{2\frac{1}{2}}$ 1250 *104*	$4p^6$ $^1S_0$ 657600 *28*																

TABLE 2. *Ionization limits and lowest terms* — continued

Z	Element	Spectrum I	II	III	IV	V	VI	VII	VIII	IX
41	Nb	$4d^4\,5s$ $^6D^\circ_{0\,1/2}$ 55511 $^6D^\circ_{1\,1/2}$ 154.19 $^6D^\circ_{2\,1/2}$ 391.99 $^6D^\circ_{3\,1/2}$ 695.25 $^6D^\circ_{4\,1/2}$ 1050.26 *22*	$4d^4$ $^5D_0$ 115500 $^5D_1$ 158.99 $^5D_2$ 438.38 $^5D_3$ 801.38 $^5D_4$ 1224.87 *23, 136*	$4d^3$ $^4F_{1\,1/2}$ 202000 $^4F_{2\,1/2}$ 515.8 $^4F_{3\,1/2}$ 1176.6 $^4F_{4\,1/2}$ 1939.0 *24, 82*	$4d^2$ $^3F_2$ 308600 $^3F_3$ 1086.4 $^3F_4$ 2344.6 *136*	$4d$ $^2D_{1\,1/2}$ 407700 $^2D_{2\,1/2}$ 1870 *104, 136*	$4p^6$ $^1S_0$ 827300 *28*	$4p^5$ $^2P^\circ_{1\,1/2}$ 1005000 $^2P^\circ_{0\,1/2}$ 19199 *28, 136*		
42	Mo	$4d^5\,5s$ $^7S_3$ 57260 *137*	$4d^5$ $^6S_{2\,1/2}$ 130300 *137*	$4d^4$ $^5D_0$ 219100 $^5D_1$ 243.10 $^5D_2$ 669.60 $^5D_3$ 1225.20 $^5D_4$ 1873.80 *158*	$4d^3$ $^4F_{1\,1/2}$ 374180 $^4F_{2\,1/2}$ 780.0 $^4F_{3\,1/2}$ 1759.0 $^4F_{4\,1/2}$ 2858.6 *137*	$4d^2$ $^3F_2$ 493360 $^3F_3$ 1585 $^3F_4$ 3359 *137*	$4d$ $^2D_{1\,1/2}$ 549000 $^2D_{2\,1/2}$ 2578 *104, 137*	$4p^6$ $^1S_0$ 1022800 *28*	$4p^5$ $^2P^\circ_{1\,1/2}$ 1235000 $^2P^\circ_{0\,1/2}$ 23273 *28, 137*	
43	Tc	$4d^5\,5s^2$ $^6S_{2\,1/2}$ 58700 *137*	$4d^5\,5s$ $^7S_3$ 123100 *137*	$4d^5$ $^6S_{2\,1/2}$ 238300 *24*						
44	Ru	$4d^7\,5s$ $^5F_5$ 59410 $^5F_4$ 1190.64 $^5F_3$ 2091.54 $^5F_2$ 2713.24 $^5F_1$ 3105.49 *101*	$4d^7$ $^4F_{4\,1/2}$ 135200 $^4F_{3\,1/2}$ 1523.1 $^4F_{2\,1/2}$ 2493.9 $^4F_{1\,1/2}$ 3104.2 *175*	$4d^6$ $^5D_4$ 229600 $^5D_3$ 1158.8 $^5D_2$ 1826.3 $^5D_1$ 2266.3 $^5D_0$ 2476.0 *137*						
45	Rh	$4d^8\,5s$ $^4F_{4\,1/2}$ 60197 $^4F_{3\,1/2}$ 1529.97 $^4F_{2\,1/2}$ 2598.03 $^4F_{1\,1/2}$ 3472.68 *137*	$4d^8$ $^3F_4$ 145800 $^3F_3$ 2401.3 $^3F_2$ 3580.7 *137*	$4d^7$ $^4F_{4\,1/2}$ 250500 $^4F_{3\,1/2}$ 2147.8 $^4F_{2\,1/2}$ 3485.7 $^4F_{1\,1/2}$ 4322.0 *84, 137*						
46	Pd	$4d^{10}$ $^1S_0$ 67236.0 *137*	$4d^9$ $^2D_{2\,1/2}$ 156700 $^2D_{1\,1/2}$ 3539 *137*	$4d^8$ $^3F_4$ 265600 $^3F_3$ 3229.3 $^3F_2$ 4687.5 *173*						
47	Ag	$5s$ $^2S_{0\,1/2}$ 61106.50 *137*	$4d^{10}$ $^1S_0$ 173300 *137*	$4d^9$ $^2D_{2\,1/2}$ 280900 $^2D_{1\,1/2}$ 4607 *137*						
48	Cd	$5s^2$ $^1S_0$ 72538.8 *137*	$5s$ $^2S_{0\,1/2}$ 136374.74 *137*	$4d^{10}$ $^1S_0$ 302300 *137*						
49	In	$5s^2\,5p$ $^2P^\circ_{0\,1/2}$ 46670.11 ±0.05 $^2P^\circ_{1\,1/2}$ 2212.598 *96*	$5s^2$ $^1S_0$ 152195 *137*	$5s$ $^2S_{0\,1/2}$ 226100 *137*	$4d^{10}$ $^1S_0$ 439000 *137*					
50	Sn	$5p^2$ $^3P_0$ 59231.8 $^3P_1$ 1691.8 $^3P_2$ 3427.7 *137*	$5s^2\,5p$ $^2P^\circ_{0\,1/2}$ 118017.0 $^2P^\circ_{1\,1/2}$ 4251.4 *137*	$5s^2$ $^1S_0$ 246020.0 *137*	$5s$ $^2S_{0\,1/2}$ 328550.0 *137*	$4d^{10}$ $^1S_0$ 583000 *137*				
51	Sb	$5p^3$ $^4S^\circ_{1\,1/2}$ 69700 *137*	$5p^2$ $^3P_0$ 133327.5 $^3P_1$ 3055.0 $^3P_2$ 5659.0 *137*	$5s^2\,5p$ $^2P^\circ_{0\,1/2}$ 204248 $^2P^\circ_{1\,1/2}$ 6576 *137*	$5s^2$ $^1S_0$ 356156 *137*	$5s$ $^2S_{0\,1/2}$ 449300 *137*	$4d^{10}$ $^1S_0$ 868000 *137*			
52	Te	$5p^4$ $^3P_2$ 72667 $^3P_1$ 4751 $^3P_0$ 4707 *137*	$5p^3$ $^4S^\circ_{1\,1/2}$ 150000 ±3000 *79*	$5p^2$ $^3P_0$ 225500 $^3P_1$ 4756.5 $^3P_2$ 8166.9 *38*	$5s^2\,5p$ $^2P^\circ_{0\,1/2}$ 301776 $^2P^\circ_{1\,1/2}$ 9222.6 *38*	$5s^2$ $^1S_0$ 473900 *38*	$5s$ $^2S_{0\,1/2}$ 570000 *38*	$4d^{10}$ $^1S_0$ 1107000 *137*		
53	I	$5p^5$ $^2P^\circ_{1\,1/2}$ 84295.1 ±0.2 $^2P^\circ_{0\,1/2}$ 7603.15 *131*	$5p^4$ $^3P_2$ 154304 ±1 $^3P_1$ 7087.0 $^3P_0$ 6447.9 *121*	$5p^3$ $^4S^\circ_{1\,1/2}$ [266000] *65*						

387-063 O - 70 (Face p. 6) No. 3

TABLE 2. *Ionization limits and lowest terms*—continued

Z	Element	Spectrum I	Spectrum II	Spectrum III	Spectrum IV	Spectrum V	Spectrum VI
54	Xe	$5p^6$ $^1S_0$ 97834.0 *137, 147*	$5p^5$ $^2P^\circ_{1\frac{1}{2}}$ 171068.4 $^2P^\circ_{0\frac{1}{2}}$ 10537.01 *137*	$5p^4$ $^3P_2$ 259089 $^3P_1$ 9794.6 $^3P_0$ 8131 *137*			
55	Cs	$6s$ $^2S_{0\frac{1}{2}}$ 31406.432 ±0.010 *11*	$5p^6$ $^1S_0$ 202263 *137*				
56	Ba	$6s^2$ $^1S_0$ 42035.14 ±0.05 *71*	$6s$ $^2S_{0\frac{1}{2}}$ 80686.87 *137*				
57	La	$5d\ 6s^2$ $^2D_{1\frac{1}{2}}$ 44981 ±5 $^2D_{2\frac{1}{2}}$ 1053.20 *72, 137*	$5d^2\ 6s^2$ $^3F_2$ 89200 ±650 $^3F_3$ 1016.10 $^3F_4$ 1970.70 *181*	$5d\ 6s^2$ $^2D_{1\frac{1}{2}}$ 154664 ±15 $^2D_{2\frac{1}{2}}$ 1603.26 *139*			
58	Ce	$4f\ 5d\ 6s^2$ $^1G^\circ_4$ 44090 ±110 *120, 156a*	$4f\ 5d^2$ $^4H^\circ_{3\frac{1}{2}}$ 87500 ±650 $^4H^\circ_{4\frac{1}{2}}$ 987.62 $^4H^\circ_{5\frac{1}{2}}$ 1873.95 $^4H^\circ_{6\frac{1}{2}}$ 2382.26 *80, 149, 181*	$4f^2$ $^3H_4$ 162900 ±120 $^3H_5$ 1526.36 $^3H_6$ 3127.05 *178*	$4f$ $^2F^\circ_{2\frac{1}{2}}$ 296200 $^2F^\circ_{3\frac{1}{2}}$ 2253 *113*		
59	Pr	$4f^3\ 6s^2$ $^4I^\circ_{4\frac{1}{2}}$ 43730 ±150 $^4I^\circ_{5\frac{1}{2}}$ 1376.54 $^4I^\circ_{6\frac{1}{2}}$ 2846.61 $^4I^\circ_{7\frac{1}{2}}$ *156, 193*	$4f^3\ 6s$ $^5I^\circ_4$ 85100 ±650 $^5I^\circ_5$ 441.94 $^5I^\circ_6$ 1649.01 $^5I^\circ_7$ 2998.31 $^5I^\circ_8$ 4437.09 *181*	$4f^3$ $^4I^\circ_{4\frac{1}{2}}$ 174420 ±130 $^4I^\circ_{5\frac{1}{2}}$ 1398.34 $^4I^\circ_{6\frac{1}{2}}$ 2893.14 $^4I^\circ_{7\frac{1}{2}}$ 4453.76 *177, 180*	$4f^2$ $^3H_4$ 314200 ±100 $^3H_5$ 2152.2 $^3H_6$ 4389.1 *179*	$4f$ $^2F^\circ_{2\frac{1}{2}}$ 463400 ±400 $^2F^\circ_{3\frac{1}{2}}$ 3027.4 *99*	
60	Nd	$4f^4\ 6s^2$ $^5I_4$ 44270 ±150 $^5I_5$ 1128.055 $^5I_6$ 2366.595 $^5I_7$ 3681.690 $^5I_8$ 5048.605 *156, 190*	$4f^4\ 6s$ $^6I_{3\frac{1}{2}}$ 86500 ±650 $^6I_{4\frac{1}{2}}$ 513.330 $^6I_{5\frac{1}{2}}$ 1470.100 $^6I_{6\frac{1}{2}}$ 2585.460 $^6I_{7\frac{1}{2}}$ 3801.935 $^6I_{8\frac{1}{2}}$ 5085.650 *181, 190*				
61	Pm	$4f^5\ 6s^2$ $^6H^\circ_{2\frac{1}{2}}$ 44800 ±150 $^6H^\circ_{3\frac{1}{2}}$ 803.82 $^6H^\circ_{4\frac{1}{2}}$ 1748.78 $^6H^\circ_{5\frac{1}{2}}$ 2797.10 $^6H^\circ_{6\frac{1}{2}}$ 3919.03 $^6H^\circ_{7\frac{1}{2}}$ 5089.79 *154, 156*	$4f^5\ 6s$ $^7H^\circ_2$ 87900 ±650 $^7H^\circ_3$ 446.45 $^7H^\circ_4$ 1133.45 $^7H^\circ_5$ 1983.52 $^7H^\circ_6$ 2950.31 $^7H^\circ_7$ $^7H^\circ_8$ *153, 181*				
62	Sm	$4f^6\ 6s^2$ $^7F_0$ 45420 ±150 $^7F_1$ 292.58 $^7F_2$ 811.92 $^7F_3$ 1489.55 $^7F_4$ 2273.09 $^7F_5$ 3125.46 $^7F_6$ 4020.66 *2, 156*	$4f^6\ 6s$ $^8F_{0\frac{1}{2}}$ 89300 ±650 $^8F_{1\frac{1}{2}}$ 326.64 $^8F_{2\frac{1}{2}}$ 838.22 $^8F_{3\frac{1}{2}}$ 1489.16 $^8F_{4\frac{1}{2}}$ 2237.97 $^8F_{5\frac{1}{2}}$ 3052.65 $^8F_{6\frac{1}{2}}$ 3909.62 *1, 181*				
63	Eu	$4f^7\ 6s^2$ $^8S^\circ_{3\frac{1}{2}}$ 45740 ±80 *168*	$4f^7\ 6s$ $^9S^\circ_4$ 90700 *167, 181*				

TABLE 2. *Ionization limits and lowest terms*—continued

Z	Element	Spectrum I	Spectrum II	Spectrum III	Spectrum IV	Spectrum V	Spectrum VI
64	Gd	$4f^7\ 5d\ 6s^2$ ${}^9D^o_2$ 49530 ±110 ${}^9D^o_3$ 215.13 ${}^9D^o_4$ 532.98 ${}^9D^o_5$ 999.11 ${}^9D^o_6$ 1719.06 *156a, 165*	$4f^7\ 5d\ 6s$ ${}^{10}D^o_{2\frac{1}{2}}$ 97900 ±3000 ${}^{10}D^o_{3\frac{1}{2}}$ 261.81 ${}^{10}D^o_{4\frac{1}{2}}$ 633.27 ${}^{10}D^o_{5\frac{1}{2}}$ 1158.94 ${}^{10}D^o_{6\frac{1}{2}}$ 1935.30 *165, 181*				
65	Tb	$4f^9\ 6s^2$ ${}^6H^o_{7\frac{1}{2}}$ [47200] ±150 ${}^6H^o_{6\frac{1}{2}}$ ${}^6H^o_{5\frac{1}{2}}$ ${}^6H^o_{4\frac{1}{2}}$ ${}^6H^o_{3\frac{1}{2}}$ ${}^6H^o_{2\frac{1}{2}}$ *156, 176*	$4f^9\ 6s$ ${}^7H_8$ 92900 ±650 ${}^7H_7$ ${}^7H_6$ ${}^7H_5$ ${}^7H_4$ ${}^7H_3$ ${}^7H_2$ *181*				
66	Dy	$4f^{10}\ 6s^2$ ${}^5I_8$ 47820 ±150 ${}^5I_7$ 4134.24 ${}^5I_6$ 7050.61 ${}^5I_5$ ${}^5I_4$ *31, 156*	$4f^{10}\ 6s$ ${}^6I_{8\frac{1}{2}}$ 94100 ±650 ${}^6I_{7\frac{1}{2}}$ 4341.10 ${}^6I_{6\frac{1}{2}}$ 7485.09 ${}^6I_{5\frac{1}{2}}$ 7463.88 ${}^6I_{4\frac{1}{2}}$ 9432.07 ${}^6I_{3\frac{1}{2}}$ 10953.94 *31, 181*				
67	Ho	$4f^{11}\ 6s^2$ ${}^4I^o_{7\frac{1}{2}}$ 48540 ±150 ${}^4I^o_{6\frac{1}{2}}$ ${}^4I^o_{5\frac{1}{2}}$ ${}^4I^o_{4\frac{1}{2}}$ *156*	$4f^{11}\ 6s$ ${}^5I^o_8$ 95200 ±650 ${}^5I^o_7$ ${}^5I^o_6$ ${}^5I^o_5$ ${}^5I^o_4$ *181*				
68	Er	$4f^{12}\ 6s^2$ ${}^3H_6$ 49210 ±150 ${}^3H_5$ 6958.34 ${}^3H_4$ 10750.99 *117, 156*	$4f^{12}\ 6s$ ${}^4H_{6\frac{1}{2}}$ 96200 ±650 ${}^4H_{5\frac{1}{2}}$ 7149.7 ${}^4H_{4\frac{1}{2}}$ 11042.8 ${}^4H_{3\frac{1}{2}}$ 10894.1 *125, 181*				
69	Tm	$4f^{13}\ 6s^2$ ${}^2F^o_{3\frac{1}{2}}$ 49840 ±150 ${}^2F^o_{2\frac{1}{2}}$ 8771.25 *126, 156*	$4f^{13}\ 6s$ ${}^3F^o_4$ 97200 ±650 ${}^3F^o_3$ 236.94 ${}^3F^o_2$ 8769.69 *126, 181*	$4f^{13}$ ${}^2F^o_{3\frac{1}{2}}$ 191200 ±500 ${}^2F^o_{2\frac{1}{2}}$ 8774.02 *180a*			
70	Yb	$4f^{14}\ 6s^2$ ${}^1S_0$ 50441.0 ±0.2 *20a*	$4f^{14}\ 6s$ ${}^2S_{0\frac{1}{2}}$ 98150 *128*	$4f^{14}$ ${}^1S_0$ 203300 *20*			
71	Lu	$5d\ 6s^2$ ${}^2D_{1\frac{1}{2}}$ 43762.39 ±0.10 ${}^2D_{2\frac{1}{2}}$ 1993.92 *20b, 110*	$6s^2$ ${}^1S_0$ 112000 ±3000 *181*				
72	Hf	$5d^2\ 6s^2$ ${}^3F_2$ 56600 ${}^3F_3$ 2356.68 ${}^3F_4$ 4567.64 *127*	$5d\ 6s^2$ ${}^2D_{1\frac{1}{2}}$ 120000 ${}^2D_{2\frac{1}{2}}$ 3050.88 *137*	$5d^2$ ${}^3F_2$ 187800 ${}^3F_3$ 3288.7 ${}^3F_4$ 6095.1 *111*	$5d$ ${}^2D_{1\frac{1}{2}}$ 268500 ±800 ${}^2D_{2\frac{1}{2}}$ 4692.0 *111*		
73	Ta	$5d^3\ 6s^2$ ${}^4F_{1\frac{1}{2}}$ 63600 ${}^4F_{2\frac{1}{2}}$ 2010.10 ${}^4F_{3\frac{1}{2}}$ 3963.92 ${}^4F_{4\frac{1}{2}}$ 5621.04 *137*					

387-063 O - 70 (Face p. 6) No. 4

TABLE 2. *Ionization limits and lowest terms*—continued

Z	Element	Spectrum I	Spectrum II	Spectrum III	Spectrum IV	Spectrum V	Spectrum VI
74	W	$5d^4\ 6s^2$ $^5D_0$ 64400 $^5D_1$ 1670.29 $^5D_2$ 3325.53 $^5D_3$ 4830.00 $^5D_4$ 6219.33 *114, 137*					
75	Re	$5d^5\ 6s^2$ $^6S_{2\frac{1}{2}}$ 63530 *137*					
76	Os	$5d^6\ 6s^2$ $^5D_4$ 70450 $^5D_3$ 4159.32 $^5D_2$ 2740.49 $^5D_1$ 5766.14 $^5D_0$ 6092.79 *108, 137*					
77	Ir	$5d^7\ 6s^2$ $^4F_{4\frac{1}{2}}$ 73000 ±800 $^4F_{3\frac{1}{2}}$ 6323.96 $^4F_{2\frac{1}{2}}$ 5784.63 $^4F_{1\frac{1}{2}}$ 4078.95 *107*					
78	Pt	$5d^9\ 6s$ $^3D_3$ 72300 $^3D_2$ 775.9 $^3D_1$ 10132.0 *137*	$5d^9$ $^2D_{2\frac{1}{2}}$ 149723 $^2D_{1\frac{1}{2}}$ 8419.9 *137*				
79	Au	$5d^{10}\ 6s$ $^2S_{0\frac{1}{2}}$ 74410.0 *137*	$5d^{10}$ $^1S_0$ 165000 *137*				
80	Hg	$6s^2$ $^1S_0$ 84184.1 *137*	$5d^{10}\ 6s$ $^2S_{0\frac{1}{2}}$ 151280 *137*	$5d^{10}$ $^1S_0$ 276000 *137*			
81	Tl	$6s^2\ 6p$ $^2P^\circ_{0\frac{1}{2}}$ 49266.7 ±0.1 $^2P^\circ_{1\frac{1}{2}}$ 7792.7 *157*	$6s^2$ $^1S_0$ 164765 ±5 *137*	$6s$ $^2S_{0\frac{1}{2}}$ 240600 *137*			
82	Pb	$6p^2$ $^3P_0$ 59819.4 ±0.3 $^3P_1$ 7819.2626 $^3P_2$ 10650.3271 *189*	$6s^2\ 6p$ $^2P^\circ_{0\frac{1}{2}}$ 121243 ±3 $^2P^\circ_{1\frac{1}{2}}$ 14081.074 *137, 189*	$6s^2$ $^1S_0$ 257592 ±5 *137*	$6s$ $^2S_{0\frac{1}{2}}$ 341350 *137*	$5d^{10}$ $^1S_0$ 555000 *137*	
83	Bi	$6p^3$ $^4S^\circ_{1\frac{1}{2}}$ 58790 *137*	$6p^2$ $^3P_0$ 134600 $^3P_1$ 13324 $^3P_2$ 17030 *137*	$6s^2\ 6p$ $^2P^\circ_{0\frac{1}{2}}$ 206180 $^2P^\circ_{1\frac{1}{2}}$ 20788 *137*	$6s^2$ $^1S_0$ 365500 *137*	$6s$ $^2S_{0\frac{1}{2}}$ 451700 *137*	$5d^{10}$ $^1S_0$ 712000 *137*
84	Po	$6p^4$ $^3P_2$ 67885.3 $^3P_1$ 16831.61 $^3P_0$ 7514.69 *29*					
85	At						
86	Rn	$6p^6$ $^1S_0$ 86692.5 *137*					
87	Fr						
88	Ra	$7s^2$ $^1S_0$ 42577.35 *137*	$7s$ $^2S_{0\frac{1}{2}}$ 81842.31 *137*				
89	Ac	$6d\ 7s^2$ $^2D_{1\frac{1}{2}}$ [55600] $^2D_{2\frac{1}{2}}$ 2231.43 *65, 137*	$7s^2$ $^1S_0$ 97300 *137*				

TABLE 2. *Ionization limits and lowest terms* — Continued

Z	Element	Spectrum I	II	III	IV	V	VI
90	Th	$6d^2\ 7s^2$ $^3F_2$ $^3F_3$ 2869.260 $^3F_4$ 4961.661 *192*	$6d^2\ 7s$ $^4F_{1\frac{1}{2}}$ [93000] $^4F_{2\frac{1}{2}}$ 1521.91 $^4F_{3\frac{1}{2}}$ 4146.57 $^4F_{4\frac{1}{2}}$ 6213.55 *65, 124*	$6d^2$ $^3F_2$ 161000 $^3F_3$ 3992.7 $^3F_4$ 6474.9 *109*	$5f$ $^2F^{\circ}_{2\frac{1}{2}}$ 231900 $^2F^{\circ}_{3\frac{1}{2}}$ 4325.38 *112*		
91	Pa						
92	U						
93	Np						
94	Pu	$5f^6\ 7s^2$ $^7F_0$ 47000 $^7F_1$ 2203.55 $^7F_2$ 4299.55 $^7F_3$ 6144.34 $^7F_4$ 7774.45 $^7F_5$ 9179.05 $^7F_6$ 10238.24 *7, 8*					
95	Am	$5f^7\ 7s^2$ $^8S^{\circ}_{3\frac{1}{2}}$ 48770 *66*					

387-063 O - 70 (Face p. 6) No. 5

48. Edlén, B., Solar Physics **9,** No. 2, 439–445 (1969).
49. Edlén, B., unpublished material (1969), (1970).
50. Edlén, B., and Risberg, P., Ark. Fys. (Stockholm) **10,** No. 39, 553–566 (1956).
51. Edlén, B., and Swensson, J. W., unpublished material (Jan. 1970).
52. Ekberg, J. O., and Svensson, L. Å., unpublished material (Jan. 1970).
53. Eriksson, K. B. S., Ark. Fys. (Stockholm) **13,** No. 25, 303–329 (1958).
54. Eriksson, K. B. S., Ark. Fys. (Stockholm) **30,** No. 16, 199–202 (1965).
55. Eriksson, K. B. S., Ark. Fys. (Stockholm) **33,** No. 25, 357–360 (1966).
56. Eriksson, K. B. S., and Isberg, H. B. S., Ark. Fys. (Stockholm) **23,** No. 47, 527–542 (1963); **33,** No. 39, 593–595 (1966).
57. Eriksson, K. B. S., and Isberg, H. B. S., Ark. Fys. (Stockholm) **37,** No. 17, 221–230 (1968).
58. Even-Zohar, M., and Fraenkel, B. S., J. Opt. Soc. Am. **58,** No. 10, 1420–1421 (1968).
59. Fawcett, B. C., Burgess, D. D., and Peacock, N. J., Proc. Phys. Soc. (London) **91,** Part 4, No. 574, 970–972 (1967).
60. Fawcett, B. C., Gabriel, A. H., and Saunders, P. A. H., Proc. Phys. Soc. (London) **90,** Part 3, No. 569, 863–867 (1967).
61. Fawcett, B. C., Jones, B. B., and Wilson, R., Proc. Phys. Soc. (London) **78,** Part 6(i), No. 505, 1223–1226 (1961).
62. Fawcett, B. C., and Peacock, N. J., Proc. Phys. Soc. (London) **91,** Part 4, No. 574, 973–975 (1967).
63. Feldman, U., Cohen, L., and Swartz, M., Astroph. J. **148,** No. 2, 585–587 (1967).
64. Feldman, U., Cohen, L., and Swartz, M., J. Opt. Soc. Am. **57,** No. 4, 535–536 (1967).
65. Finkelnburg, W., und Humbach, W., Naturwiss. **42,** 35–37 (1955).
66. Fred, M., and Tomkins, F. S., J. Opt. Soc. Am. **47,** No. 12, 1076–1087 (1957).
67. Gabriel, A. H., Fawcett, B. C., and Jordan, C., Proc. Phys. Soc. (London) **87,** Part 3, No. 557, 825–839 (1966).
68. Garcia, J. D., and Mack, J. E., J. Opt. Soc. Am. **55,** No. 6, 654–685 (1965).
69. Garcia-Riquelme, O., Opt. Pura y Aplicada (Madrid) **1,** No. 2, 53–72 (1968).
70. Garton, W. R. S., and Codling, K., J. Phys. B (Proc. Phys. Soc. London) [2] **1,** No. 1, 106–113 (1968).
71. Garton, W. R. S., and Tomkins, F. S., Astroph. J. **158,** No. 3, 1219–1230 (1969).
72. Garton, W. R. S., and Wilson, M., Astroph. J. **145,** No. 1, 333–336 (1966).
73. Giuliani, J. F., and Thekaekara, M. P., J. Opt. Soc. Am. **54,** No. 4, 460–463 (1964).
74. Glad, S., Ark. Fys. (Stockholm) **10,** No. 22, 291–340 (1956).
75. Goldsmith, S., J. Opt. Soc. Am. **59,** No. 12, 1678–1679 (L) (1969).
76. Hallin, R., Ark. Fys. (Stockholm) **31,** No. 36, 511–526 (1966).
77. Hallin, R., Ark. Fys. (Stockholm) **32,** No. 11, 201–210 (1966).
78. Hallin, R., unpublished material (1969).
79. Handrup, M. B., and Mack, J. E., Physica **30,** No. 7, 1245–1275 (1964).
80. Harrison, G. R., Albertson, W. E., and Hosford, N. F., J. Opt. Soc. Am. **31,** No. 6, 439–448 (1941).
81. Herzberg, G., and Moore, H. R., Canadian J. Phys. **37,** No. 11, 1293–1313 (1959).
82. Iglesias, L., J. Opt. Soc. Am. **45,** No. 10, 856–861 (1955).
83. Iglesias, L., An. Real Soc. Esp. Fis. y Ouim. (Madrid) [A] **58,** Nos. 7, 8, 191–222 (1962); Opt. Pura y Aplicada (Madrid) **2,** 132–145 (1969).
84. Iglesias, L., Canadian J. Phys. **44,** No. 4, 895–915 (1966).
85. Iglesias, L., J. Res. Nat. Bur. Stand. (U.S.), **72A** (Phys. and Chem.) No. 4, 295–308 (July–Aug. 1968).
86. Iglesias, L., y Velasco, R., Publ. Inst. Opt. (Madrid) No. 23, 228 pp. (1964).
87. Isberg, B., Ark. Fys. (Stockholm) **35,** No. 45, 551–562 (1967).
88. Jakobsson, L. R., Ark. Fys. (Stockholm) **34,** No. 2, 19–31 (1967).
89. Jefferies, J. T., Mem. Soc. Roy. des Sci. de Liège **54,** Part 2, Section 3, 213–234 (1969).
90. Johansson, I., Ark. Fys. (Stockholm) **15,** No. 14, 169–179 (1959).
91. Johansson, I., Ark. Fys. (Stockholm) **20,** No. 7, 135–146 (1961).
92. Johansson, L., Ark. Fys. (Stockholm) **20,** No. 33, 489–498 (1961).
93. Johansson, L., Ark. Fys. (Stockholm) **23,** No. 12, 119–128 (1962).
94. Johansson, L., Ark. Fys. (Stockholm) **31,** No. 15, 201–235 (1966).
95. Johansson, I., and Contreras, R., Ark. Fys. (Stockholm) **37,** No. 31, 513–520 (1968).
96. Johansson, I., and Litzén, U., Ark. Fys. (Stockholm) **34,** No. 46, 573–587 (1967).
97. Kaufman, V., and Andrew, K. L., J. Opt. Soc. Am. **52,** No. 11, 1223–1237 (1962).
98. Kaufman, V., and Radziemski, L. J., Jr., J. Opt. Soc. Am. **59,** No. 2, 227–228 (L) (1969).
99. Kaufman, V., and Sugar, J., J. Res. Nat. Bur. Stand. (U.S.), **71A** (Phys. and Chem.) No. 6, 583–585 (Nov.–Dec. 1967).
100. Kaufman, V., and Ward, J. F., J. Opt. Soc. Am. **56,** No. 11, 1591–1597 (1966).
101. Kessler, K. G., J. Res. Nat. Bur. Stand. (U.S.), **63A** (Phys. and Chem.) No. 3, 213–251 (May–June 1959).
102. Kiess, C. C., J. Res. Nat. Bur. Stand. (U.S.) **47,** No. 5, 385–426 (1951), RP2266.
103. Kiess, C. C., J. Res. Nat. Bur. Stand. (U.S.) **51,** No. 5, 247–305 (1953), RP2457.
104. Kiess, C. C., J. Res. Nat. Bur. Stand. (U.S.) **56,** No. 4, 167–177 (1956), RP2663.
106. Kim, H. H., J. Opt. Soc. Am. **58,** No. 5, 739–740 (A) (1968).
107. van Kleef, Th. A. M., Physica **23,** No. 9, 843–897 (1957).
108. van Kleef, Th. A. M., and Klinkenberg, P. F. A., Physica **27,** No. 1, 83–94 (1961).
109. Klinkenberg, P. F. A., Physica **16,** Nos. 7, 8, 618–650 (1950).
110. Klinkenberg, P. F. A., Physica **21,** No. 1, 53–62 (1954).
111. Klinkenberg, P. F. A., van Kleef, Th. A. M., and Noorman, P. E., Physica **27,** No. 12, 1177–1188 (1961).
112. Klinkenberg, P. F. A., and Lang, R. J., Physica **15,** Nos. 8, 9, 774–788 (1949).
113. Lang, R. J., Canadian J. Research **A14,** 127–130 (1936).
114. Laun, D. D., and Corliss, C. H., J. Res. Nat. Bur. Stand. (U.S.), **72A** (Phys. and Chem.) No. 6, 609–755 (Nov.–Dec. 1968).
115. Lidén, K., Ark. Fys. (Stockholm) **1,** No. 9, 229–267 (1949).
116. Lotz, W., J. Opt. Soc. Am. **57,** No. 7, 873–880 (1967).
117. Marquet, L. C., and Davis, S. P., J. Opt. Soc. Am. **55,** No. 5, 471–474 (1965).
118. Martin, W. C., J. Opt. Soc. Am. **49,** No. 11, 1071–1085 (1959).
119. Martin, W. C., J. Res. Nat. Bur. Stand. (U.S.), **64A** (Phys. and Chem.) No. 1, 19–28 (Jan.–Feb. 1960) and unpublished material (1970).
120. Martin, W. C., J. Opt. Soc. Am. **53,** No. 9, 1047–1050 (1963).
121. Martin, W. C., and Corliss, C. H., J. Res. Nat. Bur. Stand. (U.S.), **64A** (Phys. and Chem.) No. 6, 443–479 (Nov.–Dec. 1960).
122. Martin, W. C., and Kaufman, V., J. Res. Nat. Bur Stand. (U.S.), **74A** (Phys. and Chem.) No. 1, 11–22 (Mar.–Apr. 1970).
123. McConkey, J. W., and Kernahan, J. A., Phys. Lett. (Amsterdam) **27A,** No. 2, 82–83 (1968).

124. McNally, J. R., Jr., Harrison, G. R., and Park, H. B., J. Opt. Soc. Am. **32,** No. 6, 334–347 (1942).
125. McNally, J. R., Jr., and Vander Sluis, K. L., J. Opt. Soc. Am. **49,** No. 2, 200 (1959).
126. Meggers, W. F., Rev. Mod. Phys. **14,** Nos. 2, 3, 96–103 (1942).
127. Meggers, W. F., unpublished analysis (1959).
128. Meggers, W. F., and Moore, C. E. (Editor), J. Res. Nat. Bur. Stand. (U.S.), **71A** (Phys. and Chem.) No. 6, 396–544 (Nov.–Dec. 1967).
129. Midtal, J., and Aashamar, K., Norvegica **2,** No. 2, 99–109 (1967).
130. Minnhagen, L., Ark. Fys. (Stockholm) **18,** No. 8, 97–134 (1960).
131. Minnhagen, L., Ark. Fys. (Stockholm) **21,** No. 26, 415–478 (1962).
132. Minnhagen, L., unpublished material (September 1967).
133. Minnhagen, L., private communication (June 1969).
134. Minnhagen, L., and Hallén, K., private communication (1969).
135. Moore, C. E., "Atomic Energy Levels," Nat. Bur. Stand. (U.S.), Circ. 467, Vol. I (1949).
136. Moore, C. E., "Atomic Energy Levels," Nat. Bur. Stand. (U.S.), Circ. 467, Vol. II (1952).
137. Moore, C. E., "Atomic Energy Levels," Nat. Bur. Stand. (U.S.), Circ. 467, Vol. III (1958).
138. Moore, F. L., Jr., unpublished material (1967).
139. Odabasi, H., J. Opt. Soc. Am. **57,** No. 12, 1459–1463 (1967).
140. Ölme, A., Ark. Fys. (Stockholm) **40,** No. 2, 35–47 (1969).
141. Ölme, A., unpublished material (1970).
142. Ölme, A., Edlén, B., Johns, J. W. C., and Herzberg, G., See J. Opt. Soc. Am. **60,** No. 7, 889–891 (1970).
143. Palenius, H. P., Ark. Fys. (Stockholm) **37,** No. 23, 368–369 (A) (1968); **39,** No. 3, 15–69 (1968); **39,** No. 39, 425–427 (1969).
144. Palenius, H. P., First Ann. Conf. European Assoc. At. Sp. (A), Paris-Orsay (1969) and unpublished material (1969).
145. Pekeris, C. L., Phys. Rev. **112,** No. 5, 1649–1658 (1958); **126,** No. 4, 1470–1476 (1962).
146. Persson, W., and Minnhagen, L., Ark. Fys. (Stockholm) **37,** No. 22, 273–300 (1968).
147. Petersson, B., Ark. Fys. (Stockholm) **27,** No. 23, 317–319 (1964).
148. Poppe, R., Physica **40,** No. 1, 17–26 (1968).
149. Racah, G., Bull. Research Council Israel **5A,** 78 (1955).
150. Radziemski, L. J., Jr., Andrew, K. L., Kaufman, V., and Litzén, U., J. Opt. Soc. Am. **57,** No. 3, 336–340 (1967).
151. Radziemski, L. J., Jr., and Kaufman, V., J. Opt. Soc. Am. **59,** No. 4, 424–443 (1969).
152. Rao, Y. B., Indian J. Phys. **32,** No. 11, 497–515 (1958).
153. Reader, J., and Davis, S. P., Program, Atomic Sp. Symposium, Nat. Bur. Stand. (U.S.), p. 79 (A) (1967).
154. Reader, J., and Davis, S. P., J. Res. Nat. Bur. Stand. (U.S.), **71A** (Phys. and Chem.) No. 6, 587–599 (Nov.–Dec. 1967).
155. Reader, J., and Epstein, G. L., J. Opt. Soc. Am. **60,** No. 1, 140 (L) (1970).
155a. Reader, J., and Epstein, G. L., private communication (April 1970).
156. Reader, J., and Sugar, J., J. Opt. Soc. Am. **56,** No. 9, 1189–1194 (1966).
156a. Reader, J., and Sugar, J., J. Opt. Soc. Am. **60,** in press (L) (1970).
157. Reeves, E. M., Garton, W. R. S., and Bass, A., Proc. Phys. Soc. (London) **86,** Part 5, No. 553, 1077–1080 (1965).
158. Rico, F. R., An. Real Soc. Esp. Fis. y Quim. (Madrid) [A] **61,** Nos. 3, 4, 103–118 (1965).
159. Risberg, G., Ark. Fys. (Stockholm) **28,** No. 32, 381–395 (1965).
160. Risberg, G., Ark. Fys. (Stockholm) **37,** No. 18, 231–249 (1968).
161. Risberg, P., Ark. Fys. (Stockholm) **9,** No. 31, 483–494 (1955).
162. Risberg, P., Ark. Fys. (Stockholm) **10,** No. 41, 583–606 (1956).
163. Ross, C. B., Jr., Thesis, Purdue University (June 1969).
165. Russell, H. N., J. Opt. Soc. Am. **40,** No. 9, 550–575 (1950).
166. Russell. H. N., J. Opt. Soc. Am. **40,** No. 9, 618–619 (1950).
167. Russell, H. N., Albertson, W., and Davis, D. N., Phys. Rev. **60,** No. 9, 641–656 (1941).
168. Russell, H. N., and King, A. S., Astroph. J. **90,** No. 1, 155–203 (1939).
169. Schröder, J. F., Dissertation, Amsterdam (1970).
169a. Seaton, M. J., Proc. Phys. Soc. (London) **88,** Part 4, No. 562, 815–832 (1966).
170. Shenstone, A. G., J. Opt. Soc. Am. **44,** No. 10, 749–759 (1954).
171. Shenstone, A. G., Canadian J. Phys. **38,** No. 5, 677–692 (1960).
172. Shenstone, A. G., Proc. Roy. Soc. London [A] **261,** No. 1305, 153–174 (1961).
173. Shenstone, A. G., J. Res. Nat. Bur. Stand. (U.S.), **67A** (Phys. and Chem.) No. 2, 87–112 (Mar.–Apr. 1963).
174. Shenstone, A. G., unpublished material (Dec. 1965).
175. Shenstone, A. G., and Meggers, W. F., J. Res. Nat Bur. Stand. (U.S.) **61,** No. 5, 373–411 (1958) RP2908.
176. Sugar, J., J. Res. Nat. Bur. Stand. (U.S.), **66A** (Phys. and Chem.) No. 4, 321–324 (July–Aug. 1962).
177. Sugar, J., J. Opt. Soc. Am. **53,** No. 7, 831–839 (1963).
178. Sugar, J., J. Opt. Soc. Am. **55,** No. 1, 33–58 (1965) and unpublished material (1970).
179. Sugar, J., J. Opt. Soc. Am. **55,** No. 9, 1058–1061 (1965) and unpublished material (1970).
180. Sugar, J., J. Res. Nat. Bur. Stand. (U.S.), **73A** (Phys. and Chem.) No. 3, 333–381 (May–June 1969).
180a. Sugar, J., J. Opt. Soc. Am. **60,** No. 4, 454–466 (1970).
181. Sugar, J., and Reader, J., J. Opt. Soc. Am. **55,** No. 10, 1286–1290 (1965).
182. Svensson, L. Å., and Ekberg, J. O., Ark. Fys. (Stockholm) **37,** No. 7, 65–84 (1968).
183. Svensson, L. Å., and Ekberg, J. O., Ark. Fys. (Stockholm) **40,** No. 14, 145–163 (1969).
184. Tech, J. L., J. Res. Nat. Bur. Stand. (U.S.), **67A** (Phys. and Chem.) No. 6, 505–554 (Nov.–Dec. 1963).
185. Toresson, Y. G., Ark. Fys. (Stockholm) **17,** No. 12, 179–192 (1960).
186. Toresson, Y. G., Ark. Fys. (Stockholm) **18,** No. 28, 389–416 (1960).
187. Velasco, R., and Adames, J., Publ. Inst. Opt. (Madrid) No. 26, 124 pp. (1966).
188. Velasco, R., and Gullón, M. N., Opt. Pura y Aplicada (Madrid) **1,** No. 2, 93–102 (1968).
189. Wood, D. R., and Andrew, K. L., J. Opt. Soc. Am. **58,** No. 6, 818–829 (1968).
190. Wyart, J.-F., Thèse, Univ. Paris (Orsay), 105 pp. (1968).
191. Yoshino, K., J. Opt. Soc. Am. **59,** No. 11, 1525–1526 (A) (1969).
192. Zalubas, R., J. Opt. Soc. Am. **58,** No. 9, 1195–1199 (1968).
193. Zalubas, R., unpublished material (1969).
194. Moore, C. E., Nat. Bur. Stand. (U.S.), Spec. Publ. 306, Sections 1–4 (1969).
195. Beardon, J. A., and others, Physics Today **17,** No. 2, 48–49 (1964).
196. Ionov, N. I., and Mittsev, M. A., J. Exptl. Theoret. Phys. **13,** No. 3, 518–519 (1961); **11,** No. 4, 972–973 (L) (1960).
197. Bakulina, I. N., and Ionov, N. I., J. Exptl. Theoret. Phys. **9,** No. 4, 709–712 (1959).
198. Smith, D. H., and Hertel, G. R., J. Chem. Phys. **51,** No. 7, 3105–3107 (1969).
199. Faktor, M. M., and Hanks, R., J. Inorg. Nucl. Chem. **31,** No. 6, 1649–1659 (1969).
200. Taylor, B. N., Parker, W. H., and Langenberg, D. N., Rev. Modern Physics **41,** 375 (1969).

(cut here)

Announcement of New Publications on Standard Reference Data

Superintendent of Documents,
Government Printing Office,
Washington, D.C. 20402

Dear Sir:

Please add my name to the announcement list of new publications to be issued in the series: National Standard Reference Data Series—National Bureau of Standards.

Name____

Company____

Address____

City______________ State______________ Zip Code______________

(Notification Key N337)

Publications in the National Standard Reference Data Series National Bureau of Standards

You may use this listing as your order form by checking the proper box of the publication(s) you desire or by providing the full identification of the publication you wish to purchase. The full letter symbols with each publications number and full title of the publication and author must be given in your order, e.g. NSRDS–NBS–17, Tables of Molecular Vibrational Frequencies, Part 3, by T. Shimanouchi.

Pay for publications by check, money order, or Superintendent of Documents coupons or deposit account. Make checks and money orders payable to Superintendent of Documents. Foreign remittances should be made either by international money order or draft on an American bank. Postage stamps are not acceptable.

No charge is made for postage to destinations in the United States and possessions, Canada, Mexico, and certain Central and South American countries. To other countries, payments for documents must cover postage. Therefore, one-fourth of the price of the publication should be added for postage.

Send your order together with remittance to Superintendent of Documents, Government Printing Office, Washington, D.C. 20402.

(cut here)

- ☐ NSRDS-NBS 1, **National Standard Reference Data System—Plan of Operation,** by E. L. Brady and M. B. Wallenstein, 1964 (15 cents).
- ☐ NSRDS-NBS 2, **Thermal Properties of Aqueous Uni-univalent Electrolytes,** by V. B. Parker, 1965 (45 cents).
- ☐ NSRDS-NBS 3, Sec. 1, **Selected Tables of Atomic Spectra, Atomic Energy Levels and Multiplet Tables, Si II, Si III, Si IV,** by C. E. Moore, 1965 (35 cents).
- ☐ NSRDS-NBS 3, Sec. 2, **Selected Tables of Atomic Spectra, Atomic Energy Levels and Multiplet Tables, Si I,** by C. E. Moore, 1967 (20 cents).
- ☐ NSRDS-NBS 3, Sec. 3, **Selected Tables of Atomic Spectra, Atomic Energy Levels and Multiplet Tables, C I, C II, C III, C IV, C V, C VI,** by C. E. Moore, 1970 (in press).
- ☐ NSRDS-NBS 4, **Atomic Transition Probabilities, Volume 1, Hydrogen Through Neon,** by W. L. Wiese, M. W. Smith and B. M. Glennon, 1966 ($2.50).
- ☐ NSRDS-NBS 5, **The Band Spectrum of Carbon Monoxide,** by P. H. Krupenie, 1966 (70 cents).
- ☐ NSRDS-NBS 6, **Tables of Molecular Vibrational Frequencies, Part 1,** by T. Shimanouchi, 1967 (40 cents).
- ☐ NSRDS-NBS 7, **High Temperature Properties and Decomposition of Inorganic Salts, Part 1, Sulfates,** by K. H. Stern and E. L. Weise, 1966 (35 cents).
- ☐ NSRDS-NBS 8, **Thermal Conductivity of Selected Materials,** by R. W. Powell, C. Y. Ho, and P. E. Liley, 1966 ($1.00).
- ☐ NSRDS-NBS 9, **Bimolecular Gas Phase Reactions (rate coefficients),** by A. F. Trotman-Dickenson and G. S. Milne, 1967 ($2).
- ☐ NSRDS-NBS 10, **Selected Values of Electric Dipole Moments for Molecules in the Gas Phase,** by R. D. Nelson, Jr., D. R. Lide, Jr., and A. A. Maryott, 1967 (40 cents).
- ☐ NSRDS-NBS 11, **Tables of Molecular Vibrational Frequencies, Part 2,** by T. Shimanouchi, 1967 (30 cents).
- ☐ NSRDS-NBS 12, **Tables for the Rigid Asymmetric Rotor: Transformation Coefficients from Symmetric to Asymmetric Bases and Expectation Values of P_z^2, P_z^4, and P_z^6,** by R. H. Schwendeman, 1968 (60 cents).
- ☐ NSRDS-NBS 13, **Hydrogenation of Ethylene on Metallic Catalysts,** by J. Horiuti and K. Miyahara, 1968 ($1.00).
- ☐ NSRDS-NBS 14, **X-Ray Wavelengths and X-Ray Atomic Energy Levels,** by J. A. Bearden, 1967 (40 cents).
- ☐ NSRDS-NBS 15, **Molten Salts, Vol. 1, Electrical Conductance, Density, and Viscosity Data,** by G. Janz, F. W. Dampier, G. R. Lakshminarayanan, P. K. Lorenz, and R. P. T. Tomkins, 1968 ($3).
- ☐ NSRDS-NBS 16, **Thermal Conductivity of Selected Materials, Part 2,** by C. Y. Ho, R. W. Powell, and P. E. Liley, 1968 ($2).
- ☐ NSRDS-NBS 17, **Tables of Molecular Vibration Frequencies, Part 3,** by T. Shimanouchi, 1968 (30 cents).
- ☐ NSRDS-NBS 18, **Critical Analysis of the Heat-Capacity Data of the Literature and Evaluation of Thermodynamic Properties of Copper, Silver, and Gold From 0 to 300 K,** by G. T. Furukawa, W. G. Saba, and M. L. Reilly, 1968 (40 cents).
- ☐ NSRDS-NBS 19, **Thermodynamic Properties of Ammonia as an Ideal Gas,** by L. Haar, 1968 (20 cents).
- ☐ NSRDS-NBS 20, **Gas Phase Reaction Kinetics of Neutral Oxygen Species,** by H. S. Johnson, 1968 (45 cents).
- ☐ NSRDS-NBS 21, **Kinetic Data on Gas Phase Unimolecular Reactions,** by S. W. Benson and H. E. O'Neal ($7).
- ☐ NSRDS-NBS 22, **Atomic Transition Probabilities, Vol. II, Sodium Through Calcium, A Critical Data Compilation,** by W. L. Wiese, M. W. Smith, and B. M. Miles ($4.50).
- ☐ NSRDS-NBS 23, **Partial Grotrian Diagrams of Astrophysical Interest,** by C. E. Moore and P. W. Merrill, 1968 (55 cents).
- ☐ NSRDS-NBS 24, **Theoretical Mean Activity Coefficients of Strong Electrolytes in Aqueous Solutions from 0 to 100° C,** by Walter J. Hamer, 1968 ($4.25).
- ☐ NSRDS-NBS 25, **Electron Impact Excitation of Atoms,** by B. L. Moiseiwitsch and S. J. Smith, 1968 ($2).
- ☐ NSRDS-NBS 26, **Ionization Potentials, Appearance Potentials, and Heats of Formation of Positive Ions,** by J. L. Franklin, J. G. Dillard, H. M. Rosenstock, J. T. Herron, K. Draxl, and F. H. Field ($4).
- ☐ NSRDS-NBS 27, **Thermodynamic Properties of Argon from the Triple Point to 300 K at Pressures to 1000 Atmospheres,** by A. L. Gosman, R. D. McCarty, and J. G. Hust ($1.25).
- ☐ NSRDS-NBS 28, **Molten Salts, Vol. 2, Section 1, Electrochemistry of Molten Salts: Gibbs Free Energies and Excess Free Energies From Equilibrium-Type Cells,** by G. J. Janz and C. G. M. Dijkhuis. **Section 2, Surface Tension Data,** by G. J. Janz, G. R. Lakshminarayanan, R. P. T. Tomkins, and J. Wong ($2.75).
- ☐ NSRDS-NBS 29, **Photon Cross Sections, Attenuation Coefficients and Energy Absorption Coefficients From 10 keV to 100 GeV,** by J. H. Hubbell (75 cents).
- ☐ NSRDS-NBS 30, **High Temperature Properties and Decomposition of Inorganic Salts, Part 2, Carbonates,** by K. H. Stern and E. L. Weise (45 cents).
- ☐ NSRDS-NBS 31, **Bond Dissociation Energies in Simple Molecules,** by B. deB. Darwent (55 cents).
- ☐ NSRDS-NBS 32, **Phase Behavior in Binary and Multicomponent Systems at Elevated Pressures: *n* Pentane and Methane *n* Pentane,** by V. M. Berry, 1970 (in press).
- ☐ NSRDS-NBS 33, **Electrolytic and Conductance and the Conductances of the Acids in Water,** by W. J. Hamer and H. J. DeWane, 1970 (in press).
- ☐ NSRDS-NBS 34, **Ionization Potentials and Ionization Limits Derived from the Analyses of Optical Spectra,** by C. E. Moore, 1970 (in press).

U.S. GOVERNMENT PRINTING OFFICE : 1970 OL—387-063

NBS TECHNICAL PUBLICATIONS

PERIODICALS

JOURNAL OF RESEARCH reports National Bureau of Standards research and development in physics, mathematics, chemistry, and engineering. Comprehensive scientific pape[illegible] of the work, including labora[illegible] procedures, and theoretical and mathematical analyses. Illustrated with photographs, drawings, and charts.

Published in three sections, available separately:

- **Physics and Chemistry**

Papers of interest primarily to scientists working in these fields. This section covers a broad range of physical and chemical research, with major emphasis on standards of physical measurement, fundamental constants, and properties of matter. Issued six times a year. Annual subscription: Domestic, $9.50; foreign, $11.75*.

- **Mathematical Sciences**

Studies and compilations designed mainly for the mathematician and theoretical physicist. Topics in mathematical statistics, theory of experiment design, numerical analysis, theoretical physics and chemistry, logical design and programming of computers and computer systems. Short numerical tables. Issued quarterly. Annual subscription: Domestic, $5.00; foreign, $6.25*.

- **Engineering and Instrumentation**

Reporting results of interest chiefly to the engineer and the applied scientist. This section includes many of the new developments in instrumentation resulting from the Bureau's work in physical measurement, data processing, and development of test methods. It will also cover some of the work in acoustics, applied mechanics, building research, and cryogenic engineering. Issued quarterly. Annual subscription: Domestic, $5.00; foreign, $6.25*.

TECHNICAL NEWS BULLETIN

The best single source of information concerning the Bureau's research, developmental, cooperative and publication activities, this monthly publication is designed for the industry-oriented individual whose daily work involves intimate contact with science and technology—*for engineers, chemists, physicists, research managers, product-development managers, and company executives.* Annual subscription: Domestic, $3.00; foreign, $4.00*.

* Difference in price is due to extra cost of foreign mailing.

NONPERIODICALS

Applied Mathematics Series. Mathematical tables, manuals, and studies.

Building Science Series. Research results, test [illegible]ance criteria of building ma[illegible]tems, and structures.

Handbooks. Recommended codes of engineering and industrial practice (including safety codes) developed in cooperation with interested industries, professional organizations, and regulatory bodies.

Special Publications. Proceedings of NBS conferences, bibliographies, annual reports, wall charts, pamphlets, etc.

Monographs. Major contributions to the technical literature on various subjects related to the Bureau's scientific and technical activities.

National Standard Reference Data Series. NSRDS provides quantitative data on the physical and chemical properties of materials, compiled from the world's literature and critically evaluated.

Product Standards. Provide requirements for sizes, types, quality and methods for testing various industrial products. These standards are developed cooperatively with interested Government and industry groups and provide the basis for common understanding of product characteristics for both buyers and sellers. Their use is voluntary.

Technical Notes. This series consists of communications and reports (covering both other agency and NBS-sponsored work) of limited or transitory interest.

Federal Information Processing Standards Publications. This series is the official publication within the Federal Government for information on standards adopted and promulgated under the Public Law 89-306, and Bureau of the Budget Circular A-86 entitled, Standardization of Data Elements and Codes in Data Systems.

CLEARINGHOUSE

The Clearinghouse for Federal Scientific and Technical Information, operated by NBS, supplies unclassified information related to Government-generated science and technology in defense, space, atomic energy, and other national programs. For further information on Clearinghouse services, write:

Clearinghouse
U.S. Department of Commerce
Springfield, Virginia 22151

Order NBS publications from: Superintendent of Documents
Government Printing Office
Washington, D.C. 20402

U.S. DEPARTMENT OF COMMERCE
WASHINGTON, D.C. 20230

OFFICIAL BUSINESS

POSTAGE AND FEES PAID
U.S. DEPARTMENT OF COMMERCE