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Spectral Data and Grotrian Diagrams for Highly Ionized Cobalt, Co VIII through Co XXVII

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Wavelengths, energy levels, level classifications, oscillator strengths, and atomic transition probabilities for the cobalt ions Co VIII to Co XXVII are tabulated. A short review is given for the wavelength measurements on each stage of ionization. Grotrian diagrams are also presented to provide graphical overviews. The literature has been surveyed to March 1990.

Key words: atomic data; cobalt; energy levels; Grotrian diagrams; ions; oscillator strengths; spectra; transition probabilities; wavelengths.

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1. Introduction

We have undertaken to publish a series of compilations of spectra of highly ionized atoms of particular interest to the fusion energy community. These selected elements occur as impurities in wall materials of fusion machines or are specifically injected into the hot plasmas for diagnostics. Much new work on these spectra has appeared in recent years. We have critically compiled these data into single monographs for each element, each including wavelengths, classifications, intensities, Grotrian diagrams, and a short review of the literature for each ion. Oscillator strength and radiative transition probability data have been tabulated, when available, in order to facilitate identification of emission lines. Monographs are already published for Ti, Fe, Ni, Cu and Mo.[1–5] The present compilation contains data for Co VIII to Co XXVII.

All relevant papers published through March 1990 were collected and surveyed, and the best measurements, in our judgement, were included in the tables. We consulted the following comprehensive compilations: For wavelength data, Kelly (1987)[6] and Kaufman and Sugar (1986)[7] for forbidden lines arising within ground configurations of the type ns^2np^k ($n=2$ and 3, $k=1$ to 5), as well as a review article by Fawcett (1984)[8].

For energy level data, Sugar and Corliss (1985)[9] published a comprehensive critical compilation for the iron-group elements in all stages of ionization. Their values are adopted for this compilation, except where superseded by more recent data. For the He- and H-sequences, only theoretical results are given since they are considered to be more accurate than the experimental values. For atomic transition probabilities, calculations for numerical data in various approximations have been reported for allowed and forbidden transitions, including multiconfiguration Dirac-Fock calculations. Brief reviews of such theoretical data are given in the critical data compilation of allowed and forbidden lines by Fuhr et al. (1988)[10], from which the oscillator strength (f) and transition probability (A) data are taken.

In cases where no experimental wavelength data are available but for which transition probability data exist, the wavelengths are calculated from the energy levels quoted here using the Ritz combination principle. The wavelengths are used to calculate A-values from line strength data or f-values. We give wavelengths in air above 2000 Å and in vacuum below 2000 Å. For conversion of ionization energies from cm^{-1} to eV, we use the conversion factor 8065.5410(0.0024) cm^{-1}/eV given by Cohen and Taylor (1987)[11].

In the following section we give brief comments on each ion, including comments on the accuracy of the wavelength data.

1.1. Acknowledgments

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1.2. References for Introduction

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2. Brief Comments on Each Cobalt Ion

Co VIII (Ca sequence)

Ground state: $1s^22s^22p^63s^23p^63d^2\ ^3F_2$

Alexander *et al.* (1966)[3] classified 19 lines of the $3d^2-3d4f$ array in the range of 122.2 – 125.6 Å. An extension of the analysis was carried out by Fawcett *et al.* (1980)[28] who classified 135 lines belonging to $3p^63d^2-3p^53d^3$ and $3d^2-3d4p$, $4f$, $5f$ arrays in the range of 102.0 – 192.7 Å. We have adopted their wavelengths. The uncertainties of the wavelengths are ±0.007 to ±0.015 Å for the former two arrays in the range 153.0 – 192.7 Å and ±0.004 Å for the latter two arrays in the range of 102.0 – 134.0 Å.

Co IX (K sequence)

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

Alexander *et al.* (1965)[2] classified the $3d\ ^2D-nf\ ^2F^o$ doublets for n = 4 – 10 in the range of 70.9 – 108.7 Å.

The $3p^63d-3p^53d^2$ array was observed by Gabriel *et al.* (1966)[36] and by Goldsmith (1969)[37] who also identified the $3d$ ^{2}D$-4p$ ^{2}P° doublet in the range of 159−160 Å. A further extension with improved measurements was made by Ramonas and Ryabtsev (1980)[51], who classified 18 lines in the range of 152.7−213.6 Å, including new lines due to $3p^63d$ ^{2}D$-3p^53d^2$ (^{1}D) ^{2}F° and (^{1}G) ^{2}F°, and revised the $3d$ $^2D_{3/2}-4p$ $^2P^\circ_{1/2}$ transition. The uncertainty of their wavelengths is ±0.003 Å.

Hoory *et al.* (1970)[39] measured the spectral lines in the wavelength range of 95.8−101.5 Å with an uncertainty of ±0.005 Å and identified them as the $3p^63d-3p^53d4s$ transitions.

Co x (Ar sequence)

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

Alexander *et al.* (1965)[2] classified transitions from the $3p^54s^3$, $^1P^\circ_1$ and $3p^54d^3$, $^1P^\circ_1$ levels to the ground level at ~90 Å and ~72 Å.

The $3p^6$ $^1S_0-3p^53d$ $^1P^\circ_1$ line measured by Gabriel *et al.* (1966)[36] was found to be 158.873±0.005 Å by Goldsmith (1969)[37] and 158.88±0.03 Å by Fawcett and Hayes (1972)[26]. The wavelength of Ref. 37 is given here.

The $3p^53d-3p^54f$ transitions were classified by Fawcett *et al.* (1972)[27], including 11 lines in the range of 94.4−98.3 Å. Remeasured wavelengths with uncertainties of ±0.01 Å in the extended range of 94.4−111.6 Å were reported by Swartz *et al.* (1976)[61]. They also classified the lines at 63.017 Å and 62.332 Å as transitions from the $3p^55s$ $^{3,1}P^\circ_1$ levels to the ground level.

An isoelectronic comparison of measured wavelengths of the $3p^6$ $^1S_0-3p^53d$ $^3D_1$ spin-forbidden transition with relativistic Hartree-Fock calculations was carried out by Sugar *et al.* (1987)[58] for Fe^{8+} through Mo^{24+}. They obtained a fitted wavelength value of 200.893±0.005 Å for Co.

Co xi (Cl sequence)

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

The solar coronal line at 5188.5 Å (in air) was identified by Price (1964)[50] as the magnetic-dipole $^2P^\circ_{3/2}-^2P^\circ_{1/2}$ transition in the configuration $3s^23p^5$. This wavelength value is, however, inconsistent with the present level scheme. We give the wavelength of 5168 Å (in air), calculated from energy levels.

The classification of $3p^5-3p^44s$ lines in the wavelength range of 81.5−84.1 Å was carried out by Edlén (1937)[18]. An additional $3p^5$ $^2P^\circ_{3/2}-3p^44s$ $^4P_{5/2}$ line at 84.67±0.015 Å was measured by Fawcett *et al.* (1972)[27] using a laser-produced plasma source. They also classified the $3p^5-3p^44d$ and $3p^43d-3p^44f$ transitions in the ranges of 66.1−68.0 Å and 84.7−87.3 Å.

Wavelengths of the $3p^5-3p^43d$ transitions in the range of 158.2−177.6 Å were reported by Gabriel *et al.* (1966)[36], Goldsmith (1969)[37], and Fawcett and Hayes (1972)[26]. The wavelengths with uncertainties of ±0.005 Å are taken from Ref. 37.

Fawcett and Hayes (1972)[26] and Fawcett and Hatter (1980)[29] classified the lines at 318.85±0.03 Å and 339.81±0.03 Å, respectively, as transitions from the $3s3p^6$ $^2S_{1/2}$ level to the ground $3s^23p^5$ $^2P^\circ_{3/2,1/2}$ levels.

Co xii (S sequence)

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

Wavelengths for magnetic-dipole transitions within the ground configuration $3s^23p^4$, except for the line at 3801.2 Å (in air) for the $^3P_1-^1D_2$ transition identified by Price (1964)[50] in the solar corona, have been calculated from energy levels of Smitt *et al.* (1976)[56].

Fawcett and Hayes (1972)[26] measured wavelengths of 10 lines due to the $3p^4-3p^33d$ transitions in the range of 165.8−180.5 Å. The wavelength uncertainty is ±0.03 Å. In Ref. 26, a revised classification for the line at 168.34 Å of Gabriel *et al.* (1966)[36] was given. Improved measurements of the transitions $3s^23p^4$ $^3P-3s3p^5$ $^3P^\circ$ and $^1D_2-^1P^\circ_1$ previously classified by Fawcett and Hayes (1972)[26] in the wavelength range of 286.6−344.0 Å were carried out by Fawcett and Hatter (1980)[29], whose wavelengths with uncertainties of ±0.02 Å are given here.

Fawcett *et al.* (1972)[27] measured the $3p^4-3p^34d$ and $3p^33d-3p^34f$ arrays in the ranges of ~63 Å and ~80 Å, respectively, with an uncertainty of ±0.015 Å.

Co xiii (P sequence)

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

Wavelengths for magnetic-dipole transitions within the ground configuration $3s^23p^3$ have been obtained from level values predicted by Smitt *et al.* (1976)[56]. No observations of lines connecting the quartet and the doublet systems have been reported.

Fawcett and Hayes (1972)[26] analyzed the $3s^23p^3-3s3p^4$ and $3s^23p^3-3s^23p^23d$ arrays in the wavelength ranges of 263.4−338.8 Å and 174.8−188.9 Å. Improved measurements of the former array with wavelength uncertainty of ±0.02 Å were carried out by Fawcett and Hatter (1980)[29], who found two additional new lines: $^4S^\circ_{3/2}-^4P_{1/2}$ at 320.40 Å and $^2D^\circ_{3/2}-^2D_{3/2}$ at 310.67 Å. Note that the line at 205.38 Å in Ref. 26 has been omitted, because it does not fit with the level scheme of Smitt *et al.*

Fawcett *et al.* (1972)[27] identified five lines at about 74 Å as $3p^23d-3p^24f$ transitions. Their wavelength uncertainty is ±0.015 Å.

The $3p^3-3p^24d$ transitions below 72.7 Å are given by Fawcett *et al.*[67]

Co XIV (Si sequence)

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

Wavelengths of magnetic-dipole transitions within the $3s^23p^2$ ground configuration have been predicted by Sugar *et al.* (1990)[59]. The $3s^23p^2$ levels are derived from them.

Fawcett and Hayes (1972)[26] analyzed $3s^23p^2-3s3p^3$ and $3s^23p^2-3s^23p3d$ arrays in the wavelength ranges of 224.1 – 342.3 Å and 184.4 – 207.9 Å. Their wavelength uncertainty is ±0.03 Å. Improved wavelengths with uncertainties of ±0.02 Å were reported by Fawcett and Hatter (1980)[29] for the former array. The $3s3p^3\ ^3S_1^o$ level is derived from the two lines at 236.11 Å and 224.13 Å of the $3s^23p^2\ ^3P_{2,0}-3s3p^3\ ^3S_1^o$ transitions. The wavelength uncertainty of the $3s^23p^2\ ^3P_1-3s3p^3\ ^3S_1^o$ transition at 230.34 Å is questionable, because this line is inconsistent by about 200 cm^{-1} with the lower $3s^23p^2\ ^3P_1$ level by about 0.1 Å.

Fawcett *et al.* (1972)[27] observed the $3p^2-3p4d$ and $3p^2-3p4s$ and $3p3d-3p4f$ lines in the range of 55.7 – 69.1 Å. Their wavelength uncertainty is ±0.01 Å. Kastner *et al.* (1978)[42] reobserved these lines in the extended range of 55.1 – 74.4 Å. They give tentative classification for the $3s3p^3-3s^23p4f$ transitions.

Co XV (Al sequence)

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

The magnetic-dipole transition $3s^23p\ ^2P_{1/2}^o-3s^23p\ ^2P_{3/2}^o$ at 4350.6 Å (in air) was identified by Price (1964)[50] in the solar coronal spectrum.

Lines at 52.583 Å and 53.173 Å were classified by Edlén (1936)[17] as the $3s^23p\ ^2P_{1/2,3/2}^o-3s^24d\ ^2D_{3/2,5/2}$ doublet.

The array $3s^23p-3s3p^2$ was observed by Fawcett and Hayes (1972)[26] and more accurately by Fawcett and Hatter (1980)[29]. Fawcett and Hayes also provided identifications of the $3s^23p-3s^23d$ array the $3s3p^2\ ^4P_{5/2}-3p^3\ ^4S_{3/2}^o$ transition. The $3s3p^2\ ^4P_{1/2,3/2,5/2}-3p^3\ ^4S_{3/2}^o$ array was given by Litzén and Redfors (1988)[46]. New observations in the range of 197.5 – 337.5 Å were made by Redfors and Litzén (1989)[54] with a laser-produced plasma source. They identified all the transitions between terms of the configurations $3s^23p$, $3s3p^2$, $3s^23d$, $3p^3$, and $3s3p3d$ (except ^{4}F). Their wavelength uncertainties are ±0.02 Å. Although they show that the $3s3p(^1P^o)3d\ ^2D_{3/2}^o$ and $^2P_{3/2}^o$ levels cross at Mn, they don't interchange the designations in the wavelength list for the subsequent elements. We have made the interchange here.

Fawcett *et al.* (1972)[27] classified the $3s^23d-3s^24f$, and $3s3p3d-3s3p4f$ arrays in the ranges of ~67 Å and ~64 Å, respectively, with wavelength uncertainties of ±0.01 Å.

Co XVI (Mg sequence)

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

The magnetic-dipole $3s3p\ ^3P_1^o-3s3p\ ^3P_2^o$ at 5744 Å (in air) was classified by Price (1964)[50] in the solar coronal spectrum.

Edlén (1936)[17] found the $3s^2\ ^1S_0-3s4p\ ^1P_1^o$ resonance line at 47.483 Å and also the triplets $3s3p\ ^3P^o-3s4d\ ^3D$ and $3s3d\ ^3D-3s4f\ ^3F^o$ in the ranges of ~50 Å and ~62 Å. Identifications of the singlets $3s3p\ ^1P_1^o-3s4d\ ^1D_2$ at 53.043±0.01 Å and $3s3d\ ^1D_2-3s4f\ ^1F_3^o$ at 64.773±0.01 Å were made by Fawcett *et al.* (1972)[27]. They also identified a blended line at 56.83 Å as the $3p^2\ ^1D_2-3s4f\ ^1F_3^o$ transition. The $3p3d-3p4f$ transitions were classified by Fawcett *et al.*[27] and more completely by Kastner *et al.* (1978)[42]. We have adopted the results of Kastner *et al.*, although three blended lines have multiple classifications.

Feldman *et al.* (1971)[33] classified spectral lines of the $3s3p\ ^3P^o-3s5d\ ^3D$ array in the range of ~37 Å, measured with wavelength uncertainties of ±0.02 Å.

The rest of the $n=3-4,5$ transitions below 59.625 Å are due to the identifications of Fawcett *et al.*[67]

The inner shell $2p^63s^2\ ^1S_0-2p^53s^23d\ ^1P_0^o$ transition at 14.080 Å was observed by Swartz *et al.* (1971)[60].

Transitions among the configurations $3s^2$, $3s3p$, $3p^2$, $3s3d$ and $3p3d$ in the wavelength range of 186.4-496.6 Å produced in a laser-generated plasma were observed and analyzed by Churilov *et al.* (1985)[9]. They measured wavelengths with uncertainties of ±0.007 Å. Some revisions for the $3s3p-3p^2$, $3p^2-3p3d$, and $3s3d-3p3d$ arrays were made by Litzén and Redfors (1987)[45] who used a similar light source. Their wavelengths have uncertainties of ±0.02 Å. We have taken wavelengths and energy levels from both articles. The previous analyses of the $n=3$ complex by Fawcett and Hayes (1972)[26], Fawcett *et al.* (1972)[27], and Fawcett and Hatter (1980)[29] were extended in the above work.

The $3p3d-3d^2$ array was identified by Redfors (1988)[53], Levashov and Churilov (1988)[44], and Churilov *et al.* (1989)[10] using laser-produced plasmas. In Ref. 10, 15 lines are provided in the wavelength range of 211.5 – 285.8 Å. Wavelengths given to the third or to the second decimal place have uncertainties of ±0.01 Å and ±0.02 Å, respectively. The lower level $3p3d\ ^3P_1^o$ of the classifications of the lines at 221.08 Å and 241.157 Å should be $^3D_1^o$, according to the level scheme of Litzén and Redfors (1987)[45]. The classifications of the $3p3d\ ^3P_2^o$, $^3D_2^o-3d^2\ ^3P_2$ lines at 220.446 Å and 228.276 Å disagree with the level scheme of Churilov *et al.* (1985)[9]. We have reduced the value of the $3d^2\ ^3P_2$ by 200 cm^{-1} to accommodate these lines.

Co XVII (Na sequence)

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

Edlén (1936)[16] identified the $3s-4p$, $3p-4s$, and $4d$, and $3d-4f$ and $5f$ doublets in the wavelength range of 41.4 − 59.0 Å. Feldman *et al.* (1971)[33] extended the doublet series to $3s-np$ ($n=5,6$), $3p-nd$ ($n=5-8$), and $3d-nf$ ($n=5-7$). They reported the wavelengths in the range 27.9 − 41.4 Å measured with uncertainties of ±0.01 Å. This work includes the previous results of Feldman *et al.* (1967)[31] The $3p-5s$ and $3d-8f$ transitions at 37.768 Å and 31.38 Å, respectively, are from Fawcett *et al.*[67]

Feldman and Cohen (1967)[32] observed the lines at 15.828±0.01 Å ($J=1/2-3/2$) and 15.551±0.01 Å ($J=1/2-1/2$) belonging to the autoionization resonance transition $2p^63s\ ^2S-2p^53s^2\ ^2P^o$.

Widing *et al.* (1971)[64] classified a solar coronal line at 312.54±0.05 Å as the $3s\ ^2S_{1/2}-3p\ ^2P^o_{3/2}$ transition. The $3s\ ^2S_{1/2}-3p\ ^2P^o_{1/2}$ line was observed at 339.51±0.03 Å in a solar flare spectrum by Sandlin *et al.* (1976)[55]. These were also observed in laboratory spectra by Fawcett and Hayes (1972)[26], Fawcett *et al.* (1972)[27], and Fawcett and Hatter (1980)[29]. Wavelengths of 312.54±0.03 Å ($J=1/2-3/2$) and 339.50±0.03 Å ($J=1/2-1/2$) were obtained with a laser-produced plasma in Ref. 29. Fawcett *et al.* (1972)[27] also observed the $3p\ ^2P^o-3d\ ^2D$ doublet in the range of 234 − 250 Å with an uncertainty of ±0.02 Å.

The wavelengths of the $3s-3p$ and $3p-3d$ transitions agree with semiempirical predictions by Edlén (1978)[19] within experimental uncertainties. An isoelectronic comparison of measured wavelengths of these transitions as well as the $3d-4f$, with Dirac-Fock calculations was carried out by Reader *et al.* (1987)[52] for Ar^{7+} through Xe^{43+}. They obtained fitted wavelengths with an uncertainty of ±0.007 Å. We give their results.

Lawson and Peacock (1980)[43] identified the doublet $4d-5f$ and $4f-5g$ in the ranges of ~128 Å and ~139 Å. Their wavelengths have uncertainties of ±0.03 Å.

Co XVIII (Ne sequence)

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

Resonance lines were first measured by Tyrén (1938)[62], who identified those from the $n=3$ levels, including $2s2p^63p\ ^{3,1}P^o_1$, in the range of 12.6 − 15.5 Å. Subsequently, Feldman and Cohen (1967)[30] observed two lines from the $2s^22p^54d\ ^3D^o_1$, $^1P^o_1$ levels to the ground level in the range of ~11 Å. Swartz *et al.* (1971)[60] extended the identifications to transitions from the upper levels $2p^54s\ ^{3,1}P^o_1$ and $2p^5nd\ ^3D^o_1$, $^1P^o_1$ ($n=5,6$). New and improved observations with laser-produced plasmas were reported by Boiko *et al.* (1978)[5], Gordon *et al.* (1980)[38], and Chang *et al.* (1987)[8]. Tabulated wavelengths with uncertainties of ±0.005 Å have been taken from Gordon *et al.* Additional wavelengths below 9.5 Å are given by Boiko *et al.* for $2p^57d\ ^3D^o_1$ and $^1P^o_1$, and $2p^58d\ ^3D^o_1$ and by Chang *et al.* for $2p^58d\ ^1P^o_1$ and $2p^59d\ ^3D^o_1$ and $^1P^o_1$. Chang *et al.* also identified three more lines at 11.155, 10.025, and 9.748 Å as transitions from the $^3P^o_1$ levels of the $2p^54d$, $2s2p^64p$, and $2p^56d$ configurations to the ground level. It should be noted that the classification of $2p^6\ ^1S_0-2p^55d\ ^{1,3}P^o_1$ transitions at 10.234 Å and 10.368 Å by Spector *et al.* (1980)[57] does not agree with the results quoted here.

Observations of the $2p^53p-2p^54d$ transitions were made by Kastner *et al.* (1975)[41] in the range of 44.8 − 45.74 Å.

Co XIX (F sequence)

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

Spectral lines for the $2p^5-2p^43s$ and $2p^5-2p^43d$ arrays were observed and classified by Cohen *et al.* (1968)[11] and by Swartz *et al.* (1971)[60]. Revisions and additions to these earlier works were made by Feldman *et al.* (1973)[34], Boiko *et al.* (1978)[6], and Boiko *et al.* (1979)[7]. Gordon *et al.* (1980)[38] remeasured these arrays as well as $2s^22p^5-2s2p^53p$ and $2p^5-2p^44d$ and $-2p^44s$ transitions. These lines in the range of 10.2 − 14.8 Å have uncertainties of ±0.005 Å. The additional three lines at 13.246, 13.157, and 12.876 Å are from Ref. 7. The classifications $2p^5\ ^2P^o_{3/2}-2p^4(^3P)4d\ ^2F_{5/2}$ at 10.471 Å and $2p^5\ ^2P^o_{1/2}-2p^4(^3P)4d\ ^2D_{3/2}$ at 10.633 Å by Spector *et al.* (1980)[57] do not correspond with the results quoted here. In a recent work of Chang *et al.* (1987)[8], 19 new lines belonging to the above arrays were proposed. However, there appear discrepancies more than ±0.01 Å between their wavelengths and recalculated ones from the levels quoted here. Furthermore, the $2p^5\ ^2P^o$ splitting derived from their data shows a large range of values, some far from the average. We have therfore omitted their results.

Doschek *et al.* (1974)[12] identified the $2s^22p^5\ ^2P^o_{3/2,1/2}-2s2p^6\ ^2S_{1/2}$ transitions at 88.35±0.02 Å and 99.02±0.02 Å in a laser produced plasma. They were also observed by Lawson and Peacock (1980)[43] with a similar light source.

Co XX (O sequence)

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

Doschek *et al.* (1974)[12] classified eight lines of the $2s^22p^4-2s2p^5$ array in the range of 86 − 106 Å. The line at 109.14 Å was identified by Doschek *et al.* (1975)[13] as the $2s2p^5\ ^1P^o_1-2p^6\ ^1S_0$ transition. New measurements and additional classifications of the $n=2-2$ transitions in the extended range of 74 − 145 Å were made by Lawson and Peacock (1980)[43], who gave their wavelength uncertainty as ±0.03 Å. The results of Ref. 43 have been tabulated here.

The $2p^4-2p^33s$, $2p^33d$, and $2p^34d$ arrays were identified by Gordon *et al.* (1980)[38] in the wavelength ranges of

13.2 – 13.8 Å, 12.2 – 12.6 Å, and 9.6 – 9.9 Å. The uncertainty of the wavelengths is ±0.005 Å. Some blended lines having multiple classifications are included. These transitions were also observed by Chang *et al.* (1987)[8], who identified six more lines, including the $2s^22p^4$ $^1D_2 - 2s2p^43d$ $^1F_3$ forbidden transition. The line at 12.423 Å, classified as arising from the $2p^3(^2P^o)3d$ $^3P^o_2$ level, disagrees with the levels derived by Gordon *et al.* and has been omitted.

Co XXI (N sequence)

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

Doschek *et al.* (1974)[12] observed nine lines in the range of 85.4 – 125.2 Å, which they assigned to the the $2s^22p^3 - 2s2p^4$ array. Doschek *et al.* (1975)[13] identified the $2s2p^4$ $^2D_{5/2} - 2p^5$ $^2P^o_{3/2}$ transition at 106.23 ± 0.015 Å. Additional identifications in these arrays were made by Lawson and Peacock (1980)[43], who measured wavelengths of 30 lines in the extended range of 75.8 – 130.1 Å. Their wavelengths, obtained from a laser-produced plasma, have uncertainties of ±0.03 Å.

Chang *et al.* (1987)[8] identified five lines in the range of 11.5 – 12.3 Å as the $2p^3 - 2p^23d$ transitions. Their identifications, however, have been omitted, because they do not give consistent values for the upper levels.

Co XXII (C sequence)

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

The $2s^22p^2 - 2s2p^3$ array was first identified by Feldman *et al.* (1975)[35]. It was more extensively observed by Lawson and Peacock (1980)[43] with a laser-produced plasma. Wavelengths of 18 lines of this array and 20 lines of the $2s2p^3 - 2p^4$ array were measured in the range of 78.9 – 170.1 Å with uncertainties of ±0.03 Å. Smoothed values for these wavelengths along the isoelectronic sequence are given by Edlén (1985)[23]. They indicate that the value for $2s2p^3$ $^5S^o_2$ is wrong.

Chang *et al.* (1987)[8] reported the identifications of $2p^2 - 2p3s$ and $2p^2 - 2p3d$ transitions in the range of 11.4 – 12.3 Å. However, we have not adopted these because the levels derived from their data are not self consistent.

Co XXIII (B sequence)

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

New measurements and classifications of the $2s^22p - 2s2p^2$ array, improving those of Doschek *et al.* (1975)[13] were given by Lawson and Peacock (1980)[43] who assigned seven lines in the wavelength range of 93.9 – 147.1 Å to this array. They also identified 17 lines due to the $2s2p^2 - 2p^3$ array in the range of 103.8 – 171.5 Å. The spin-forbidden $^4P_{5/2} - ^2D^o_{5/2}$ transition at 103.80 Å is given as tentative. Edlén (1983)[22] assigned the wavelength of 103.718 Å to this transition. Tabulated wavelengths were measured with uncertainties of ±0.03 Å. Smoothed values for these wavelengths along isoelectronic sequence are given in Ref. 22. The designations of the two levels sp^2 $^2P_{1/2}$, $^2S_{1/2}$ were interchanged by Edlén.

The $2p2p^2 - 2s2p(^3P^o)3d$ transitions were first provided by Spector *et al.* (1980)[57] and more extensively by Chang *et al.* (1987)[8] with 19 spectral lines in the range of 10.7 – 11.2 Å, including the $2p2p^2 - 2s2p(^1P^o)3d$ transitions. However, their identifications of the $2s2p^2$ $^4P_{5/2,3/2} - 2s2p(^3P^o)3d$ $^4D^o_{5/2}$ lines at 10.901 Å and 10.899 Å are questionable, because the $2s2p^2$ ^4P term splitting is inconsistent with that of Lawson and Peacock. Therefore we have designated all of their wavelengths as tentative. The uncertainty of the wavelengths is ±0.005 Å.

Co XXIV (Be sequence)

Ground state: $1s^22s^2$ $^1S_0$

Lawson and Peacock (1980)[43] classified the $2s2p - 2p^2$ array in the range of 128.2 – 204.1 Å in addition to the $2s^2$ $^1S_0 - 2s2p$ $^1P^o_1$ resonance line at 125.15 Å. The uncertainty of the wavelengths is ±0.03 Å for lines shorter than 180 Å and ±0.06 Å for longer wavelengths. Smoothed value along isoelectronic sequence are provided for these wavelengths by Edlén (1983)[21] and (1985)[24].

Transition arrays for $n = 2$ to 3 in the wavelength range of 9.9 – 11.5 Å were reported by Boiko *et al.* (1977)[4] and Boiko *et al.* (1978)[5] with a measurement uncertainty of ±0.003 Å. Many of the lines are given as unresolved blended lines. Reobservation of these arrays was made by Chang *et al.* (1987)[8], who identified five lines with an uncertainty of ±0.005 Å. They also claim to resolve blended lines identified Boiko *et al.* However, we have not adopted these wavelengths. It should be noted that the classifications of seven lines of $2s2p - 2p3p$, $2p^2 - 2p3d$, and $2s2p - 2s3s$ arrays by Spector *et al.* (1980)[57] do not fit with the results quoted here.

Co XXV (Li sequence)

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

For the $2s - 2p$ transitions, we have tabulated wavelengths derived from the semi-empirical values by Edlén (1979)[20], (1983)[21]. Spectral lines of the doublets $2s$ $^2S - 3p$ $^2P^o$, $2p$ $^2P^o - 3d$ ^2D, and $2p$ $^2P^o - 3s$ ^2S were identified by Chang *et al.* (1987)[8] with a wavelength uncertainty of ±0.005 Å. The earlier work of Spector *et al.* (1980)[57] provided the $2s$ $^2S_{1/2} - 3p$ $^2P^o_{1/2}$ and $2p$ $^2P^o_{1/2,3/2} - 3d$ $^2D_{3/2,5/2}$ transitions.

Co XXVI (He sequence)

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

Calculated energy levels of the configurations $1s2s$ and $1s2p$ have been made by Drake (1988)[15] with an uncertainty of $\pm 75\text{cm}^{-1}$. The levels with $n=3$ of Drake (1985)[14] have been reduced by 18.5 cm^{-1}, as indicated by the differences between the $n=2$ levels in these calculations. For the levels with $n=4-5$, calculations of Vainshtein and Safronova (1985)[63] have been tabulated after adjusting them by about 1500 cm^{-1} to the ground state binding energy obtained by Drake[15]. Wavelengths are calculated from the energy levels by the Ritz combination principle. The best measurements of the $1s^2\ {}^1S_0-1s2p\ {}^1P_1^\circ$ line are at 1.7122 ± 0.0006 Å by Morita (1983)[48] and Morita and Fujita (1985)[49] and at 1.71110 ± 0.00015 Å by Aglitsky *et al.* (1988)[1].

Co XXVII (H sequence)

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

Since no observations have been reported, we give wavelengths calculated from the theoretical level energies by Johnson and Soff (1985)[40] for the $n=2$ shell, whose estimated uncertainty is $\pm30\ \text{cm}^{-1}$. They are in close agreement with the calculations by Mohr (1983)[47]. All levels with $n=3-5$ were calculated by Erickson (1977)[25]. For the ns and np ($n=3-5$) levels, Erickson's values for the binding energies were subtracted from the ground state binding energy given by Johnson and Soff to obtain the predicted wavelengths.

Oscillator strengths and transition probabilities were calculated from line strength data of the hydrogen spectrum by Wiese *et al.* (1966)[66].

3. Explanation of Tables of Spectroscopic Data

Co VIII, Co XXVII, etc.

According to spectroscopic convention, Co I indicates the first spectrum, i.e., the spectrum of the neutral atom; Co II denotes the second spectrum, belonging to the singly ionized atom; and so on.

H-Sequence, C-Sequence, etc.

Indicates that the respective Co ion has the same number of electrons as neutral hydrogen, neutral carbon, etc.

IP

Principal ionization energy of the tabulated ions in cm^{-1} (eV).

λ(Å)

Wavelength of listed spectral lines in Angstrom units (10^{-8}cm).

C,T,P

Superscripts to the right of a wavelength value have the following meanings:

- C wavelength calculated from energy level data using the Ritz combination principle.
- T wavelength tentatively identified.
- P wavelength predicted along a isoelectronic sequence.

Classification

Standard spectroscopic designation for lower (first) and upper levels generating the spectral lines; electronic configurations followed by the term in *LS*-, *jj*- or *jK*-coupling notation. The "°" on the term indicates odd parity. A term enclosed in parentheses refers to an intermediate state. Where only the total angular momentum *J* is given in successive listings, the preceding configuration and term labels apply.

Energy Levels

Level values (in cm^{-1}) for lower (first) and upper (second) level of the transition. A symbol ? after the level value indicates level was derived from a tentatively classified line.

Int.

Approximate intensity of a spectral line, generally visually estimated from the blackness (or density) of the line on photographic plates. In case where its *gf*-value is available, the intensity data is omitted.

gf

This column lists the product of the statistical weight of the lower level and the absorption oscillator strength or *f*-value for electric dipole transitions. 1.23−1 means 1.23×10^{-1}. *f*-values are not given for magnetic-dipole (M1) transitions.

A

Radiative transition probability in s^{-1}. 1.23+11 means 1.23×10^{11}.

Acc

Accuracy estimate for the oscillator strength and transition probability data, taken from the NIST reference tables on atomic transition probabilities (see, e.g. Ref. 10 for detailed explanation). The accuracy is indicated by the following letter symbols, which are identical with the notation used in the NIST reference book:

A for uncertainties within 3%
B for uncertainties within 10%
C for uncertainties within 25%
D for uncertainties within 50%
E for uncertainties greater than 50%

References
Reference sources for the data. The numbers are keyed to the bibliographic listing following the tables. When several references are listed, they are distinguished by superscripts on the numbers as follows:

- ° reference from which the adopted wavelength value is taken.
- * reference containing the adopted oscillator strength and/or the transition probability.
- Δ reference from which the estimated intensity is taken.

4. Spectroscopic Data for Co VIII through Co XXVII

Co VIII (Ca sequence) Ionization Energy = 1 273 000 cm^{-1} (157.8 eV)

λ (Å)	Classification		Energy Levels (cm^{-1})		Int.	gf	A (s^{-1})	Acc.	References
192.619	$3p^63d^2\ ^1G_4$	$3p^63d4p\ ^3F^o_4$	32 360	551 524		2.2−3	4.4+7	E	28°,65*
192.332	$3p^63d^2\ ^3P_1$	$3p^63d4p\ ^3D^o_1$	22 839	542 701		3.3−2	2.0+9	D	28°,65*
191.757	1	2	22 839	544 314		1.7−1	6.2+9	D	28°,65*
191.645	2	3	24 055	545 834		2.1−1	5.4+9	D	28°,65*
191.262	$3p^63d^2\ ^1D_2$	$3p^63d4p\ ^1D^o_2$	19 624	542 430		4.2−1	1.5+10	D	28°,65*
190.574	$3p^63d^2\ ^3P_2$	$3p^63d4p\ ^3F^o_3$	24 055	548 799		2.7−2	7.1+8	E	28°,65*
190.574	$3p^63d^2\ ^1D_2$	$3p^63d4p\ ^3D^o_2$	19 624	544 314		1.0−1	3.7+9	E	28°,65*
190.342	$3p^63d^2\ ^1G_4$	$3p^63d4p\ ^1F^o_3$	32 360	557 736		1.8	4.7+10	D	28°,65*
189.472	$3p^63d^2\ ^1D_2$	$3p^63d4p\ ^3F^o_2$	19 624	547 400		2.0−1	7.4+9	E	28°,65*
189.040	$3p^63d^2\ ^1G_4$	$3p^5(^2P^o)3d^3(^2H)\ ^3G^o_5$	32 360	561 346		1.1−1	1.9+9	E	28°,65*
188.674	$3p^63d^2\ ^3P_2$	$3p^63d4p\ ^3P^o_1$	24 055	554 082		1.6−1	9.9+9	D	28°,65*
188.345	2	2	24 055	554 998		7.0−1	2.6+10	D	28°,65*
188.241	1	1	22 839	554 082		1.6−1	9.9+9	D	28°,65*
188.165	1	0	22 839	554 287		1.9−1	3.6+10	D	28°,65*
188.054	0	1	22 304	554 082		1.6−1	1.0+10	D	28°,65*
187.909	1	2	22 839	554 998		1.1−1	4.1+9	D	28°,65*
187.375	$3p^63d^2\ ^3P_2$	$3p^63d4p\ ^1F^o_3$	24 055	557 736		2.4−2	6.5+8	E	28°,65*
187.092	$3p^63d^2\ ^1D_2$	$3p^63d4p\ ^3P^o_1$	19 624	554 082		8.0−2	5.2+9	E	28°,65*
185.835	$3p^63d^2\ ^1D_2$	$3p^63d4p\ ^1F^o_3$	19 624	557 736		3.2−2	8.9+8	D	28°,65*
185.461	$3p^63d^2\ ^3P_2$	$3p^63d4p\ ^1P^o_1$	24 055	563 271		8.5−2	5.5+9	E	28°,65*
185.041	1	1	22 839	563 271		3.0−3	2.0+8	E	28°,65*
184.861	0	1	22 304	563 271		1.5−2	9.8+8	E	28°,65*
184.850	$3p^63d^2\ ^3F_3$	$3p^63d4p\ ^1D^o_2$	1 430	542 430		9.8−2	3.9+9	E	28°,65*
184.356	2	2	0	542 430		2.5−1	9.9+9	E	28°,65*
184.265	$3p^63d^2\ ^3F_4$	$3p^63d4p\ ^3D^o_3$	3 144	545 834		1.3	3.5+10	D	28°,65*
184.265	2	1	0	542 701		7.0−1	4.7+10	D	28°,65*
184.203	3	2	1 430	544 314		9.1−1	3.5+10	D	28°,65*
183.686	3	3	1 430	545 834		2.8−1	8.0+9	D	28°,65*
183.939	$3p^63d^2\ ^1D_2$	$3p^63d4p\ ^1P^o_1$	19 624	563 271		3.1−1	2.0+10	D	28°,65*

Co VIII (Ca sequence) Ionization Energy = 1 273 000 cm^{-1} (157.8 eV) – Continued

λ (Å)	Classification		Energy Levels (cm^{-1})		Int.	gf	A (s^{-1})	Acc.	References
183.266	$3p^63d^2\ ^3F_4$	$3p^63d4p\ ^3F^\circ_3$	3 144	548 799		2.6–1	7.3+9	D	28°,65*
183.167	$_3$	$_2$	1 430	547 400		9.1–2	3.7+9	D	28°,65*
182.686	$_3$	$_3$	1 430	548 799		2.7–1	7.7+9	D	28°,65*
182.686	$_2$	$_2$	0	547 400		2.1–1	8.4+9	D	28°,65*
182.355	$_4$	$_4$	3 144	551 524		7.4–1	1.7+10	D	28°,65*
181.786	$_3$	$_4$	1 430	551 524		2.9–2	6.5+8	D	28°,65*
180.422	$3p^63d^2\ ^3F_3$	$3p^5(^2P^\circ)3d^3(^2H)\ ^3G^\circ_3$	1 430	555 699		4.5–2	1.3+9	D	28°,65*
179.949	$_2$	$_3$	0	555 699		1.6	4.8+10	D	28°,65*
179.731	$_3$	$_4$	1 430	557 817		3.4	7.8+10	D	28°,65*
179.147	$_4$	$_5$	3 144	561 346		4.6	8.6+10	D	28°,65*
179.068	$3p^63d^2\ ^1G_4$	$3p^5(^2P^\circ)3d^3(^2H)\ ^1H^\circ_5$	32 360	590 805		3.5	6.6+10	D	28°,65*
173.742	$3p^63d^2\ ^3P_2$	$3p^5(^2P^\circ)3d^3(^2F)\ ^3D^\circ_2$	24 055	599 641		2.0–1	8.8+9	D	28°,65*
173.561	$_0$	$_1$	22 304	598 440		6.8–1	5.0+10	D	28°,65*
173.373	$_1$	$_2$	22 839	599 641		1.3	5.6+10	D	28°,65*
172.776	$_2$	$_3$	24 055	602 844		1.3	3.9+10	D	28°,65*
172.767	$3p^63d^2\ ^1D_2$	$3p^5(^2P^\circ)3d^3(^2F)\ ^3D^\circ_1$	19 624	598 440		5.5–3	4.1+8	E	28°,65*
172.402	$_2$	$_2$	19 624	599 641		8.5–1	3.8+10	E	28°,65*
171.460	$_2$	$_3$	19 624	602 844		2.0	6.6+10	E	28°,65*
171.522	$3p^63d^2\ ^3P_1$	$3p^5(^2P^\circ)3d^3(^2F)\ ^1D^\circ_2$	22 839	605 841		3.3–1	1.5+10	E	28°,65*
171.107	$3p^63d^2\ ^3P_2$	$3p^5(^2P^\circ)3d^3(^2G)\ ^1F^\circ_3$	24 055	608 501		1.8	6.1+10	E	28°,65*
170.589	$3p^63d^2\ ^1D_2$	$3p^5(^2P^\circ)3d^3(^2F)\ ^1D^\circ_2$	19 624	605 841		2.5	1.2+11	D	28°,65*
170.169	$3p^63d^2\ ^3F_4$	$3p^5(^2P^\circ)3d^3(^2H)\ ^1H^\circ_5$	3 144	590 805		1.9–1	4.0+9	E	28°,65*
169.819	$3p^63d^2\ ^1D_2$	$3p^5(^2P^\circ)3d^3(^2G)\ ^1F^\circ_3$	19 624	608 501		1.9	6.3+10	D	28°,65*
169.711	$3p^63d^2\ ^3P_1$	$3p^5(^2P^\circ)3d^3(^4P)\ ^3P^\circ_0$	22 839	612 076		6.3–1	1.4+11	D	28°,65*
169.537	$_2$	$_1$	24 055	613 869		5.5–1	4.3+10	D	28°,65*
169.196	$_1$	$_1$	22 839	613 869		5.7–1	4.5+10	D	28°,65*
169.051	$_0$	$_1$	22 304	613 869		5.8–1	4.5+10	D	28°,65*
168.084	$_2$	$_2$	24 055	619 010		2.4	1.2+11	D	28°,65*
167.738	$_1$	$_2$	22 839	619 010		5.4–1	2.6+10	D	28°,65*
168.921	$3p^63d^2\ ^3P_2$	$3p^5(^2P^\circ)3d^3(^4F)\ ^3F^\circ_2$	24 055	616 019		2.9–2	1.3+9	D	28°,65*
167.152	$3p^63d^2\ ^3F_3$	$3p^5(^2P^\circ)3d^3(^2F)\ ^3D^\circ_2$	1 430	599 641		4.1–1	1.9+10	D	28°,65*
166.256	$_3$	$_3$	1 430	602 844		9.1–2	3.1+9	D	28°,65*
167.016	$3p^63d^2\ ^1D_2$	$3p^5(^2P^\circ)3d^3(^4F)\ ^3F^\circ_3$	19 624	618 348		1.8–1	6.2+9	E	28°,65*
165.191	$3p^63d^2\ ^3F_4$	$3p^5(^2P^\circ)3d^3(^2G)\ ^1F^\circ_3$	3 144	608 501		1.8–1	6.4+9	E	28°,65*
164.721	$_3$	$_3$	1 430	608 501		1.6–1	5.6+9	E	28°,65*
162.708	$3p^63d^2\ ^3F_3$	$3p^5(^2P^\circ)3d^3(^4F)\ ^3F^\circ_2$	1 430	616 019		2.7–1	1.4+10	D	28°,65*
162.57	$_4$	$_3$	3 144	618 348		2.8–1	1.0+10	D	28°,65*
162.337	$_2$	$_2$	0	616 019		4.3	2.2+11	D	28°,65*
162.095	$_3$	$_3$	1 430	618 348		6.2	2.2+11	D	28°,65*
161.917	$_4$	$_4$	3 144	620 737		8.9	2.5+11	D	28°,65*
161.733	$_2$	$_3$	0	618 348		5.0–1	1.9+10	D	28°,65*
161.479	$_3$	$_4$	1 430	620 737		5.6–1	1.6+10	D	28°,65*
158.783	$3p^63d^2\ ^1G_4$	$3p^5(^2P^\circ)3d^3(^2H)\ ^1G^\circ_4$	32 360	662 151		1.3+1	3.7+11	D	28°,65*
158.066	$3p^63d^2\ ^3P_2$	$3p^5(^2P^\circ)3d^3(^4F)\ ^3D^\circ_3$	24 055	656 715		2.0	7.8+10	D	28°,65*
157.984	$_2$	$_2$	24 055	657 020		3.1–1	1.7+10	D	28°,65*
157.687	$_1$	$_2$	22 839	657 020		1.3	7.2+10	D	28°,65*
157.416	$_1$	$_1$	22 839	658 136		3.6–1	3.1+10	D	28°,65*
157.266	$_0$	$_1$	22 304	658 136		5.1–1	4.6+10	D	28°,65*

Co VIII (Ca sequence) Ionization Energy = 1 273 000 cm⁻¹ (157.8 eV) — Continued

λ (Å)	Classification		Energy Levels (cm⁻¹)		Int.	gf	A (s⁻¹)	Acc.	References
157.773	$3p^63d^2\ ^1D_2$	$3p^5(^2P^\circ)3d^3(^2P)\ ^1P^\circ_1$	19 624	653 446		1.0	8.8+10	D	28°,65*
156.958	$3p^63d^2\ ^1D_2$	$3p^5(^2P^\circ)3d^3(^4F)\ ^3D^\circ_3$	19 624	656 715		1.8−1	7.0+9	E	28°,65*
153.926	$3p^63d^2\ ^1G_4$	$3p^5(^2P^\circ)3d^3(^2F)\ ^1F^\circ_3$	32 360	682 051		8.1	3.3+11	D	28°,65*
153.005	$3p^63d^2\ ^3F_4$	$3p^5(^2P^\circ)3d^3(^4F)\ ^3D^\circ_3$	3 144	656 715		7.7	3.2+11	D	28°,65*
152.597	3	3	1 430	656 715		4.3−1	1.8+10	D	28°,65*
152.534	3	2	1 430	657 020		5.3	3.0+11	D	28°,65*
152.200	2	2	0	657 020		4.9−1	2.8+10	D	28°,65*
151.944	2	1	0	658 136		2.9	2.8+11	D	28°,65*
152.896	$3p^63d^2\ ^3P_2$	$3p^5(^2P^\circ)3d^3(^4P)\ ^3S^\circ_1$	24 055	678 094		2.6	2.5+11	D	28°,65*
152.597	1	1	22 839	678 094		1.7	1.7+11	D	28°,65*
150.958	$3p^63d^2\ ^1D_2$	$3p^5(^2P^\circ)3d^3(^2F)\ ^1F^\circ_3$	19 624	682 051		6.5	2.6+11	D	28°,65*
150.701	$3p^63d^2\ ^3P_2$	$3p^5(^2P^\circ)3d^3(^2D)\ ^1P^\circ_1$	24 055	687 584		3.9−1	3.8+10	E	28°,65*
149.718	$3p^63d^2\ ^1D_2$	$3p^5(^2P^\circ)3d^3(^2D)\ ^1P^\circ_1$	19 624	687 584		2.5	2.5+11	D	28°,65*
133.985	$3p^63d^2\ ^1S_0$	$3p^63d4f\ ^3D^\circ_1$	74 247	820 599	0				28
132.756	$3p^63d^2\ ^1S_0$	$3p^63d4f\ ^1P^\circ_1$	74 247	827 508		1.4	1.8+11	D	28°,65*
128.397	$3p^63d^2\ ^1G_4$	$3p^63d4f\ ^1G^\circ_4$	32 360	811 205		1.9	8.4+10	D	28°,65*
127.916	$3p^63d^2\ ^1G_4$	$3p^63d4f\ ^3F^\circ_4$	32 360	814 130		2.7−1	1.2+10	E	28°,65*
125.821	$3p^63d^2\ ^1G_4$	$3p^63d4f\ ^1H^\circ_5$	32 360	827 140		8.1	3.1+11	D	28°,65*
125.566	$3p^63d^2\ ^3P_2$	$3p^63d4f\ ^3D^\circ_3$	24 055	820 450		9.0−1	5.5+10	D	28°,65*
125.350	1	2	22 839	820 605		2.5	2.1+11	D	28°,65*
125.350	1	1	22 839	820 599		3.3−1	4.7+10	D	28°,65*
125.268	0	1	22 304	820 599		1.2	1.7+11	D	28°,65*
125.340	$3p^63d^2\ ^3P_2$	$3p^63d4f\ ^1F^\circ_3$	24 055	821 881		2.8	1.7+11	E	28°,65*
125.155	$3p^63d^2\ ^1D_2$	$3p^63d4f\ ^1D^\circ_2$	19 624	818 633		1.9	1.7+11	D	28°,65*
125.155	$3p^63d^2\ ^3P_2$	$3p^63d4f\ ^3P^\circ_2$	24 055	823 064		2.2	1.9+11	D	28°,65*
125.071	2	1	24 055	823 613		5.0−1	7.3+10	D	28°,65*
124.878	1	1	22 839	823 613		6.6−1	9.4+10	D	28°,65*
124.830	1	0	22 839	823 928		4.2−1	1.8+11	D	28°,65*
124.795	0	1	22 304	823 613		9.3−2	1.3+10	D	28°,65*
124.871	$3p^63d^2\ ^1D_2$	$3p^63d4f\ ^3D^\circ_3$	19 624	820 450		2.7	1.6+11	E	28°,65*
124.649	$3p^63d^2\ ^1D_2$	$3p^63d4f\ ^1F^\circ_3$	19 624	821 881		1.1	7.2+10	D	28°,65*
123.753	$3p^63d^2\ ^3F_4$	$3p^63d4f\ ^1G^\circ_4$	3 144	811 205		2.2−1	1.1+10	E	28°,65*
123.489	3	4	1 430	811 205		2.1−1	1.0+10	E	28°,65*
123.307	$3p^63d^2\ ^3F_4$	$3p^63d4f\ ^3F^\circ_4$	3 144	814 130		2.3	1.1+11	D	28°,65*
123.239	3	2	1 430	812 862		1.5−1	1.3+10	D	28°,65*
123.173	3	3	1 430	813 298		1.8	1.1+11	D	28°,65*
123.045	3	4	1 430	814 130		4.3−1	2.1+10	D	28°,65*
123.022	2	2	0	812 862		1.5	1.3+11	D	28°,65*
122.956	2	3	0	813 298		4.7−1	2.9+10	D	28°,65*
122.577	$3p^63d^2\ ^3F_4$	$3p^63d4f\ ^3G^\circ_4$	3 144	818 958		7.2−1	3.6+10	D	28°,65*
122.488	3	3	1 430	817 839		5.4−1	3.4+10	D	28°,65*
122.472	4	5	3 144	819 657		7.6	3.1+11	D	28°,65*
122.320	3	4	1 430	818 958		5.4	2.7+11	D	28°,65*
122.273	2	3	0	817 839		3.9	2.5+11	D	28°,65*

Co VIII (Ca sequence) Ionization Energy = 1 273 000 cm⁻¹ (157.8 eV) – Continued

λ (Å)	Classification		Energy Levels (cm⁻¹)		Int.	*gf*	*A* (s⁻¹)	Acc.	References
105.594	$3p^63d^2\ ^1G_4$	$3p^63d5f\ ^3F^o_4$	32 360	979 360	1				28
104.801	$3p^63d^2\ ^1G_4$	$3p^63d5f\ ^1H^o_5$	32 360	986 549	5				28
104.180	$3p^63d^2\ ^3P_2$	$3p^63d5f\ ^1F^o_3$	24 055	983 954	4				28
104.180	$3p^63d^2\ ^3P_1$	$3p^63d5f\ ^3D^o_2$	22 839	982 716	4				28
103.809	$3p^63d^2\ ^1D_2$	$3p^63d5f\ ^3D^o_3$	19 624	982 933	2				28
103.699	$3p^63d^2\ ^1D_2$	$3p^63d5f\ ^1F^o_3$	19 624	983 954	1				28
102.480	$3p^63d^2\ ^3F_3$	$3p^63d5f\ ^1G^o_4$	1 430	977 281	0				28
102.439	$3p^63d^2\ ^3F_4$	$3p^63d5f\ ^3F^o_4$	3 144	979 360	2				28
102.367	3	3	1 430	978 307	2				28
102.249	2	2	0	978 005	1				28
102.086	$3p^63d^2\ ^3F_4$	$3p^63d5f\ ^3G^o_4$	3 144	982 728	1				28
102.033	4	5	3 144	983 219	4				28
101.904	3	4	1 430	982 728	3				28
101.904	2	3	0	981 316					28

Co IX (K sequence) Ionization Energy = 1 501 300 cm⁻¹ (186.13 eV)

λ (Å)	Classification		Energy Levels (cm⁻¹)		Int.	*gf*	*A* (s⁻¹)	Acc.	References
213.574	$3p^63d\ ^2D_{3/2}$	$3p^5(^2P^o)3d^2(^1G)\ ^2F^o_{5/2}$	0	468 222	300				51
212.907	5/2	7/2	2 451	472 140	300				51
207.180	$3p^63d\ ^2D_{5/2}$	$3p^5(^2P^o)3d^2(^1D)\ ^2F^o_{7/2}$	2 451	485 123		2.0−1	4.0+9	D−	51°,65*
201.086	5/2	5/2	2 451	499 750		1.0−2	2.9+8	E	51°,65*
200.100	3/2	5/2	0	499 750		1.4−1	4.0+9	D−	51°,65*
172.917	$3p^63d\ ^2D_{5/2}$	$3p^5(^2P^o)3d^2(^3F)\ ^2F^o_{5/2}$	2 451	580 759		2.1−1	7.8+9	E	51°,65*
172.190	3/2	5/2	0	580 759		2.8	1.1+11	D−	51°,65*
170.695	5/2	7/2	2 451	588 291		4.1	1.2+11	D−	51°,65*
159.972	$3p^63d\ ^2D_{3/2}$	$3p^64p\ ^2P^o_{1/2}$	0	625 109	250				51
159.575	5/2	3/2	2 451	629 117	300				51
158.953	3/2	3/2	0	629 117	100				51
155.669	$3p^63d\ ^2D_{5/2}$	$3p^5(^2P^o)3d^2(^3F)\ ^2D^o_{5/2}$	2 451	644 843		7.2	3.3+11	D−	51°,65*
155.530	5/2	3/2	2 451	645 408		5.1−1	3.5+10	E	51°,65*
155.076	3/2	5/2	0	644 843		5.2−1	2.4+10	E	51°,65*
154.942	3/2	3/2	0	645 408		4.8	3.3+11	D−	51°,65*
153.803	$3p^63d\ ^2D_{3/2}$	$3p^5(^2P^o)3d^2(^3P)\ ^2P^o_{1/2}$	0	650 182		1.8	2.6+11	D−	51°,65*
153.308	5/2	3/2	2 451	654 735		3.4	2.4+11	D−	51°,65*
152.733	3/2	3/2	0	654 735		3.8−1	2.7+10	E	51°,65*
108.667	$3p^63d\ ^2D_{5/2}$	$3p^64f\ ^2F^o_{7/2}$	2 451	922 690	10				2
108.390	3/2	5/2	0	922 590	9				2
101.410	$3p^63d\ ^2D_{3/2}$	$3p^53d(^3P^o)4s\ ^2P^o_{1/2}$	0	986 100		1.6−1	5.1+10	D−	39°,65*
101.107	5/2	3/2	2 451	991 510		2.9−1	4.7+10	D−	39°,65*
100.856	3/2	3/2	0	991 510		3.3−2	5.4+9	E	39°,65*
100.636	$3p^63d\ ^2D_{5/2}$	$3p^53d(^3F^o)4s\ ^4F^o_{7/2}$	2 451	996 130	1				39
100.210	3/2	5/2	0	997 900	4				39

Co IX (K sequence) Ionization Energy = 1 501 300 cm^{-1} (186.13 eV) – Continued

λ (Å)	Classification		Energy Levels (cm^{-1})		Int.	*gf*	*A* (s^{-1})	Acc.	References
99.921	$3p^63d$ $^2D_{5/2}$	$3p^53d(^3F^o)4s$ $^2F^o_{7/2}$	2 451	1 003 240		6.6 – 1	5.3 + 10	D –	39°,65*
99.284	5/2	5/2	2 451	1 009 670		3.1 – 2	3.5 + 9	E	39°,65*
99.042	3/2	5/2	0	1 009 670		4.4 – 1	4.9 + 10	D –	39°,65*
97.854	$3p^63d$ $^2D_{5/2}$	$3p^53d(^3D^o)4s$ $^4D^o_{7/2}$	2 451	1 024 380	4				39
97.587	5/2	5/2	2 451	1 027 170	4				39
97.355	3/2	5/2	0	1 027 170	2				39
96.541	$3p^63d$ $^2D_{5/2}$	$3p^53d(^1F^o)4s$ $^2F^o_{7/2}$	2 451	1 038 280	3				39
96.305	$3p^63d$ $^2D_{5/2}$	$3p^53d(^3D^o)4s$ $^2D^o_{3/2}$	2 451	1 040 830	2				39
96.076	5/2	5/2	2 451	1 043 280	6				39
96.076	3/2	3/2	0	1 040 830	6				39
95.852	3/2	5/2	0	1 043 280	2				39
88.636	$3p^63d$ $^2D_{5/2}$	$3p^65f$ $^2F^o_{7/2}$	2 451	1 130 690	8				2
88.446	3/2	5/2	0	1 130 660	7				2
80.544	$3p^63d$ $^2D_{5/2}$	$3p^66f$ $^2F^o_{7/2}$	2 451	1 244 010	6				2
80.388	3/2	5/2	0	1 243 970	5				2
76.305	$3p^63d$ $^2D_{5/2}$	$3p^67f$ $^2F^o_{7/2}$	2 451	1 313 020	4				2
76.160	3/2	5/2	0	1 313 020	3				2
73.798	$3p^63d$ $^2D_{5/2}$	$3p^68f$ $^2F^o_{7/2}$	2 451	1 357 500	3				2
73.665	3/2	5/2	0	1 357 500	2				2
72.177	$3p^63d$ $^2D_{5/2}$	$3p^69f$ $^2F^o_{7/2}$	2 451	1 387 960	2				2
72.048	3/2	5/2	0	1 387 960	1				2
71.053	$3p^63d$ $^2D_{5/2}$	$3p^610f$ $^2F^o_{7/2}$	2 451	1 409 880	1				2
70.928	3/2	5/2	0	1 409 880	0				2

Co X (Ar sequence) Ionization Energy = 2 221 000 cm^{-1} (275.4 eV)

λ (Å)	Classification		Energy Levels (cm^{-1})		Int.	*gf*	*A* (s^{-1})	Acc.	References
200.893^P	$3p^6$ $^1S_0$	$3p^53d$ $^3D^o_1$	0	497 780					58
158.873	$3p^6$ $^1S_0$	$3p^5(^2P^o)3d$ $^1P^o_1$	0	629 430		2.5	2.2 + 11	C	37°,65*
111.542	$3p^5(^2P^o)3d$ $^1P^o_1$	$3p^5(^2P^o_{1/2})4f$ $^2[^5/_2]_2$	629 430	1 525 950	4				61
99.596	$3p^5(^2P^o)3d$ $^1F^o_3$	$3p^5(^2P^o_{3/2})4f$ $^2[^7/_2]_4$			4				61
98.261	$3p^5(^2P^o)3d$ $^3D^o_3$	$3p^5(^2P^o_{3/2})4f$ $^2[^7/_2]_4$			8				61
97.924	$3p^5(^2P^o)3d$ $^1F^o_3$	$3p^5(^2P^o_{1/2})4f$ $^2[^7/_2]_4$			5				61
97.575	$3p^5(^2P^o)3d$ $^3D^o_2$	$3p^5(^2P^o_{1/2})4f$ $^2[^7/_2]_3$			5				61
97.123	$3p^5(^2P^o)3d$ $^1D^o_2$	$3p^5(^2P^o_{1/2})4f$ $^2[^5/_2]_3$			3				61
96.300	$3p^5(^2P^o)3d$ $^3F^o_2$	$3p^5(^2P^o_{3/2})4f$ $^2[^7/_2]_3$			5				61
96.215	$3p^5(^2P^o)3d$ $^3F^o_3$	$3p^5(^2P^o_{3/2})4f$ $^2[^9/_2]_4$			6				61
96.047	4	5			10				61
95.109	$3p^5(^2P^o)3d$ $^3P^o_2$	$3p^5(^2P^o_{3/2})4f$ $^2[^3/_2]_2$			2				61
94.692	1	1			1				61
94.517	1	2			3				61
94.431	0	1			2				61

Co X (Ar sequence) Ionization Energy = 2 221 000 cm^{-1} (275.4 eV) – Continued

λ (Å)	Classification				Energy Levels (cm^{-1})		Int.	gf	A (s^{-1})	Acc.	References
94.789	$3p^5(^2P^o)3d$	$^3P^o_2$	$3p^5(^2P^o_{3/2})4f$	$^2[^5/_2]_3$			1				61
90.474	$3p^6$	$^1S_0$	$3p^5(^2P^o)4s$	$^3P^o_1$	0	1 105 290		1.6 − 1	4.3 + 10	D	2°,65*
88.994	$3p^6$	$^1S_0$	$3p^5(^2P^o)4s$	$^1P^o_1$	0	1 123 670		2.3 − 1	6.5 + 10	D	2°,65*
72.454	$3p^6$	$^1S_0$	$3p^5(^2P^o)4d$	$^3P^o_1$	0	1 380 190		3.9 − 1	1.7 + 11	D	2°,65*
71.488	$3p^6$	$^1S_0$	$3p^5(^2P^o)4d$	$^1P^o_1$	0	1 398 800		2.0 − 1	8.7 + 10	D	2°,65*
63.017	$3p^6$	$^1S_0$	$3p^5(^2P^o)5s$	$^3P^o_1$	0	1 586 870					61
62.332	$3p^6$	$^1S_0$	$3p^5(^2P^o)5s$	$^1P^o_1$	0	1 604 310					61

Co XI (Cl sequence) Ionization Energy = 2 460 000 cm^{-1} (305 eV)

λ (Å)	Classification				Energy Levels (cm^{-1})		Int.	gf	A (s^{-1})	Acc.	References
5168.[C]	$3s^23p^5$	$^2P^o_{3/2}$	$3s^23p^5$	$^2P^o_{1/2}$	0	19 345		M1	1.3 + 2	B	50,65*
339.81	$3s^23p^5$	$^2P^o_{1/2}$	$3s3p^6$	$^2S_{1/2}$	19 345	313 630		6.6 − 2	1.9 + 9	C −	29°,65*
318.85		3/2		1/2	0	313 630		1.37 − 1	4.50 + 9	C −	26°,65*
177.586	$3s^23p^5$	$^2P^o_{1/2}$	$3s^23p^4(^1D)3d$	$^2S_{1/2}$	19 345	582 510		4.14 − 1	4.38 + 10	C −	37°,65*
171.668		3/2		1/2	0	582 510		1.2	1.3 + 11	C −	37°,65*
170.337	$3s^23p^5$	$^2P^o_{1/2}$	$3s^23p^4(^3P)3d$	$^2P_{3/2}$	19 345	606 420	2				37
168.327		1/2		1/2	19 345	613 480	90				37
164.913		3/2		3/2	0	606 420	120				37
162.998		3/2		1/2	0	613 480	1				37
163.323	$3s^23p^5$	$^2P^o_{1/2}$	$3s^23p^4(^3P)3d$	$^2D_{3/2}$	19 345	631 680		2.98	1.86 + 11	C	37°,65*
162.565		3/2		5/2	0	615 140		4.60	1.94 + 11	C	37°,65*
158.278		3/2		3/2	0	631 680		7.2 − 2	4.7 + 9	D	37°,65*
89.31	$3s^23p^4(^1D)3d$	$^2F_{7/2}$	$3s^23p^4(^1D)4f$	$^2G^o_{9/2}$							67
88.52	$3s^23p^4(^3P)3d$	$^2F_{7/2}$	$3s^23p^4(^3P)4f$	$^2G^o_{9/2}$							67
88.07		5/2		7/2							67
88.20	$3s^23p^4(^1S)3d$	$^2D_{5/2}$	$3s^23p^4(^1S)4f$	$^2F^o_{7/2}$							67
87.78		3/2		5/2							67
87.49	$3s^23p^4(^3P)3d$	$^4F_{7/2}$	$3s^23p^4(^3P)4f$	$^4G^o_{9/2}$							27
87.27		9/2		11/2							27
86.95		3/2		5/2							27
86.87		5/2		7/2							27
87.35	$3s^23p^4(^1D)3d$	$^2G_{9/2}$	$3s^23p^4(^1D)4f$	$^2H^o_{11/2}$							27
84.72	$3s^23p^4(^3P)3d$	$^4D_{7/2}$	$3s^23p^4(^3P)4f$	$^4F^o_{9/2}$							27
84.67	$3s^23p^5$	$^2P^o_{3/2}$	$3s^23p^4(^3P)4s$	$^4P_{5/2}$	0	1 181 100					27
84.039		3/2		3/2	0	1 189 920	2				18
83.861	$3s^23p^5$	$^2P^o_{1/2}$	$3s^23p^4(^3P)4s$	$^2P_{1/2}$	19 345	1 211 780	1				18
83.190		3/2		3/2	0	1 202 070	3				18
82.527		3/2		1/2	0	1 211 780	0				18
82.759	$3s^23p^5$	$^2P^o_{1/2}$	$3s^23p^4(^1D)4s$	$^2D_{3/2}$	19 345	1 227 710	2				18
81.507		3/2		5/2	0	1 226 890	3				18

Co XI (Cl sequence) Ionization Energy = 2 460 000 cm^{-1} (305 eV) – Continued

λ (Å)	Classification				Energy Levels (cm^{-1})		Int.	gf	A (s^{-1})	Acc.	References
67.97	$3s^23p^5$	$^2P^o_{3/2}$	$3s^23p^4(^3P)4d$	$^2D_{5/2}$	0	1 471 200					27
66.49	$3s^23p^5$	$^2P^o_{1/2}$	$3s^23p^4(^1D)4d$	$^2D_{3/2}$	19 345	1 523 400					27
66.19		3/2		5/2	0	1 510 800					27

Co XII (S sequence) Ionization Energy = 271 000 cm^{-1} (336 eV)

λ (Å)	Classification				Energy Levels (cm^{-1})		Int.	gf	A (s^{-1})	Acc.	References
6319.^{C}	$3s^23p^4$	$^3P_2$	$3s^23p^4$	$^3P_1$	0	15 820		M1	8.4+1	C+	65*
3801.2	$3s^23p^4$	$^3P_1$	$3s^23p^4$	$^1D_2$	15 820	42 120		M1	1.3+1	E	50°,65*
2373.4^C		2		2	0	42 120		M1	1.6+2	E	65*
1368.7^C	$3s^23p^4$	$^3P_1$	$3s^23p^4$	$^1S_0$	15 820	88 880		M1	1.6+3	E	65*
343.86	$3s^23p^4$	$^3P_1$	$3s3p^5$	$^3P^o_2$	15 820	306 640	1				29
332.66^T		1		0	15 820	316 430?	0				29
332.01		0		1	17 070	318 280	1				29
330.62		1		1	15 820	318 280	1				29
326.12		2		2	0	306 640		1.8−1	2.3+9	E	29°,65*
314.19		2		1	0	318 280	2				29
286.64	$3s^23p^4$	$^1D_2$	$3s3p^5$	$^1P^o_1$	42 120	390 990		3.2−1	8.8+9	D	26°,65*
180.45	$3s^23p^4$	$^3P_1$	$3s^23p^3(^2D^o)3d$	$^3P^o_2$	15 820	569 990					26
175.44		2		2	0	569 990		2.8	1.2+11	D	26°,65*
172.41	$3s^23p^4$	$^1D_2$	$3s^23p^3(^2D^o)3d$	$^1D^o_2$	42 120	622 130		2.9	1.3+11	D	26°,65*
172.33	$3s^23p^4$	$^1S_0$	$3s^23p^3(^2D^o)3d$	$^1P^o_1$	88 880	669 160		2.06	1.54+11	C−	26°,65*
170.33	$3s^23p^4$	$^3P_1$	$3s^23p^3(^4S^o)3d$	$^3D^o_2$	15 820	602 920					26
169.04		0		1	17 070	608 660					26
168.68		1		1	15 820	608 660					26
168.34		2		3	0	594 040					26
165.86		2		2	0	602 920					26
169.91	$3s^23p^4$	$^1D_2$	$3s^23p^3(^2D^o)3d$	$^1F^o_3$	42 120	630 670		5.30	1.75+11	C−	26°,65*
80.19	$3s^23p^3(^2D^o)3d$	$^3G^o_5$	$3s^23p^3(^2D^o)4f$	$^3H_6$							27
80.14		4		5							27
79.31	$3s^23p^33d$	$^5G^o_5$	$3s^23p^34f$	$^5F_5$							27
79.21		3		4							27
63.80	$3s^23p^4$	$^3P_2$	$3s^23p^3(^4S^o)4d$	$^3D^o_3$	0	1 567 400					27
63.70	$3s^23p^4$	$^1S_0$	$3s^23p^3(^2D^o)4d$	$^1P^o_1$	88 880	1 658 800					27
63.60	$3s^23p^4$	$^1D_2$	$3s^23p^3(^2D^o)4d$	$^1D^o_2$	42 120	1 614 400					27
63.47	$3s^23p^4$	$^1D_2$	$3s^23p^3(^2D^o)4d$	$^1F^o_3$	42 120	1 617 700					27

Co XIII (P sequence) Ionization Energy = 3 057 000 cm^{-1} (379 eV)

λ (Å)	Classification		Energy Levels (cm^{-1})		Int.	gf	A (s^{-1})	Acc.	References
2791.7^{C}	$3s^23p^3$ $^2D^\circ_{3/2}$	$3s^23p^3$ $^2P^\circ_{1/2}$	43 650	79 460		M1	1.1+2	C	65*
2598.^{C}	5/2	3/2	49 690	88 170		M1	1.3+2	C	65*
2245.5^{C}	3/2	3/2	43 650	88 170		M1	3.5+2	C	65*
2290.2^{C}	$3s^23p^3$ $^4S^\circ_{3/2}$	$3s^23p^3$ $^2D^\circ_{3/2}$	0	43 650		M1	9.0+1	C	65*
2011.8^{C}	3/2	5/2	0	49 690		M1	3.8	E	65*
1258.5^{C}	$3s^23p^3$ $^4S^\circ_{3/2}$	$3s^23p^3$ $^2P^\circ_{1/2}$	0	79 460		M1	2.8+2	D	65*
1134.17^{C}	3/2	3/2	0	88 170		M1	4.7+2	C	65*
360.54^{C}	$3s^23p^3$ $^2P^\circ_{3/2}$	$3s3p^4$ $^2D_{3/2}$	88 170	365 530		5.9−4	3.1+7	E	65*
357.04^{C}	3/2	5/2	88 170	368 250		1.9−2	6.8+8	D	65*
349.56^{C}	1/2	3/2	79 460	365 530		1.2−2	3.4+8	D	65*
338.80	$3s^23p^3$ $^4S^\circ_{3/2}$	$3s3p^4$ $^4P_{5/2}$	0	295 160		1.9−1	1.8+9	D	29°,65*
325.70	3/2	3/2	0	307 030		1.3−1	2.1+9	D	29°,65*
320.40	3/2	1/2	0	312 110		6.4−2	2.1+9	D	29°,65*
316.62^{C}	$3s^23p^3$ $^2D^\circ_{5/2}$	$3s3p^4$ $^2D_{3/2}$	49 690	365 530		1.9−3	3.2+7	E	65*
313.91	5/2	5/2	49 690	368 250		2.9−1	3.3+9	D	29°,65*
310.67	3/2	3/2	43 650	365 530		2.4−1	4.1+9	D	29°,65*
308.07^{C}	3/2	5/2	43 650	368 250		1.5−3	1.8+7	E	65*
271.16	$3s^23p^3$ $^2D^\circ_{5/2}$	$3s3p^4$ $^2P_{3/2}$	49 690	418 480	5				29
263.41	3/2	1/2	43 650	423 290	2				29
215.19^{C}	$3s^23p^3$ $^2P^\circ_{3/2}$	$3s^23p^2(^3P)3d$ $^4P_{3/2}$	88 170	552 880		7.2−3	2.5+8	E	65*
213.38^{C}	3/2	1/2	88 170	556 820		1.0−2	7.2+8	E	65*
209.49^{C}	1/2	1/2	79 460	556 820		8.8−3	6.7+8	E	65*
200.72^{C}	$3s^23p^3$ $^2D^\circ_{5/2}$	$3s^23p^2(^3P)3d$ $^4P_{5/2}$	49 690	547 890		5.4−2	1.6+9	E	65*
198.73^{C}	5/2	3/2	49 690	552 880		1.2−2	5.0+8	E	65*
198.32^{C}	3/2	5/2	43 650	547 890		2.3−2	6.5+8	E	65*
194.87^{C}	3/2	1/2	43 650	556 820		5.2−2	4.7+9	E	65*
198.15^{C}	$3s^23p^3$ $^2P^\circ_{3/2}$	$3s^23p^2(^1D)3d$ $^2D_{3/2}$	88 170	592 830		1.2−2	5.2+8	E	65*
197.62^{C}	3/2	5/2	88 170	594 200		2.4−1	7.0+9	D	65*
194.79^{C}	1/2	3/2	79 460	592 830		1.7−1	7.5+9	D	65*
188.89	$3s^23p^3$ $^2P^\circ_{1/2}$	$3s^23p^2(^1D)3d$ $^2P_{1/2}$	79 460	608 870					26
188.42	3/2	3/2	88 170	618 880		1.2	5.4+10	E	26°,65*
185.39	1/2	3/2	79 460	618 880		4.0−1	1.9+10	E	26°,65*
184.11^{C}	$3s^23p^3$ $^2D^\circ_{5/2}$	$3s^23p^2(^1D)3d$ $^2D_{3/2}$	49 690	592 830		2.5−1	1.3+10	D	65*
183.65	5/2	5/2	49 690	594 200		1.5	4.9+10	D	26°,65*
182.09	3/2	3/2	43 650	592 830		1.3	6.5+10	D	26°,65*
181.64^{C}	3/2	5/2	43 650	594 200		4.8−2	1.8+9	D	65*
182.52	$3s^23p^3$ $^4S^\circ_{3/2}$	$3s^23p^2(^3P)3d$ $^4P_{5/2}$	0	547 890		2.7	8.9+10	D	26°,65*
180.87	3/2	3/2	0	552 880		1.8	9.4+10	D	26°,65*
179.59	3/2	1/2	0	556 820		9.2−1	9.4+10	D	26°,65*
178.98	$3s^23p^3$ $^2P^\circ_{3/2}$	$3s^23p^2(^3P)3d$ $^2D_{5/2}$	88 170	646 890					26
175.77	1/2	3/2	79 460	648 390					26
175.69^{C}	$3s^23p^3$ $^2D^\circ_{5/2}$	$3s^23p^2(^1D)3d$ $^2P_{3/2}$	49 690	618 880		1.6−2	8.7+8	E	65*
173.84^{C}	3/2	3/2	43 650	618 880		3.2−2	1.7+9	E	65*
174.82	$3s^23p^3$ $^2D^\circ_{5/2}$	$3s^23p^2(^1D)3d$ $^2F_{7/2}$	49 690	621 710		4.2	1.1+11	E	26°,65*
168.29^{C}	$3s^23p^3$ $^4S^\circ_{3/2}$	$3s^23p^2(^1D)3d$ $^2D_{5/2}$	0	594 200		5.2−3	2.1+8	E	65*
74.38	$3s^23p^2(^1D)3d$ $^2G_{9/2}$	$3s^23p^2(^1D)4f$ $^2H^\circ_{11/2}$							27
74.03	7/2	9/2							27
73.86	$3s^23p^2(^3P)3d$ $^4D_{7/2}$	$3s^23p^2(^3P)4f$ $^4F^\circ_{9/2}$							27

Co XIII (P sequence) Ionization Energy = 3 057 000 cm^{-1} (379 eV) – Continued

λ (Å)	Classification		Energy Levels (cm^{-1})		Int.	*gf*	*A* (s^{-1})	Acc.	References
73.66	$3s^23p^2(^3P)3d$ $^4F_{9/2}$	$3s^23p^2(^3P)4f$ $^4G^\circ_{11/2}$							27
73.58	$_{7/2}$	$_{9/2}$							27
72.66	$3s^23p^3$ $^2P^\circ_{3/2}$	$3s^23p^24d$ $^2D_{5/2}$	88 170	1 464 400					67
72.56	$_{3/2}$	$_{3/2}$	88 170	1 466 300					67
72.02	$3s^23p^3$ $^2D^\circ_{3/2}$	$3s^23p^24d$ $^2P_{1/2}$	43 650	1 432 200					67
71.84	$_{5/2}$	$_{3/2}$	49 690	1 441 700					67
70.68	$3s^23p^3$ $^2D^\circ_{5/2}$	$3s^23p^24d$ $^2D_{5/2}$	49 690	1 464 500					67
69.83	$3s^23p^3$ $^4S^\circ_{3/2}$	$3s^23p^24d$ $^4P_{5/2}$	0	1 432 000					67
60.11	$3s^23p^3$ $^2P^\circ_{3/2}$	$3s^23p^2(^1D)4d$ $^2D_{5/2}$	88 170	1 751 800					67
59.99	$3s^23p^3$ $^2D^\circ_{3/2}$	$3s^23p^2(^3P)4d$ $^2F_{5/2}$	43 650	1 710 600					67
59.86	$_{5/2}$	$_{7/2}$	49 690	1 720 300					67
59.53	$3s^23p^3$ $^2D^\circ_{5/2}$	$3s^23p^24d$ $^4D_{7/2}$	49 690	1 729 500					67

Co XIV (Si sequence) Ionization Energy = 3 315 000 cm^{-1} (411 eV)

λ (Å)	Classification		Energy Levels (cm^{-1})		Int.	*gf*	*A* (s^{-1})	Acc.	References
9242.2^{P}	$3s^23p^2$ $^3P_1$	$3s^23p^2$ $^3P_2$	11 844	22 661		M1	1.44+1	C+	59°,65*
8440.8^{P}	$_0$	$_1$	0	11 844		M1	2.99+1	C+	59°,65*
3099.2^{P}	$3s^23p^2$ $^3P_2$	$3s^23p^2$ $^1D_2$	22 661	54 921		M1	1.2+2	E	59°,65*
2320.4^{P}	$_1$	$_2$	11 844	54 921		M1	1.1+2	E	59°,65*
1120.6^{P}	$3s^23p^2$ $^3P_1$	$3s^23p^2$ $^1S_0$	11 844	101 080		M1	1.6+3	E	59°,65*
384.68^{C}	$3s^23p^2$ $^1D_2$	$3s3p^3$ $^3D^\circ_3$	54 921	314 880		1.9−2	1.2+8	E	65*
342.21	$3s^23p^2$ $^3P_2$	$3s3p^3$ $^3D^\circ_3$	22 661	314 880		1.7−1	1.4+9	D	29°,65*
334.21	$_1$	$_2$	11 844	311 050		1.4−1	1.7+9	D	29°,65*
298.42	$3s^23p^2$ $^3P_2$	$3s3p^3$ $^3P^\circ_2$	22 661	357 760		2.4−1	3.7+9	D	29°,65*
296.66	$3s^23p^2$ $^1D_2$	$3s3p^3$ $^1D^\circ_2$	54 921	392 010	4				29
239.33	$3s^23p^2$ $^1D_2$	$3s3p^3$ $^1P^\circ_1$	54 921	472 750	7				29
236.11	$3s^23p^2$ $^3P_2$	$3s3p^3$ $^3S^\circ_1$	22 661	446 180	9				29
230.34	$_1$	$_1$	11 844	446 180	5				29
224.13	$_0$	$_1$	0	446 180	3				29
207.85	$3s^23p^2$ $^1D_2$	$3s^23p3d$ $^1D^\circ_2$	54 921	536 040					26
203.34^{C}	$3s^23p^2$ $^1D_2$	$3s^23p3d$ $^3D^\circ_3$	54 921	546 710		2.0−2	4.5+8	E	65*
200.75	$3s^23p^2$ $^3P_2$	$3s^23p3d$ $^3P^\circ_2$	22 661	520 800					26
197.01	$_2$	$_1$	22 661	530 230					26
196.48	$_1$	$_2$	11 844	520 800					26
188.60	$_0$	$_1$	0	530 230					26
195.66	$3s^23p^2$ $^1S_0$	$3s^23p3d$ $^1P^\circ_1$	101 080	612 170		1.0	6.0+10	D	26°,65*
191.76	$3s^23p^2$ $^3P_2$	$3s^23p3d$ $^3D^\circ_1$	22 661	544 100					26
190.82	$_2$	$_3$	22 661	546 710		2.7	7.1+10	D	26°,65*
190.65	$_2$	$_2$	22 661	547 230					26
187.89	$_1$	$_1$	11 844	544 100					26
186.79	$_1$	$_2$	11 844	547 230					26

Co XIV (Si sequence) Ionization Energy = 3 315 000 cm^{-1} (411 eV) – Continued

λ (Å)	Classification		Energy Levels (cm^{-1})		Int.	gf	A (s^{-1})	Acc.	References
190.75	$3s^23p^2\ ^3P_1$	$3s^23p3d\ ^1D^o_2$	11 844	536 040					26
184.41	$3s^23p^2\ ^1D_2$	$3s^23p3d\ ^1F^o_3$	54 921	597 250		2.5	7.2+10	C	26°,65*
174.04^C	$3s^23p^2\ ^3P_2$	$3s^23p3d\ ^1F^o_3$	22 661	597 250		1.3−1	4.2+9	E	65*
163.35^C	$3s^23p^2\ ^3P_0$	$3s^23p3d\ ^1P^o_1$	0	612 170		6.5−3	5.4+8	E	65*
74.379	$3s^23p3d\ ^1P^o_1$	$3s^23p4f\ ^1D_2$	612 170	1 956 600					42
73.402	$3s^23p3d\ ^1F^o_3$	$3s^23p4f\ ^1G_4$	597 250	1 959 600		5.3	7.3+11	E	42°,65*
71.493^T	$3s^23p3d\ ^3D^o_3$	$3s^23p4f\ ^3F_4$	546 710	1 945 400?					42
70.698^T	$3s^23p3d\ ^3P^o_0$	$3s^23p4f\ ^3D_1$							42
69.017	$3s^23p3d\ ^3F^o_3$	$3s^23p4f\ ^3G_4$							42
68.807	4	5				6.4	8.2+11	D	42°,65*
67.069	$3s^23p^2\ ^1D_2$	$3s^23p4s\ ^1P^o_1$	54 921	1 545 920					27
66.195^T	$3s3p^3\ ^1D^o_2$	$3s^23p4f\ ^3G_3$	392 010	1 902 700?					42
66.050	$3s^23p^2\ ^3P_2$	$3s^23p4s\ ^3P^o_2$	22 661	1 536 660					27
65.585	1	2	11 844	1 536 660					27
65.712^T	$3s3p^3\ ^1D^o_2$	$3s^23p4f\ ^1F_3$	392 010	1 913 800?					42
56.900	$3s^23p^2\ ^1S_0$	$3s^23p4d\ ^1P^o_1$	101 080	1 858 500					42
56.115	$3s^23p^2\ ^1D_2$	$3s^23p4d\ ^1F^o_3$	54 921	1 837 000		1.7	5.1+11	D	42°,65*
56.021	$3s^23p^2\ ^3P_2$	$3s^23p4d\ ^3D^o_3$	22 661	1 807 700					42
55.782	1	1	11 844	1 804 500					27
55.762	1	2	11 844	1 805 200					42
55.42^T	0	1	0	1 804 500					42
55.431	$3s^23p^2\ ^3P_2$	$3s^23p4d\ ^3F^o_3$	22 661	1 826 700					42
55.10^T	$3s^23p^2\ ^3P_2$	$3s^23p4d\ ^3P^o_0$	22 661	1 838 000?					42

Co XV (Al sequence) Ionization Energy = 3 580 000 cm^{-1} (444 eV)

λ (Å)	Classification		Energy Levels (cm^{-1})		Int.	gf	A (s^{-1})	Acc.	References
4350.6	$3s^23p\ ^2P^o_{1/2}$	$3s^23p\ ^2P^o_{3/2}$	0	22 979		M1	1.09+2	C+	50°,65*
337.422	$3s3p^2\ ^2D_{3/2}$	$3p^3\ ^2D^o_{3/2}$	322 738	619 102	3				54
334.852	5/2	5/2	325 788	624 427	4				54
333.60^C	$3s^23p\ ^2P^o_{3/2}$	$3s3p^2\ ^2D_{3/2}$	22 979	322 738		4.0−3	6.0+7	E	65*
330.247	3/2	5/2	22 979	325 788		2.0−1	2.1+9	D	54°,65*
309.849	1/2	3/2	0	322 738		1.6−1	2.7+9	D	54°,65*
272.855	$3s^23d\ ^2D_{5/2}$	$3s3p(^1P^o)3d\ ^2F^o_{7/2}$	508 779	875 274	7				54
268.424	3/2	5/2	506 191	878 736	4				54
272.159	$3s3p^2\ ^2D_{3/2}$	$3p^3\ ^2P^o_{1/2}$	322 738	690 170	2				54
271.126	5/2	3/2	325 788	694 620	2				54

Co XV (Al sequence) Ionization Energy = 3 580 000 cm^{-1} (444 eV) – Continued

λ (Å)	Classification		Energy Levels (cm^{-1})		Int.	*gf*	*A* (s^{-1})	Acc.	References
271.83^C	$3s^23p$ $^2P^o_{3/2}$	$3s3p^2$ $^2S_{1/2}$	22 979	390 851		1.7–2	7.6+8	E	65*
255.852	1/2	1/2	0	390 851		4.2–1	2.2+10	E	54°,65*
270.378	$3s3p^2$ $^4P_{5/2}$	$3p^3$ $^4S^o_{3/2}$	263 175	633 024		7.8–1	1.7+10	D	54°,65*
262.249	3/2	3/2	251 704	633 024		5.2–1	1.3+10	D	54°,65*
255.828	1/2	3/2	242 133	633 024		2.8–1	7.3+9	D	54°,65*
255.762	$3s^23d$ $^2D_{5/2}$	$3s3p(^1P^o)3d$ $^2D^o_{3/2}$	508 779	899 768					54
253.239	5/2	5/2	508 779	903 680	4				54
255.113	$3s^23d$ $^2D_{3/2}$	$3s3p(^1P^o)3d$ $^2P^o_{1/2}$	506 191	898 174	3				54
251.949	3/2	3/2	506 191	903 110	2				54
253.326	$3s^23p$ $^2P^o_{3/2}$	$3s3p^2$ $^2P_{1/2}$	22 979	417 743		4.4–1	2.4+10	E	54°,65*
247.740	3/2	3/2	22 979	426 641		1.36	3.7+10	C–	54°,65*
239.376	1/2	1/2	0	417 743		2.2–1	1.3+10	E	54°,65*
234.385	1/2	3/2	0	426 641		2.80–1	8.5+9	C–	54°,65*
225.083	$3s3p^2$ $^2D_{5/2}$	$3s3p(^3P^o)3d$ $^2D^o_{5/2}$	325 788	770 069	3				54
223.992	3/2	3/2	322 738	769 183					54
211.879	$3s3p^2$ $^2S_{1/2}$	$3s3p(^3P^o)3d$ $^2P^o_{3/2}$	390 851	862 818	1				54
210.861	$3s3p^2$ $^2D_{3/2}$	$3s3p(^3P^o)3d$ $^2F^o_{5/2}$	322 738	796 984	2				54
204.394	5/2	7/2	325 788	815 039	3				54
209.873	$3s3p^2$ $^2P_{3/2}$	$3s3p(^1P^o)3d$ $^2P^o_{3/2}$	426 641	903 110	2				54
209.620	$3s3p^2$ $^2P_{3/2}$	$3s3p(^1P^o)3d$ $^2D^o_{5/2}$	426 641	903 680	3				54
207.458	1/2	3/2	417 743	899 768	3				54
206.924	$3s^23p$ $^2P^o_{3/2}$	$3s^23d$ $^2D_{3/2}$	22 979	506 191		2.4–1	9.1+9	D	54°,65*
205.848	3/2	5/2	22 979	508 779		1.6	4.3+10	D	54°,65*
197.554	1/2	3/2	0	506 191		9.0–1	3.9+10	D	54°,65*
205.229	$3s3p^2$ $^4P_{3/2}$	$3s3p(^3P^o)3d$ $^4P^o_{5/2}$	251 704	738 965	2				54
203.468	$3s3p^2$ $^4P_{5/2}$	$3s3p(^3P^o)3d$ $^4D^o_{7/2}$	263 175	754 653	3				54
203.086	5/2	5/2	263 175	755 592	3				54
199.558	1/2	1/2	242 133	743 240	1				54
198.451	3/2	5/2	251 704	755 592	1				54
66.913	$3s^23d$ $^2D_{5/2}$	$3s^24f$ $^2F^o_{7/2}$	508 779	2 003 200					27
66.819	3/2	5/2	506 191	2 002 800					27
64.480	$3s3p3d$ $^4F^o_{7/2}$	$3s3p4f$ $^4G_{9/2}$	1 449 100	3 000 000					27
64.356	5/2	7/2	1 446 100	3 000 000					27
64.229	9/2	11/2	1 443 100	3 000 000					27
53.173	$3s^23p$ $^2P^o_{3/2}$	$3s^24d$ $^2D_{5/2}$	22 979	1 903 600	2				17
52.583	1/2	3/2	0	1 901 800	1				17

Co XVI (Mg sequence) Ionization Energy = 4 129 200 cm^{-1} (511.96 eV)

λ (Å)	Classification		Energy Levels (cm^{-1})		Int.	*gf*	*A* (s^{-1})	Acc.	References
5764.	$3s3p$ $^3P^o_1$	$3s3p$ $^3P^o_2$	256 060	273 414		M1		E	50°,65*
496.543	$3s3d$ $^1D_2$	$3p3d$ $^1D^o_2$	812 929	1 014 316		1.5–1	8.1+8	D–	9°,65*
449.391	$3s3p$ $^1P^o_1$	$3p^2$ $^1D_2$	376 323	598 840		2.5–1	1.7+9	E	9°,65*
402.171	$3s3p$ $^1P^o_1$	$3p^2$ $^3P_2$	376 323	624 984	190				9

Co XVI (Mg sequence) Ionization Energy = 4 129 200 cm^{-1} (511.96 eV) – Continued

λ (Å)	Classification				Energy Levels (cm^{-1})		Int.	*gf*	*A* (s^{-1})	Acc.	References
390.533^P	$3s^2$	$^1S_0$	$3s3p$	$^3P^o_1$	0	256 060		3.7–3	5.4+7	E	9°,65*
380.759^C	$3s3d$	$^3D_3$	$3p3d$	$^3F^o_2$	728 136	990 769		1.2–3	1.1+7	E	65*
377.779		2		2	726 039	990 769		1.0–1	9.8+8	D	9°,65*
375.886		1		2	724 731	990 769		3.6–1	3.4+9	D–	9°,65*
363.98		3		3	728 136	1 002 876		1.6–1	1.2+9	C	45°,65*
361.223		2		3	726 039	1 002 876		6.5–1	4.8+9	C–	9°,65*
345.996		3		4	728 136	1 017 157		1.08	6.7+9	C	9°,65*
310.324	$3s3d$	$^1D_2$	$3p3d$	$^1F^o_3$	812 929	1 135 167		2.0	2.0+10	D	9°,65*
310.324	$3s3d$	$^3D_3$	$3p3d$	$^3P^o_2$	728 136	1 050 383	440				9
294.575^C		2		1	726 039	1 065 511		1.3–1	3.3+9	E	65*
293.721^C		1		0	724 731	1 065 190		1.6–1	1.2+10	C	65*
293.44		1		1	724 731	1 065 511		3.3–1	8.5+9	E	45°,65*
309.85	$3s3d$	$^3D_2$	$3p3d$	$^3D^o_1$	726 039	1 048 776		3.1–1	7.2+9	E	45°,65*
308.599^C		1		1	724 731	1 048 776		9.6–2	2.2+9	E	65*
298.037		3		3	728 136	1 063 667		7.7–2	8.3+8	C–	9°,65*
296.184^C		2		3	726 039	1 063 667		2.0–1	2.2+9	C	65*
294.185		2		2	726 039	1 065 955	190				9
307.300	$3s3p$	$^3P^o_2$	$3p^2$	$^1D_2$	273 414	598 840		1.8–1	2.5+9	E	9°,65*
291.735		1		2	256 060	598 840		9.0–2	1.4+9	E	9°,65*
302.94	$3s3p$	$^1P^o_1$	$3p^2$	$^1S_0$	376 323	706 420		3.0–1	2.2+10	C–	45°,65*
302.659	$3s3p$	$^3P^o_2$	$3p^2$	$^3P_1$	273 414	603 814		3.2–1	7.9+9	C	9°,65*
298.444		1		0	256 060	591 131		2.6–1	2.0+10	C	9°,65*
287.564		1		1	256 060	603 814		2.0–1	5.4+9	C	9°,65*
284.434		2		2	273 414	624 984		8.0–1	1.3+10	D	9°,65*
281.902		0		1	249 081	603 814		2.8–1	7.8+9	C	9°,65*
271.057		1		2	256 060	624 984		2.5–1	4.6+9	D	9°,65*
298.30	$3s3d$	$^1D_2$	$3p3d$	$^1P^o_1$	812 929	1 148 160		5.5–1	1.4+10	D	45°,65*
285.77	$3p3d$	$^1P^o_1$	$3d^2$	$^1D_2$	1 148 160	1 498 090	1				10
271.437	$3p3d$	$^1F^o_3$	$3d^2$	$^1G_4$	1 135 167	1 503 577	5				10
265.729	$3s^2$	$^1S_0$	$3s3p$	$^1P^o_1$	0	376 323		7.96–1	2.51+10	C+	9°,65*
256.86	$3p^2$	$^3P_2$	$3p3d$	$^1D^o_2$	624 984	1 014 316	2				45
250.224	$3p3d$	$^3D^o_2$	$3d^2$	$^3F_3$	1 065 955	1 465 589	2				10
247.199		3		4	1 063 667	1 468 205	4				10
241.157		1		2	1 048 776	1 463 403	2				10
240.858	$3p3d$	$^3P^o_2$	$3d^2$	$^3F_3$	1 050 383	1 465 589	1				10
240.688	$3p^2$	$^1D_2$	$3p3d$	$^1D^o_2$	598 840	1 014 316		6.5–1	1.5+10	E	9°,65*
235.965^C	$3p^2$	$^3P_2$	$3p3d$	$^3D^o_1$	624 984	1 048 776		7.0–3	2.8+8	E	65*
227.955		2		3	624 984	1 063 667		1.3	2.4+10	D–	9°,65*
226.772		2		2	624 984	1 065 955	130				9
224.738^C		1		1	603 814	1 048 776		1.0–1	4.6+9	E	65*
218.51		0		1	591 131	1 048 776		6.0–1	2.8+10	E	45°,65*
216.384		1		2	603 814	1 065 955	90				9
229.037	$3s3p$	$^1P^o_1$	$3s3d$	$^1D_2$	376 323	812 929		1.8	4.5+10	D	9°,65*
228.276	$3p3d$	$^3D^o_2$	$3d^2$	$^3P_2$	1 065 955	1 504 024	1				10
221.08		1		0	1 048 776	1 501 101	0				10
227.188	$3p3d$	$^1P^o_1$	$3d^2$	$^1S_0$	1 148 160	1 588 324	1				10

Co XVI (Mg sequence) Ionization Energy = 4 129 200 cm^{-1} (511.96 eV) – Continued

λ (Å)	Classification		Energy Levels (cm^{-1})		Int.	*gf*	*A* (s^{-1})	Acc.	References
227.001^{C}	$3p^2$ $^3P_2$	$3p3d$ $^3P^o_1$	624 984	1 065 511		1.6 – 1	6.9 + 9	E	65*
223.928	$_1$	$_2$	603 814	1 050 383	130				9
216.74	$_1$	$_0$	603 814	1 065 190		1.6 – 1	2.3 + 10	C –	45°,65*
216.59	$_1$	$_1$	603 814	1 065 511		3.3 – 1	1.6 + 10	E	45°,65*
226.38	$3p^2$ $^1S_0$	$3p3d$ $^1P^o_1$	706 420	1 148 160		6.0 – 1	2.6 + 10	C –	45°,65*
221.702	$3p3d$ $^3F^o_4$	$3d^2$ $^3F_4$	1 017 157	1 468 205	1				10
216.117	$_3$	$_3$	1 002 876	1 465 589	1				10
211.580	$_2$	$_2$	990 769	1 463 403	1				10
221.574^{C}	$3s3p$ $^3P^o_2$	$3s3d$ $^3D_1$	273 414	724 731		1.4 – 2	6.3 + 8	D –	65*
220.921	$_2$	$_2$	273 414	726 039		2.1 – 1	5.9 + 9	C –	9°,65*
219.915	$_2$	$_3$	273 414	728 136		1.19	2.35 + 10	C –	9°,65*
213.370	$_1$	$_1$	256 060	724 731		2.2 – 1	1.1 + 10	C	9°,65*
212.778	$_1$	$_2$	256 060	726 039		6.6 – 1	1.9 + 10	C –	9°,65*
210.239	$_0$	$_1$	249 081	724 731		2.9 – 1	1.5 + 10	C –	9°,65*
221.39	$3p3d$ $^3P^o_2$	$3d^2$ $^3P_1$	1 050 383	1 502 075	1				10
220.446	$_2$	$_2$	1 050 383	1 504 024	1				10
215.145	$3p^2$ $^1D_2$	$3p3d$ $^3D^o_3$	598 840	1 063 667	90				9
206.708	$3p3d$ $^1D^o_2$	$3d^2$ $^1D_2$	1 014 316	1 498 090	1				10
186.455	$3p^2$ $^1D_2$	$3p3d$ $^1F^o_3$	598 840	1 135 167					9
182.043^{C}	$3p^2$ $^1D_2$	$3p3d$ $^1P^o_1$	598 840	1 148 160		6.5 – 3	4.4 + 8	E	65*
64.780^{T}	$3p3d$ $^1P^o_1$	$3p4f$ $^1D_2$	1 148 160	26 918 00?					42
64.773	$3s3d$ $^1D_2$	$3s4f$ $^1F^o_3$	812 929	2 356 800					27
64.537	$3p3d$ $^1F^o_3$	$3p4f$ $^1G_4$	1 135 167	2 684 700		6.3	1.1 + 12	C	42°,65*
63.017^{T}	$3p3d$ $^3P^o_2$	$3p4f$ $^1F_3$	1 050 383	2 637 100					42
62.805	$3p3d$ $^3D^o_3$	$3p4f$ $^3F_4$	1 063 667	2 655 900					42
62.805	$_1$	$_2$	1 048 776	2 641 000					42
62.412	$3p3d$ $^3D^o_2$	$3p4f$ $^3D_3$	1 065 955	2 668 200					42
62.334	$3p3d$ $^3P^o_1$	$3p4f$ $^3D_2$	1 065 511	2 669 800					42
62.131	$_0$	$_1$	1 065 190	2 674 900		9.2 – 1	5.3 + 11	C	42°,65*
62.131	$_1$	$_1$	1 065 511	2 674 900					42
61.982	$3s3d$ $^3D_3$	$3s4f$ $^3F^o_4$	728 136	2 341 500	2				17
61.916	$_2$	$_3$	726 039	2 341 100	2				17
61.875	$_1$	$_2$	724 731	2 340 900	1				17
61.621	$3p3d$ $^1D^o_2$	$3p4f$ $^1F_3$	1 014 316	2 637 100					42
61.200	$3p3d$ $^3F^o_3$	$3p4f$ $^3G_4$	1 002 876	2 636 900					42
61.025	$_2$	$_3$	990 769	2 629 400					42
61.025	$_4$	$_5$	1 017 157	2 656 400		7.2	1.2 + 12	C	42°,65*
59.625	$3p^2$ $^3P_2$	$3p4s$ $^3P^o_2$	624 984	2 302 100					67
58.96	$3s3p$ $^3P^o_2$	$3s4s$ $^3S_1$	273 414	1 969 500					67
58.365	$_1$	$_1$	256 060	1 969 500					67
58.127	$_0$	$_1$	249 081	1 969 500					67
56.83	$3p^2$ $^1D_2$	$3s4f$ $^1F^o_3$	598 840	2 356 800					27
53.043	$3s3p$ $^1P^o_1$	$3s4d$ $^1D_2$	376 323	2 261 600					27

Co XVI (Mg sequence) Ionization Energy = 4 129 200 cm^{-1} (511.96 eV) – Continued

λ (Å)	Classification				Energy Levels (cm^{-1})		Int.	*gf*	*A* (s^{-1})	Acc.	References
51.279	$3p^2$	$^1D_2$	$3p4d$	$^1F^\circ_3$	598 840	2 549 000					67
51.239	$3p^2$	$^3P_2$	$3p4d$	$^3D^\circ_3$	624 984	2 576 600					67
51.007		1		2	603 814	2 564 300					67
50.94		0		1	591 131	2 554 200					67
50.393	$3s3p$	$^3P^\circ_2$	$3s4d$	$^3D_2$	273 414	2 257 800					17
50.357		2		3	273 414	2 259 200	2				17
49.979		1		1	256 060	2 256 900					17
49.958		1		2	256 060	2 257 800	1				17
49.808		0		1	249 081	2 256 900	1				17
47.483	$3s^2$	$^1S_0$	$3s4p$	$^1P^\circ_1$	0	2 106 020		3.81 – 1	3.76 + 11	C	17°,65*
46.522	$3s3p$	$^3P^\circ_2$	$3p4p$	$^3P_1$	273 414	2 422 900					67
46.433	$3s3p$	$^3P^\circ_2$	$3p4p$	$^3D_3$	273 414	2 427 100					67
44.253	$3s3d$	$^3D_3$	$3s5f$	$^3F^\circ_4$	728 136	2 987 900					67
38.84^{T}	$3s3p$	$^3P^\circ_2$	$3s5s$	$^3S_1$	273 414	28 481 00?					67
37.401	$3s3p$	$^3P^\circ_2$	$3s5d$	$^3D_3$	273 414	2 947 100	3				33
37.165		1		2	256 060	2 946 800	2				33
37.070		0		1	249 081	2 946 700	1				33
14.080	$2p^63s^2$	$^1S_0$	$2p^53s^23d$	$^1P^\circ_1$	0	7 102 300					60

Co XVII (Na sequence) Ionization Energy = 4 408 500 cm^{-1} (546.58 eV)

λ (Å)	Classification				Energy Levels (cm^{-1})		Int.	*gf*	*A* (s^{-1})	Acc.	References
855.066^{C}	$4s$	$^2S_{1/2}$	$4p$	$^2P^\circ_{1/2}$	2 079 550	2 196 500		3.4 – 1	1.5 + 9	C	65*
787.216^{C}		1/2		3/2	2 079 550	2 206 580		7.4 – 1	2.0 + 9	C	65*
679.763^{C}	$4p$	$^2P^\circ_{3/2}$	$4d$	$^2D_{3/2}$	2 206 580	2 353 690		1.6 – 1	5.6 + 8	C	65*
672.631^{C}		3/2		5/2	2 206 580	2 355 250		1.4	3.4 + 9	C	65*
636.173^{C}		1/2		3/2	2 196 500	2 353 690		8.2 – 1	3.4 + 9	C	65*
339.516^{P}	$3s$	$^2S_{1/2}$	$3p$	$^2P^\circ_{1/2}$	0	294 537		2.38 – 1	6.86 + 9	B	52°,65*
312.559^{P}		1/2		3/2	0	319 940		5.22 – 1	8.93 + 9	B	52°,65*
276.932^{C}	$5d$	$^2D_{3/2}$	$6p$	$^2P^\circ_{1/2}$	3 102 200	3 463 300		4.48 – 1	1.94 + 10	C	65*
275.330^{C}		5/2		3/2	3 103 000	3 466 200		7.8 – 1	1.7 + 10	C	65*
274.725^{C}		3/2		3/2	3 102 200	3 466 200		8.8 – 2	1.9 + 9	D	65*
269.906^{C}	$5f$	$^2F^\circ_{5/2}$	$6d$	$^2D_{3/2}$	3 135 200	3 505 700		2.5 – 1	5.7 + 9	C	65*
269.687^{C}		7/2		5/2	3 135 300	3 506 100		3.6 – 1	5.5 + 9	C	65*
269.615^{C}		5/2		5/2	3 135 200	3 506 100		1.8 – 2	2.8 + 8	D	65*
249.834^{P}	$3p$	$^2P^\circ_{3/2}$	$3d$	$^2D_{3/2}$	319 940	720 211		1.04 – 1	2.78 + 9	B	52°,65*
247.540^{P}		3/2		5/2	319 940	723 915		9.52 – 1	1.72 + 10	B	52°,65*
234.918^{P}		1/2		3/2	294 537	720 211		5.58 – 1	1.68 + 10	B	52°,65*
237.248^{C}	$5d$	$^2D_{5/2}$	$6f$	$^2F^\circ_{7/2}$	3 103 000	3 524 500		3.7	5.5 + 10	C	65*
237.248^{C}		5/2		5/2	3 103 000	3 524 500		1.9 – 1	3.8 + 9	D	65*
236.799^{C}		3/2		5/2	3 102 200	3 524 500		2.6	5.1 + 10	C	65*
210.571^{C}	$5p$	$^2P^\circ_{3/2}$	$6d$	$^2D_{3/2}$	3 030 800	3 505 700		1.1 – 1	4.1 + 9	D	65*
210.393^{C}		3/2		5/2	3 030 800	3 506 100		1.0	2.5 + 10	C	65*
208.507^{C}		1/2		3/2	3 026 100	3 505 700		5.5 – 0	2.11 + 10	C	65*
201.776^{C}	$5s$	$^2S_{1/2}$	$6p$	$^2P^\circ_{1/2}$	2 967 700	3 463 300		1.8 – 1	1.5 + 10	C	65*
200.602^{C}		1/2		3/2	2 967 700	3 466 200		3.66 – 1	1.5 + 10	C	65*

Co XVII (Na sequence) Ionization Energy = 4 408 500 cm^{-1} (546.58 eV) – Continued

λ (Å)	Classification		Energy Levels (cm^{-1})		Int.	*gf*	*A* (s^{-1})	Acc.	References
163.292^{C}	5*f* $^2F^o_{5/2}$	7*d* $^2D_{3/2}$	3 135 200	3 747 600		4.4-2	2.8+9	D	65*
163.212^{C}	7/2	5/2	3 135 300	3 748 000		6.5-2	2.7+9	D	65*
163.185^{C}	5/2	5/2	3 135 200	3 748 000		3.2-3	1.3+8	E	65*
152.486^{C}	5*d* $^2D_{5/2}$	7*f* $^2F^o_{7/2}$	3 103 000	3 758 800		1.0	3.6+10	C	65*
152.486^{C}	5/2	5/2	3 103 000	3 758 800		5.0-2	2.4+9	D	65*
152.300^{C}	3/2	5/2	3 102 200	3 758 800		7.2-1	3.4+10	C	65*
148.719^{C}	4*d* $^2D_{3/2}$	5*p* $^2P^o_{1/2}$	2 353 690	3 026 100		2.9-1	4.3+10	C	65*
148.028^{C}	5/2	3/2	2 355 250	3 030 800		5.2-1	3.9+10	C	65*
147.687^{C}	3/2	3/2	2 353 690	3 030 800		5.6-2	4.2+9	D	65*
146.540^{C}	4*f* $^2F^o_{5/2}$	5*d* $^2D_{3/2}$	2 419 790	3 102 200		1.0-1	8.1+9	C	65*
146.501^{C}	7/2	5/2	2 420 410	3 103 000		1.4-1	7.6+9	C	65*
146.368^{C}	5/2	5/2	2 419 790	3 103 000		7.2-3	3.9+8	D	65*
139.509^{C}	5*p* $^2P^o_{3/2}$	7*d* $^2D_{3/2}$	3 030 800	3 747 600		3.7-2	3.2+9	D	65*
139.431^{C}	3/2	5/2	3 030 800	3 748 000		3.3-1	1.9+10	C	65*
138.600^{C}	1/2	3/2	3 026 100	3 747 600		1.8-1	1.6+10	C	65*
139.04	4*f* $^2F^o_{7/2}$	5*g* $^2G_{9/2}$	2 420 410	3 139 500					43
138.97	5/2	7/2	2 419 790	3 139 500					43
131.385^{C}	4*p* $^2P^o_{3/2}$	5*s* $^2S_{1/2}$	2 206 580	2 967 700		4.08-1	7.9+10	C	65*
129.668^{C}	1/2	1/2	2 196 500	2 967 700		2.0-1	4.1+10	C	65*
128.21^{C}	4*d* $^2D_{5/2}$	5*f* $^2F^o_{5/2}$	2 355 250	3 135 200		2.1-1	1.4+10	D	65*
128.20	5/2	7/2	2 355 250	3 135 300		4.3	2.2+11	C	43°,65*
127.96	3/2	5/2	2 353 690	3 135 200		2.8	1.9+11	C	43°,65*
111.655^{C}	4*p* $^2P^o_{3/2}$	5*d* $^2D_{3/2}$	2 206 580	3 102 200		1.2-1	1.5+10	D	65*
111.555^{C}	3/2	5/2	2 206 580	3 103 000		1.0	9.2+10	C	65*
110.412^{C}	1/2	3/2	2 196 500	3 102 200		5.8-1	7.9+10	C	65*
105.647^{C}	4*s* $^2S_{1/2}$	5*p* $^2P^o_{1/2}$	2 079 550	3 026 100		1.7-1	5.1+10	C	65*
105.125^{C}	1/2	3/2	2 079 550	3 030 800		3.38-1	5.1+10	C	65*
92.107^{C}	4*f* $^2F^o_{7/2}$	6*d* $^2D_{5/2}$	2 420 410	3 506 100		2.5-2	3.2+9	D	65*
92.089^{C}	5/2	3/2	2 419 790	3 505 700		1.7-2	3.4+9	D	65*
92.055^{C}	5/2	5/2	2 419 790	3 506 100		1.2-3	1.6+8	E	65*
90.122^{C}	4*d* $^2D_{3/2}$	6*p* $^2P^o_{1/2}$	2 353 690	3 463 300		4.80-2	1.97+10	C	65*
90.013^{C}	5/2	3/2	2 355 250	3 466 200		8.64-2	1.77+10	C	65*
89.887^{C}	3/2	3/2	2 353 690	3 466 200		9.6-3	1.9+9	D	65*
85.525^{C}	4*d* $^2D_{5/2}$	6*f* $^2F^o_{7/2}$	2 355 250	3 524 500		1.0	1.2+11	C	65*
85.525^{C}	5/2	5/2	2 355 250	3 524 500		5.3-2	8.1+9	D	65*
85.411^{C}	3/2	5/2	2 353 690	3 524 500		7.2-1	1.1+11	C	65*
76.975^{C}	4*p* $^2P^o_{3/2}$	6*d* $^2D_{3/2}$	2 206 580	3 505 700		3.7-2	1.0+10	D	65*
76.951^{C}	3/2	5/2	2 206 580	3 506 100		3.3-1	6.2+10	C	65*
76.383^{C}	1/2	3/2	2 196 500	3 505 700		1.9-1	5.3+10	C	65*
75.325^{C}	4*f* $^2F^o_{7/2}$	7*d* $^2D_{5/2}$	2 420 410	3 748 000		8.8-3	1.7+9	D	65*
75.312^{C}	5/2	3/2	2 419 790	3 747 600		6.0-3	1.8+9	D	65*
75.289^{C}	5/2	5/2	2 419 790	3 748 000		4.4-4	8.7+7	E	65*
72.267^{C}	4*s* $^2S_{1/2}$	6*p* $^2P^o_{1/2}$	2 079 550	3 463 300		5.4-2	3.5+10	C	65*
72.116^{C}	1/2	3/2	2 079 550	3 466 200		1.1-1	3.4+10	C	65*
71.248^{C}	4*d* $^2D_{5/2}$	7*f* $^2F^o_{7/2}$	2 355 250	3 758 800		4.1-1	6.8+10	C	65*
71.248^{C}	5/2	5/2	2 355 250	3 758 800		2.1-2	4.6+9	D	65*
71.169^{C}	3/2	5/2	2 353 690	3 758 800		2.9-1	6.4+10	C	65*
67.737^{C}	3*d* $^2D_{3/2}$	4*p* $^2P^o_{1/2}$	720 211	2 196 500		1.2-1	8.8+10	C-	65*
67.446^{C}	5/2	3/2	723 915	2 206 580		2.2-1	8.1+10	C-	65*
67.278^{C}	3/2	3/2	720 211	2 206 580		2.5-2	9.1+9	D	65*

Co XVII (Na sequence) Ionization Energy = 4 408 500 cm^{-1} (546.58 eV) – Continued

λ (Å)	Classification				Energy Levels (cm^{-1})		Int.	*gf*	$A (s^{-1})$	Acc.	References
64.892[C]	4*p*	$^2P^o_{3/2}$	7*d*	$^2D_{3/2}$	2 206 580	3 747 600		1.8−2	7.0+9	D	65*
64.875[C]		3/2		5/2	2 206 580	3 748 000		1.6−1	4.2+10	C	65*
64.470[C]		1/2		3/2	2 196 500	3 747 600		9.0−2	3.6+10	C	65*
58.967[C]	3*d*	$^2D_{5/2}$	4*f*	$^2F^o_{5/2}$	723 915	2 419 790		2.65−1	8.5+10	C	65*
58.945[P]		5/2		7/2	723 915	2 420 410		5.3	1.3+12	C	52°,65*
58.838[P]		3/2		5/2	720 211	2 419 790		3.7	1.2+12	C	52°,65*
56.833	3*p*	$^2P^o_{3/2}$	4*s*	$^2S_{1/2}$	319 940	2 079 550					16
56.021		1/2		1/2	294 537	2 079 550					16
49.171	3*p*	$^2P^o_{3/2}$	4*d*	$^2D_{3/2}$	319 940	2 353 690		1.30−1	9.0+10	C	16°,65*
49.133		3/2		5/2	319 940	2 355 250		1.16	5.4+11	C	16°,65*
48.564		1/2		3/2	294 537	2 353 690		6.2−1	4.4+11	C	16°,65*
45.527	3*s*	$^2S_{1/2}$	4*p*	$^2P^o_{1/2}$	0	2 196 500		1.57−1	2.53+11	C+	16°,65*
45.319		1/2		3/2	0	2 206 580		2.92−1	2.37+11	C	16°,65*
43.367[C]	3*d*	$^2D_{3/2}$	5*p*	$^2P^o_{1/2}$	720 211	3 026 100		2.0−2	3.6+10	D	65*
43.349[C]		5/2		3/2	723 915	3 030 800		3.7−2	3.2+10	D	65*
43.279[C]		3/2		3/2	720 211	3 030 800		4.0−3	3.6+9	E	65*
41.472[C]	3*d*	$^2D_{5/2}$	5*f*	$^2F^o_{5/2}$	723 915	3 135 200		4.9−2	3.2+10	D	65*
41.462		5/2		7/2	723 915	3 135 300		9.72−1	4.73+11	C	16°,65*
41.404		3/2		5/2	720 211	3 135 200		6.8−1	4.4+11	C	33°,65*
37.768	3*p*	$^2P^o_{3/2}$	5*s*	$^2S_{1/2}$	319 940	2 967 700		4.8−2	1.1+11	C	65*,67°
36.466[C]	3*d*	$^2D_{5/2}$	6*p*	$^2P^o_{3/2}$	723 915	3 466 200		1.3−2	1.6+10	D	65*
36.455[C]		3/2		1/2	720 211	3 463 300		6.8−3	1.7+10	D	65*
36.417[C]		3/2		3/2	720 211	3 466 200		1.4−3	1.8+9	E	65*
35.942[C]	3*p*	$^2P^o_{3/2}$	5*d*	$^2D_{3/2}$	319 940	3 102 200		4.0−2	5.1+10	D	65*
35.932		3/2		5/2	319 940	3 103 000		3.6−1	3.1+11	C	33°,65*
35.617		1/2		3/2	294 537	3 102 200		2.0−1	2.7+11	C	33°,65*
35.707[C]	3*d*	$^2D_{5/2}$	6*f*	$^2F^o_{5/2}$	723 915	3 524 500		1.8−2	1.6+10	D	65*
35.707		5/2		7/2	723 915	3 524 500		3.6−1	2.3+11	C	33°,65*
35.660		3/2		5/2	720 211	3 524 500		2.6−1	2.2+11	C	33°,65*
33.046	3*s*	$^2S_{1/2}$	5*p*	$^2P^o_{1/2}$	0	3 026 100		4.8−2	1.5+11	C	33°,65*
32.995		1/2		3/2	0	3 030 800		1.0−1	1.6+11	C	33°,65*
32.951	3*d*	$^2D_{5/2}$	7*f*	$^2F^o_{7/2}$	723 915	3 758 800		1.76−1	1.35+11	C	33°,65*
32.950[C]		5/2		5/2	723 915	3 758 800		9.0−3	9.1+9	D	65*
32.910		3/2		5/2	720 211	3 758 800		1.24−1	1.27+11	C	33°,65*
31.390[C]	3*p*	$^2P^o_{3/2}$	6*d*	$^2D_{3/2}$	319 940	3 505 700		1.8−2	3.1+10	D	65*
31.386		3/2		5/2	319 940	3 506 100		1.64−1	1.86+11	C	33°,65*
31.142		1/2		3/2	294 537	3 505 700		9.2−2	1.6+11	C	33°,65*
31.38	3*d*	$^2D_{5/2}$	8*f*	$^2F^o_{7/2}$	723 915	3 910 700					67
29.174[C]	3*p*	$^2P^o_{3/2}$	7*d*	$^2D_{3/2}$	319 940	3 747 600		1.0−2	2.0+10	D	65*
29.171		3/2		5/2	319 940	3 748 000		8.8−2	1.2+11	C	33°,65*
28.960		1/2		3/2	294 537	3 747 600		5.04−2	1.0+11	C	33°,65*
28.874	3*s*	$^2S_{1/2}$	6*p*	$^2P^o_{1/2}$	0	3 463 300		2.2−2	8.8+10	C	33°,65*
28.85		1/2		3/2	0	3 466 200		4.4−2	8.6+10	C	33°,65*
27.902	3*p*	$^2P^o_{3/2}$	8*d*	$^2D_{5/2}$	319 940	3 903 900					33
15.828	$2p^63s$	$^2S_{1/2}$	$2p^53s^2$	$^2P^o_{3/2}$	0	6 317 900					32
15.551		1/2		1/2	0	6 430 500					32

Co XVIII (Ne sequence) Ionization Energy = 11 269 000 cm^{-1} (1397.2 eV)

λ (Å)	Classification		Energy Levels (cm^{-1})		Int.	*gf*	*A* (s^{-1})	Acc.	References
45.640	$2p^53p\ ^3P_2$	$2p^54d\ ^3F^\circ_3$							41
45.454	$2p^53p\ ^1D_2$	$2p^54d\ ^1F^\circ_3$							41
45.454	$2p^53p\ ^3D_1$	$2p^54d\ ^3D^\circ_2$							41
44.959	2	3							41
45.35	$2p^53p\ ^3D_3$	$2p^54d\ ^3F^\circ_4$				2.1	7.6+11	D−	41°,65*
44.869	$2p^53p\ ^1P_1$	$2p^54d\ ^1D^\circ_2$							41
15.437	$2p^6\ ^1S_0$	$2p^5(^2P^\circ_{3/2})3s\ (^3/_2,^1/_2)^\circ_1$	0	6 477 900		1.19−1	1.11+12	C	38°,65*
15.169	$2p^6\ ^1S_0$	$2p^5(^2P^\circ_{1/2})3s\ (^1/_2,^1/_2)^\circ_1$	0	6 592 400		1.05−1	1.01+12	C	38°,65*
14.041	$2p^6\ ^1S_0$	$2p^53d\ ^3P^\circ_1$	0	7 122 000		1.2−2	1.3+11	E	38°,65*
13.868	$2p^6\ ^1S_0$	$2p^53d\ ^3D^\circ_1$	0	7 210 800		7.0−1	8.1+12	D	38°,65*
13.634	$2p^6\ ^1S_0$	$2p^53d\ ^1P^\circ_1$	0	7 334 600		2.40	2.87+13	C	38°,65*
12.667	$2s^22p^6\ ^1S_0$	$2s2p^63p\ ^3P^\circ_1$	0	7 894 500					38
12.606	$2s^22p^6\ ^1S_0$	$2s2p^63p\ ^1P^\circ_1$	0	7 932 700		2.9−1	4.1+12	D	38°,65*
11.486	$2p^6\ ^1S_0$	$2p^5(^2P^\circ_{3/2})4s\ (^3/_2,^1/_2)^\circ_1$	0	8 706 000		2.5−2	4.2+11	D	38°,65*
11.321	$2p^6\ ^1S_0$	$2p^5(^2P^\circ_{1/2})4s\ (^1/_2,^1/_2)^\circ_1$	0	8 833 000		2.2−2	3.8+11	D	38°,65*
11.155	$2p^6\ ^1S_0$	$2p^54d\ ^3P^\circ_1$	0	8 965 000		3.4−3	6.1+10	E	8°,65*
11.108	$2p^6\ ^1S_0$	$2p^54d\ ^3D^\circ_1$	0	9 003 000		4.2−1	7.6+12	D	38°,65*
10.975	$2p^6\ ^1S_0$	$2p^54d\ ^1P^\circ_1$	0	9 112 000		5.1−1	9.4+12	D	38°,65*
10.207	$2p^6\ ^1S_0$	$2p^55d\ ^3P^\circ_1$	0	9 797 000					38
10.184	$2p^6\ ^1S_0$	$2p^55d\ ^3D^\circ_1$	0	9 819 000					38
10.066	$2p^6\ ^1S_0$	$2p^55d\ ^1P^\circ_1$	0	9 934 000					38
10.030	$2s^22p^6\ ^1S_0$	$2s2p^64p\ ^1P^\circ_1$	0	9 970 000		1.2−1	2.7+12	D	38°,65*
10.025	$2s^22p^6\ ^1S_0$	$2s2p^64p\ ^3P^\circ_1$	0	9 980 000					8
9.748	$2p^6\ ^1S_0$	$2p^56d\ ^3P^\circ_1$	0	10 260 000					8
9.742	$2p^6\ ^1S_0$	$2p^56d\ ^3D^\circ_1$	0	10 265 000					38
9.633	$2p^6\ ^1S_0$	$2p^56d\ ^1P^\circ_1$	0	10 381 000					38
9.501	$2p^6\ ^1S_0$	$2p^57d\ ^3D^\circ_1$	0	10 525 000					5
9.371	$2p^6\ ^1S_0$	$2p^57d\ ^1P^\circ_1$	0	10 671 000					5
9.347	$2p^6\ ^1S_0$	$2p^58d\ ^3D^\circ_1$	0	10 699 000					5
9.225	$2p^6\ ^1S_0$	$2p^59d\ ^3D^\circ_1$	0	10 840 000					8
9.200	$2p^6\ ^1S_0$	$2p^58d\ ^1P^\circ_1$	0	10 870 000					8
9.070	$2p^6\ ^1S_0$	$2p^59d\ ^1P^\circ_1$	0	11 030 000					8

Co XIX (F sequence) Ionization Energy = 12 135 000 cm^{-1} (1504.6 eV)

λ (Å)	Classification		Energy Levels (cm^{-1})		Int.	gf	A (s^{-1})	Acc.	References
819.9C	$2s^22p^5\ ^2P^o_{3/2}$	$2s^22p^5\ ^2P^o_{1/2}$	0	121 960		M1	3.25+4	C+	65*
99.02	$2s^22p^5\ ^2P^o_{1/2}$	$2s2p^6\ ^2S_{1/2}$	121 960	1 131 860		1.03−1	3.5+10	C+	12°,65*
88.35	3/2	1/2	0	1 131 860		2.34−1	1.0+11	C+	12°,65*
14.794	$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^4(^3P)3s\ ^2P_{3/2}$	121 960	6 880 900					38
14.557	1/2	1/2	121 960	6 991 500		1.1−1	1.8+12	D−	38°,65*
14.534	3/2	3/2	0	6 880 900	5				7Δ,38°
14.303	3/2	1/2	0	6 991 500		9.6−2	1.6+12	E	38°,65*
14.594	$2s^22p^5\ ^2P^o_{3/2}$	$2s^22p^4(^3P)3s\ ^4P_{5/2}$	0	6 852 100					38
14.355	3/2	3/2	0	6 966 200	4				7Δ,38°
14.423	$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^4(^1D)3s\ ^2D_{3/2}$	121 960	7 055 300		2.0−1	1.6+12	D	38°,65*
14.184	3/2	5/2	0	7 050 200		2.4−1	1.3+12	D	38°,65*
14.041	$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^4(^1S)3s\ ^2S_{1/2}$	121 960	7 243 900		8.0−2	1.3+12	D−	38°,65*
13.314	$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^4(^3P)3d\ ^2P_{3/2}$	121 960	7 632 800	5				7Δ,38°
13.289	$2s^22p^5\ ^2P^o_{3/2}$	$2s^22p^4(^3P)3d\ ^4P_{1/2}$	0	7 525 000	6				7Δ,38°
13.258	3/2	3/2	0	7 542 600	7				7Δ,38°
13.246	3/2	5/2	0	7 549 400	8				7
13.240	$2s^22p^5\ ^2P^o_{3/2}$	$2s^22p^4(^3P)3d\ ^2F_{5/2}$	0	7 552 900					38
13.192	$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^4(^1D)3d\ ^2S_{1/2}$	121 960	7 701 800		1.6−1	3.0+12	E	38°,65*
12.985	3/2	1/2	0	7 701 800		9.6−1	1.9+13	D	38°,65*
13.157	$2s^22p^5\ ^2P^o_{3/2}$	$2s^22p^4(^3P)3d\ ^2D_{3/2}$	0	7 600 500	6				7
13.084	3/2	5/2	0	7 642 900	12				7Δ,38°
13.151	$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^4(^1D)3d\ ^2P_{3/2}$	121 960	7 725 900	6				7Δ,38°
13.084	1/2	1/2	121 960	7 764 900	10				7Δ,38°
12.942	3/2	3/2	0	7 725 900	9				7Δ,38°
12.876	3/2	1/2	0	7 764 900	7				7
13.123	$2s^22p^5\ ^2P^o_{3/2}$	$2s^22p^4(^3P)3d\ ^4D_{3/2}$	0	7 620 200					38
13.097	$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^4(^1D)3d\ ^2D_{3/2}$	121 960	7 757 700	12				7Δ,38°
12.942	3/2	5/2	0	7 726 800	10				7Δ,38°
12.890	3/2	3/2	0	7 757 700	7				7Δ,38°
12.828	$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^4(^1S)3d\ ^2D_{3/2}$	121 960	7 917 400	5				7Δ,38°
12.300	$2s^22p^5\ ^2P^o_{1/2}$	$2s2p^5(^3P^o)3p\ ^4P_{3/2}$	121 960	8 252 000					38
12.155	3/2	5/2	0	8 227 000					38
12.281	$2s^22p^5\ ^2P^o_{3/2}$	$2s2p^5(^3P^o)3p\ ^4D_{5/2}$	0	8 143 000					38
12.238	3/2	3/2	0	8 171 000					38
12.224	$2s^22p^5\ ^2P^o_{1/2}$	$2s2p^5(^3P^o)3p\ ^2D_{3/2}$	121 960	8 303 000					38
12.212	3/2	5/2	0	8 189 000					38
12.193	$2s^22p^5\ ^2P^o_{1/2}$	$2s2p^5(^3P^o)3p\ ^2S_{1/2}$	121 960	8 323 000					38
12.015	3/2	1/2	0	8 323 000					38
12.168	$2s^22p^5\ ^2P^o_{3/2}$	$2s2p^5(^3P^o)3p\ ^2P_{3/2}$	0	8 218 000					38
12.155	3/2	1/2	0	8 227 000					38
11.954	$2s^22p^5\ ^2P^o_{1/2}$	$2s2p^5(^1P^o)3p\ ^2D_{3/2}$	121 960	8 487 000					38
11.744	3/2	5/2	0	8 515 000					38
11.906	$2s^22p^5\ ^2P^o_{1/2}$	$2s2p^5(^1P^o)3p\ ^2P_{1/2}$	121 960	8 521 000					38
11.892	1/2	3/2	121 960	8 531 000					38

Co XIX (F sequence) Ionization Energy = 12 135 000 cm^{-1} (1504.6 eV) – Continued

λ (Å)	Classification		Energy Levels (cm^{-1})		Int.	*gf*	*A* (s^{-1})	Acc.	References
10.776	$2s^22p^5\ ^2P^o_{3/2}$	$2s^22p^4(^3P)4s\ ^2P_{3/2}$	0	9 280 000					38
10.704	$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^4(^1D)4s\ ^2D_{3/2}$	121 960	9 464 000					38
10.568	$_{3/2}$	$_{5/2}$	0	9 462 000					38
10.645	$2s^22p^5\ ^2P^o_{3/2}$	$2s^22p^4(^3P)4s\ ^4P_{3/2}$	0	9 394 000					38
10.477	$2s^22p^5\ ^2P^o_{3/2}$	$2s^22p^4(^3P)4d\ ^2D_{5/2}$	0	9 545 000					38
10.477	$_{3/2}$	$_{3/2}$	0	9 545 000					38
10.406	$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^4(^1D)4d\ ^2D_{3/2}$	121 960	9 732 000					38
10.290	$_{3/2}$	$_{5/2}$	0	9 718 000					38
10.406	$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^4(^1D)4d\ ^2P_{1/2}$	121 960	9 732 000					38
10.290	$_{3/2}$	$_{3/2}$	0	9 718 000					38
10.406	$2s^22p^5\ ^2P^o_{3/2}$	$2s^22p^4(^3P)4d\ ^4F_{3/2}$	0	9 610 000					38
10.406	$_{3/2}$	$_{5/2}$	0	9 610 000					38
10.373	$2s^22p^5\ ^2P^o_{3/2}$	$2s^22p^4(^3P)4d\ ^4P_{5/2}$	0	9 640 000					38
10.290	$2s^22p^5\ ^2P^o_{3/2}$	$2s^22p^4(^1D)4d\ ^2S_{1/2}$	0	9 718 000					38
10.275	$2s^22p^5\ ^2P^o_{3/2}$	$2s^22p^4(^1D)4d\ ^2F_{5/2}$	0	9 732 000					38
10.206	$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^4(^1S)4d\ ^2D_{3/2}$	121 960	9 920 000					38

Co XX (O sequence) Ionization Energy = 12 930 000 cm^{-1} (1603 eV)

λ (Å)	Classification		Energy Levels (cm^{-1})		Int.	*gf*	*A* (s^{-1})	Acc.	References
4249.^{C}	$2s^22p^4\ ^3P_0$	$2s^22p^4\ ^3P_1$	83 890	107 420		M1	1.7+2	C	65*
930.9^C	$_2$	$_1$	0	107 420		M1	2.46+4	C	65*
1221.^{C}	$2s^22p^4\ ^3P_1$	$2s^22p^4\ ^1D_2$	107 420	189 290		M1	8.3+2	D	65*
528.3^C	$_2$	$_2$	0	189 290		M1	2.7+4	D	65*
390.9^C	$2s^22p^4\ ^3P_1$	$2s^22p^4\ ^1S_0$	107 420	363 240		M1	2.3+5	D	65*
144.92^C	$2s^22p^4\ ^1S_0$	$2s2p^5\ ^3P^o_1$	363 240	1 053 290		8.9−3	9.4+8	E	65*
126.22	$2s^22p^4\ ^1D_2$	$2s2p^5\ ^3P^o_2$	189 290	981 550		3.2−2	2.7+9	E	43°,65*
114.40	$2s^22p^4\ ^3P_1$	$2s2p^5\ ^3P^o_2$	107 420	981 550		1.07−1	1.09+10	C	43°,65*
105.72	$_1$	$_1$	107 420	1 053 290		6.75−2	1.34+10	C	43°,65*
103.16	$_0$	$_1$	83 890	1 053 290		8.3−2	1.7+10	C	43°,65*
101.88	$_2$	$_2$	0	981 550		3.2−1	4.2+10	C	43°,65*
99.89	$_1$	$_0$	107 420	1 108 520		9.99−2	6.7+10	C	43°,65*
94.94	$_2$	$_1$	0	1 053 290		1.47−1	3.64+10	C	43°,65*
109.14	$2s2p^5\ ^1P^o_1$	$2p^6\ ^1S_0$	1 349 530	2 265 740		3.09−1	1.73+11	C	43°,65*
101.39	$2s^22p^4\ ^1S_0$	$2s2p^5\ ^1P^o_1$	363 240	1 349 530		5.2−2	1.1+10	C	43°,65*
86.19	$2s^22p^4\ ^1D_2$	$2s2p^5\ ^1P^o_1$	189 290	1 349 530		5.30−1	1.59+11	C	43°,65*
82.48	$2s2p^5\ ^3P^o_1$	$2p^6\ ^1S_0$	1 053 290	2 265 740		1.7−2	1.6+10	E	43°,65*
80.51	$2s^22p^4\ ^3P_1$	$2s2p^5\ ^1P^o_1$	107 420	1 349 530		3.9−3	1.3+9	E	43°,65*
79.01	$_0$	$_1$	83 890	1 349 530		5.4−3	1.9+9	E	43°,65*
74.10	$_2$	$_1$	0	1 349 530		3.7−2	1.5+10	E	43°,65*

Co xx (O sequence) Ionization Energy = 12 930 000 cm^{-1} (1603 eV) – Continued

λ (Å)	Classification		Energy Levels (cm^{-1})		Int.	*gf*	*A* (s^{-1})	Acc.	References
13.825	$2s^22p^4\ ^3P_1$	$2s^22p^3(^4S^\circ)3s\ ^3S^\circ_1$	107 420	7 338 000					38
13.786	$_0$	$_1$	83 890	7 338 000		5.3−2	6.2+11	D	38°,65*
13.634	$_2$	$_1$	0	7 338 000		2.4−1	2.9+12	D−	38°,65*
13.775	$2s^22p^4\ ^1D_2$	$2s^22p^3(^2D^\circ)3s\ ^3D^\circ_2$	189 290	7 447 000					38
13.676	$2s^22p^4\ ^1S_0$	$2s^22p^3(^2P^\circ)3s\ ^1P^\circ_1$	363 240	7 688 000					38
13.661	$2s^22p^4\ ^1D_2$	$2s^22p^3(^2D^\circ)3s\ ^1D^\circ_2$	189 290	7 507 000		3.5−1	2.5+12	E	38°,65*
13.634	$2s^22p^4\ ^3P_1$	$2s^22p^3(^2D^\circ)3s\ ^3D^\circ_1$	107 420	7 447 000		1.3−1	1.5+12	D−	38°,65*
13.634	$_1$	$_2$	107 420	7 447 000					38
13.425	$_2$	$_2$	0	7 447 000					38
13.356	$_2$	$_3$	0	7 487 000		2.3−1	1.3+12	D+	38°,65*
13.517	$2s^22p^4\ ^3P_1$	$2s^22p^3(^2D^\circ)3s\ ^1D^\circ_2$	107 420	7 507 000		4.2−2	3.1+11	E	38°,65*
13.321[C]	$_2$	$_2$	0	7 507 000		2.3−2	1.7+11	E	65*
13.496	$2s^22p^4\ ^1D_2$	$2s^22p^3(^2P^\circ)3s\ ^3P^\circ_1$	189 290	7 599 000		5.5−2	6.7+11	E	38°,65*
13.356	$_2$	$_2$	189 290	7 668 000					38
13.372	$2s^22p^4\ ^3P_1$	$2s^22p^3(^2P^\circ)3s\ ^3P^\circ_0$	107 420	7 586 000		3.3−2	1.2+12	C	38°,65*
13.307[C]	$_0$	$_1$	83 890	7 599 000		6.9−2	8.7+11	E	65*
13.240	$_1$	$_2$	107 420	7 668 000		1.0−1	7.8+11	E	38°,65*
13.314	$2s^22p^4\ ^1D_2$	$2s^22p^3(^2P^\circ)3s\ ^1P^\circ_1$	189 290	7 688 000					38
12.606	$2s^22p^4\ ^3P_2$	$2s^22p^3(^4S^\circ)3d\ ^3D^\circ_3$	0	7 933 000		1.5	9.3+12	E	38°,65*
12.551	$2s^22p^4\ ^1D_2$	$2s^22p^3(^2D^\circ)3d\ ^1F^\circ_3$	189 290	8 150 000		1.9	1.2+13	D	38°,65*
12.551	$2s^22p^4\ ^1D_2$	$2s^22p^3(^2P^\circ)3d\ ^3F^\circ_3$	189 290	8 157 000					38
12.551	$2s^22p^4\ ^1S_0$	$2s^22p^3(^2P^\circ)3d\ ^1P^\circ_1$	363 240	8 331 000		2.4		D	38°,65*
12.551	$2s^22p^4\ ^3P_1$	$2s^22p^3(^2D^\circ)3d\ ^3P^\circ_2$	107 420	8 110 000					38
12.331	$_2$	$_2$	0	8 110 000					38
12.513	$2s^22p^4\ ^1D_2$	$2s^22p^3(^2P^\circ)3d\ ^3P^\circ_2$	189 290	8 181 000					38
12.348	$2s^22p^4\ ^1D_2$	$2s^22p^3(^2P^\circ)3d\ ^1D^\circ_2$	189 290	8 288 000					38
12.348	$2s^22p^4\ ^1D_2$	$2s^22p^3(^2P^\circ)3d\ ^1F^\circ_3$	189 290	8 288 000					38
12.348	$2s^22p^4\ ^3P_2$	$2s^22p^3(^2D^\circ)3d\ ^3D^\circ_3$	0	8 098 000		3.8	2.4+13	E	38°,65*
12.300	$2s^22p^4\ ^3P_1$	$2s^22p^3(^2P^\circ)3d\ ^3P^\circ_1$	107 420	8 237 000					38
12.282[C]	$2s^22p^4\ ^1D_2$	$2s^22p^3(^2P^\circ)3d\ ^1P^\circ_1$	189 290	8 331 000		1.0−1		D	65*
12.281	$2s^22p^4\ ^3P_2$	$2s^22p^3(^2D^\circ)3d\ ^1F^\circ_3$	0	8 150 000					38
12.238	$2s^22p^4\ ^3P_1$	$2s^22p^3(^2P^\circ)3d\ ^3D^\circ_2$	107 420	8 279 000					38
11.880	$2s^22p^4\ ^1D_2$	$2s2p^43d\ ^1F_3$	189 290	8 607 000					8
9.970	$2s^22p^4\ ^3P_1$	$2s^22p^3(^4S^\circ)4d\ ^3D^\circ_2$	107 420	10 146 000					8
9.924	$_0$	$_1$	83 890	10 160 000					38
9.856	$_2$	$_2$	0	10 146 000					38
9.856	$_2$	$_3$	0	10 146 000					38
9.856	$2s^22p^4\ ^1D_2$	$2s^22p^3(^2D^\circ)4d\ ^1D^\circ_2$	189 290	10 335 000					38
9.856	$2s^22p^4\ ^1D_2$	$2s^22p^3(^2D^\circ)4d\ ^1F^\circ_3$	189 290	10 335 000					38
9.856	$2s^22p^4\ ^1S_0$	$2s^22p^3(^2P^\circ)4d\ ^1P^\circ_1$	363 240	10 509 000					38

Co XX (O sequence) Ionization Energy = 12 930 000 cm^{-1} (1603 eV) – Continued

λ (Å)	Classification		Energy Levels (cm^{-1})		Int.	*gf*	*A* (s^{-1})	Acc.	References
9.828	$2s^22p^4\ ^3P_1$	$2s^22p^3(^2D^\circ)4d\ ^3D^\circ_2$	107 420	10 306 000					38
9.694	$_2$	$_3$	0	10 316 000					38
9.681	$_2$	$_2$	0	10 306 000					38
9.784	$2s^22p^4\ ^1D_2$	$2s^22p^3(^2P^\circ)4d\ ^3F^\circ_3$	189 290	10 410 000					8
9.742	$2s^22p^4\ ^3P_2$	$2s^22p^3(^2D^\circ)4d\ ^3F^\circ_3$	0	10 265 000					38
9.694	$2s^22p^4\ ^1D_2$	$2s^22p^3(^2P^\circ)4d\ ^1F^\circ_3$	189 290	10 505 000					38
9.694	$2s^22p^4\ ^1D_2$	$2s^22p^3(^2P^\circ)4d\ ^3D^\circ_2$	189 290	10 510 000					38
9.694	$2s^22p^4\ ^3P_1$	$2s^22p^3(^2P^\circ)4d\ ^3P^\circ_2$	107 420	10 423 000					38
9.633	$_1$	$_1$	107 420	10 488 000					38
9.681	$2s^22p^4\ ^3P_2$	$2s^22p^3(^2D^\circ)4d\ ^3S^\circ_1$	0	10 330 000					38
9.661	$2s^22p^4\ ^3P_0$	$2s^22p^3(^2P^\circ)4d\ ^3D^\circ_1$	83 890	10 435 000					8
9.603	$_1$	$_2$	107 420	10 510 000					8

Co XXI (N sequence) Ionization Energy = 13 990 000 cm^{-1} (1735 eV)

λ (Å)	Classification		Energy Levels (cm^{-1})		Int.	*gf*	*A* (s^{-1})	Acc.	References
2247.^{C}	$2s^22p^3\ ^2D^\circ_{3/2}$	$2s^22p^3\ ^2D^\circ_{5/2}$	147 040	191 530		M1	6.7+2	C	65*
1270.^{C}	$2s^22p^3\ ^2P^\circ_{1/2}$	$2s^22p^3\ ^2P^\circ_{3/2}$	280 260	359 000		M1	3.0+3	C–	65*
750.6^C	$2s^22p^3\ ^2D^\circ_{3/2}$	$2s^22p^3\ ^2P^\circ_{1/2}$	147 040	280 260		M1	7.6+3	D	65*
597.1^C	$_{5/2}$	$_{3/2}$	191 530	359 000		M1	2.0+4	D	65*
471.8^C	$_{3/2}$	$_{3/2}$	147 040	359 000		M1	7.7+4	D	65*
680.1^C	$2s^22p^3\ ^4S^\circ_{3/2}$	$2s^22p^3\ ^2D^\circ_{3/2}$	0	147 040		M1	2.6+4	D	65*
522.1^C	$_{3/2}$	$_{5/2}$	0	191 530		M1	2.4+3	D–	65*
356.8^C	$2s^22p^3\ ^4S^\circ_{3/2}$	$2s^22p^3\ ^2P^\circ_{1/2}$	0	280 260		M1	5.0+4	D	65*
278.55^C	$_{3/2}$	$_{3/2}$	0	359 000		M1	3.7+4	D	65*
227.25^C	$2s^22p^3\ ^2P^\circ_{3/2}$	$2s2p^4\ ^4P_{5/2}$	359 000	799 040		1.3–3	2.8+7	E	65*
192.12^C	$_{3/2}$	$_{3/2}$	359 000	879 510		5.2–3	2.3+8	E	65*
160.51^C	$_{1/2}$	$_{1/2}$	280 260	903 260		2.8–3	3.6+8	E	65*
164.61^C	$2s^22p^3\ ^2D^\circ_{5/2}$	$2s2p^4\ ^4P_{5/2}$	191 530	799 040		8.4–3	3.4+8	E	65*
153.37^C	$_{3/2}$	$_{5/2}$	147 040	799 040		2.0–2	9.5+8	E	65*
145.35^C	$_{5/2}$	$_{3/2}$	191 530	879 510		9.0–4	7.1+7	E	65*
136.52^C	$_{3/2}$	$_{3/2}$	147 040	879 510		2.2–3	2.0+8	E	65*
132.24^C	$_{3/2}$	$_{1/2}$	147 040	903 260		2.7–3	5.1+8	E	65*
157.40^C	$2s2p^4\ ^2P_{1/2}$	$2p^5\ ^2P^\circ_{3/2}$	1 434 220	2 069 550		2.46–2	1.66+9	C	65*
133.06	$_{3/2}$	$_{3/2}$	1 318 040	2 069 550		3.4–1	3.2+10	C	43°,65*
131.09	$_{1/2}$	$_{1/2}$	1 434 220	2 197 070		1.8–1	3.5+10	C	43°,65*
113.76	$_{3/2}$	$_{1/2}$	1 318 040	2 197 070		1.70–1	4.37+10	C	43°,65*
133.64^C	$2s^22p^3\ ^2P^\circ_{3/2}$	$2s2p^4\ ^2D_{3/2}$	359 000	1 107 300		7.2–3	6.7+8	D	65*
130.02	$_{3/2}$	$_{5/2}$	359 000	1 128 160		9.64–2	6.3+9	C	43°,65*
120.91	$_{1/2}$	$_{3/2}$	280 260	1 107 300		2.66–2	3.03+9	C	43°,65*
125.15	$2s^22p^3\ ^4S^\circ_{3/2}$	$2s2p^4\ ^4P_{5/2}$	0	799 040		1.96–1	1.39+10	C	43°,65*
113.70	$_{3/2}$	$_{3/2}$	0	879 510		1.62–1	2.08+10	C	43°,65*
110.71	$_{3/2}$	$_{1/2}$	0	903 260		8.68–2	2.36+10	C	43°,65*

Co XXI (N sequence) Ionization Energy = 13 990 000 cm^{-1} (1735 eV)

λ (Å)	Classification		Energy Levels (cm^{-1})		Int.	gf	A (s^{-1})	Acc.	References
124.67	$2s2p^4\ ^2S_{1/2}$	$2p^5\ ^2P^o_{3/2}$	1 267 430	2 069 550		9.34−2	1.0+10	C	43°,65*
107.57^C	$_{1/2}$	$_{1/2}$	1 267 430	2 197 070		1.2−2	3.4+9	D	65*
110.08	$2s^22p^3\ ^2P^o_{3/2}$	$2s2p^4\ ^2S_{1/2}$	359 000	1 267 430		8.0−3	2.2+9	D	43°,65*
101.30	$_{1/2}$	$_{1/2}$	280 260	1 267 430		1.2−1	4.0+10	C	43°,65*
106.76	$2s^22p^3\ ^2D^o_{5/2}$	$2s2p^4\ ^2D_{5/2}$	191 530	1 128 160		3.7−1	3.6+10	C	43°,65*
104.14	$_{3/2}$	$_{3/2}$	147 040	1 107 300		3.0−1	4.7+10	C	43°,65*
101.92^C	$_{3/2}$	$_{5/2}$	147 040	1 128 160		6.0−4	6.4+7	E	65*
106.23	$2s2p^4\ ^2D_{5/2}$	$2p^5\ ^2P^o_{3/2}$	1 128 160	2 069 550		3.1−1	4.6+10	C	43°,65*
103.93	$_{3/2}$	$_{3/2}$	1 107 300	2 069 550		1.35−1	2.08+10	C	43°,65*
91.76	$_{3/2}$	$_{1/2}$	1 107 300	2 197 070		1.20−1	4.77+10	C	43°,65*
104.27	$2s^22p^3\ ^2P^o_{3/2}$	$2s2p^4\ ^2P_{3/2}$	359 000	1 318 040		6.36−2	9.8+9	C	43°,65*
96.36	$_{1/2}$	$_{3/2}$	280 260	1 318 040		5.80−2	1.04+10	C	43°,65*
93.00	$_{3/2}$	$_{1/2}$	359 000	1 434 220		2.8−1	1.1+11	C	43°,65*
86.66	$_{1/2}$	$_{1/2}$	280 260	1 434 220		9.4−3	4.2+9	D	43°,65*
90.31	$2s^22p^3\ ^4S^o_{3/2}$	$2s2p^4\ ^2D_{3/2}$	0	1 107 300		1.5−2	3.0+9	E	43°,65*
89.25	$2s^22p^3\ ^2D^o_{3/2}$	$2s2p^4\ ^2S_{1/2}$	147 040	1 267 430		1.2−1	5.0+10	E	43°,65*
88.77	$2s^22p^3\ ^2D^o_{5/2}$	$2s2p^4\ ^2P_{3/2}$	191 530	1 318 040		5.2−1	1.1+11	C	43°,65*
85.40	$_{3/2}$	$_{3/2}$	147 040	1 318 040		6.00−2	1.37+10	C	43°,65*
77.69	$_{3/2}$	$_{1/2}$	147 040	1 434 220		5.16−2	2.85+10	C	43°,65*
85.74^C	$2s2p^4\ ^4P_{1/2}$	$2p^5\ ^2P^o_{3/2}$	903 260	2 069 550		3.4−3	7.7+8	E	65*
84.03	$_{3/2}$	$_{3/2}$	879 510	2 069 550		1.0−2	2.4+9	E	43°,65*
78.71	$_{5/2}$	$_{3/2}$	799 040	2 069 550		1.5−2	4.0+9	E	43°,65*
77.29^C	$_{1/2}$	$_{1/2}$	903 260	2 197 070		2.2−3	1.2+9	E	65*
75.90	$_{3/2}$	$_{1/2}$	879 510	2 197 070		6.8−4	3.9+8	E	43°,65*
78.90	$2s^22p^3\ ^4S^o_{3/2}$	$2s2p^4\ ^2S_{1/2}$	0	1 267 430		5.2−3	2.8+9	E	43°,65*
75.87	$2s^22p^3\ ^4S^o_{3/2}$	$2s2p^4\ ^2P_{3/2}$	0	1 318 040		2.1−2	6.0+9	E	43°,65*
12.214	$2p^3\ ^2D^o_{5/2}$	$2p^23d\ ^2D_{5/2}$	191 530						8
11.907	$2p^3\ ^2P^o_{3/2}$	$2p^23d\ ^2P_{3/2}$	359 000						8
11.797	$2p^3\ ^2P^o_{3/2}$	$2p^23d\ ^2D_{5/2}$	359 000						8
11.714	$2p^3\ ^4S^o_{3/2}$	$2p^23d\ ^4P_{5/2}$	0						8
11.576	$2p^3\ ^4S^o_{3/2}$	$2p^23d\ ^2P_{3/2}$	0						8

Co XXII (C sequence) Ionization Energy = 14 890 000 cm^{-1} (1846 eV)

λ (Å)	Classification		Energy Levels (cm^{-1})		Int.	gf	A (s^{-1})	Acc.	References
2104.^{C}	$2s^22p^2\ ^3P_1$	$2s^22p^2\ ^3P_2$	90 730	138 250		M1	1.05+3	C	65*
1102.2^C	$_0$	$_1$	0	90 730		M1	1.19+4	C	65*
696.5^C	$2s^22p^2\ ^3P_2$	$2s^22p^2\ ^1D_2$	138 250	281 820		M1	2.4+4	C	65*
523.3^C	$_1$	$_2$	90 730	281 820		M1	2.6+4	D	65*
307.89^C	$2s^22p^2\ ^3P_1$	$2s^22p^2\ ^1S_0$	90 730	415 520		M1	2.1+5	D	65*
252.71^C	$2s2p^3\ ^1P^o_1$	$2p^4\ ^3P_2$	1 356 870	1 752 580		5.7−3	1.2+8	E	65*
196.60^C	$_1$	$_1$	1 356 870	1 865 530		1.6−2	9.0+8	E	65*
252.20^C	$2s^22p^2\ ^3P_2$	$2s2p^3\ ^5S^o_2$	138 250	534 760		2.3−3	4.8+7	E	65*
225.21^C	$_1$	$_2$	90 730	534 760		2.1−3	5.6+7	E	65*

Co XXII (C sequence) Ionization Energy = 14 890 000 cm⁻¹ (1846 eV) — Continued

λ (Å)	Classification		Energy Levels (cm⁻¹)		Int.	*gf*	*A* (s⁻¹)	Acc.	References
239.05[C]	$2s^22p^2\ ^1S_0$	$2s2p^3\ ^3D^o_1$	415 520	833 840		1.5−3	5.8+7	E	65*
185.03[C]	$2s2p^3\ ^1D^o_2$	$2p^4\ ^3P_2$	1 212 130	1 752 580		2.4−2	9.4+8	E	65*
153.05[C]	2	1	1 212 130	1 865 530		6.0−3	5.7+8	E	65*
181.15[C]	$2s^22p^2\ ^1D_2$	$2s2p^3\ ^3D^o_1$	281 820	833 840		3.6−3	2.4+8	E	65*
180.36[C]	2	2	281 820	836 280		9.5−4	3.9+7	E	65*
170.16[C]	2	3	281 820	869 510		3.9−2	1.3+9	E	65*
171.79	$2s2p^3\ ^3S^o_1$	$2p^4\ ^3P_2$	1 170 450	1 752 580		1.5−1	6.9+9	C	43°,65*
146.40	1	0	1 170 450	1 853 530		7.11−2	2.21+10	C	43°,65*
143.87	1	1	1 170 450	1 865 530		1.5−1	1.6+10	C	43°,65*
171.49[C]	$2s^22p^2\ ^1S_0$	$2s2p^3\ ^3P^o_1$	415 520	998 650		2.6−3	2.0+8	E	65*
170.09	$2s2p^3\ ^1P^o_1$	$2p^4\ ^1D_2$	1 356 870	1 944 800		1.17−1	5.4+9	C	43°,65*
143.76[C]	$2s^22p^2\ ^3P_2$	$2s2p^3\ ^3D^o_1$	138 250	833 840		1.1−3	1.2+8	E	65*
143.26[C]	2	2	138 250	836 280		7.5−4	4.9+7	E	65*
136.75	2	3	138 250	869 510		1.37−1	7.0+9	C	43°,65*
134.57	1	1	90 730	833 840		5.1−3	6.3+8	D	43°,65*
134.13	1	2	90 730	836 280		1.49−1	1.1+10	C	43°,65*
119.92	0	1	0	833 840		9.6−2	1.5+10	C	43°,65*
139.50[C]	$2s^22p^2\ ^1D_2$	$2s2p^3\ ^3P^o_1$	281 820	998 650		2.5−3	2.9+8	E	65*
135.42[C]	2	2	281 820	1 020 290		3.2−3	2.3+8	E	65*
136.56	$2s2p^3\ ^3P^o_2$	$2p^4\ ^3P_2$	1 020 290	1 752 580		5.30−2	3.79+9	C	43°,65*
132.63	1	2	998 650	1 752 580		5.43−2	4.12+9	C	43°,65*
118.31	2	1	1 020 290	1 865 530		1.24−1	1.98+10	C	43°,65*
116.97	1	0	998 650	1 853 530		4.44−2	2.16+10	C	43°,65*
115.36[C]	1	1	998 650	1 865 530		2.4−3	4.1+8	E	65*
113.93	0	1	987 830	1 865 530		3.34−2	5.7+9	C	43°,65*
136.49	$2s2p^3\ ^1D^o_2$	$2p^4\ ^1D_2$	1 212 130	1 944 800		5.30−1	3.8+10	C	43°,65*
132.46[C]	$2s^22p^2\ ^1S_0$	$2s2p^3\ ^3S^o_1$	415 520	1 170 450		6.7−3	8.5+8	E	65*
119.55	$2s2p^3\ ^1P^o_1$	$2p^4\ ^1S_0$	1 356 870	2 193 340		1.9−1	9.1+10	C	43°,65*
116.22	$2s^22p^2\ ^3P_2$	$2s2p^3\ ^3P^o_1$	138 250	998 650		1.8−2	3.0+9	D	43°,65*
113.37	2	2	138 250	1 020 290		2.40−1	2.49+10	C	43°,65*
111.47	1	0	90 730	987 830		4.95−2	2.66+10	C	43°,65*
110.14	1	1	90 730	998 650		1.11−1	2.03+10	C	43°,65*
107.58	1	2	90 730	1 020 290		2.0−3	2.3+8	E	43°,65*
100.14	0	1	0	998 650		1.98−2	4.39+9	C	43°,65*
113.24	$2s2p^3\ ^3D^o_3$	$2p^4\ ^3P_2$	869 510	1 752 580		3.09−1	3.21+10	C	43°,65*
109.14	2	2	836 280	1 752 580		1.45−1	1.62+10	C	43°,65*
108.84	1	2	833 840	1 752 580		4.23−2	4.76+9	C	43°,65*
98.07	1	0	833 840	1 853 530		5.82−2	4.04+10	C	43°,65*
97.16	2	1	836 280	1 865 530		1.01−1	2.38+10	C	43°,65*
96.93	1	1	833 840	1 865 530		7.05−2	1.67+10	C	43°,65*
112.53[C]	$2s^22p^2\ ^1D_2$	$2s2p^3\ ^3S^o_1$	281 820	1 170 450		2.7−3	4.7+8	E	65*
108.16	$2s2p^3\ ^3P^o_2$	$2p^4\ ^1D_2$	1 020 290	1 944 800		3.4−2	3.8+9	E	43°,65*
105.69[C]	1	2	998 650	1 944 800		1.5−2	1.8+9	E	65*
107.49	$2s^22p^2\ ^1D_2$	$2s2p^3\ ^1D^o_2$	281 820	1 212 130		4.4−1	5.0+10	C	43°,65*
106.23	$2s^22p^2\ ^1S_0$	$2s2p^3\ ^1P^o_1$	415 520	1 356 870		1.00−1	1.97+10	C	43°,65*
97.76[C]	$2s2p^3\ ^3S^o_1$	$2p^4\ ^1S_0$	1 170 450	2 193 340		9.3−3	6.5+9	E	65*

Co XXII (C sequence) Ionization Energy = 14 890 000 cm^{-1} (1846 eV) – Continued

λ (Å)	Classification		Energy Levels (cm^{-1})		Int.	gf	A (s^{-1})	Acc.	References
96.88	$2s^22p^2\ ^3P_2$	$2s2p^3\ ^3S^o_1$	138 250	1 170 450		2.9−1	7.0+10	C	43°,65*
92.61	1	1	90 730	1 170 450		1.05−1	2.72+10	C	43°,65*
85.43	0	1	0	1 170 450		3.39−2	1.03+10	C	43°,65*
93.12	$2s^22p^2\ ^3P_2$	$2s2p^3\ ^1D^o_2$	138 250	1 212 130		7.0−2	1.1+10	E	43°,65*
89.17^C	1	2	90 730	1 212 130		3.3−3	5.5+8	E	65*
93.02	$2s^22p^2\ ^1D_2$	$2s2p^3\ ^1P^o_1$	281 820	1 356 870		3.0−1	7.7+10	C	43°,65*
93.00	$2s2p^3\ ^3D^o_3$	$2p^4\ ^1D_2$	869 510	1 944 800		4.8−2	7.3+9	E	43°,65*
90.21^C	2	2	836 280	1 944 800		5.0−3	8.2+8	E	65*
83.70^C	$2s2p^3\ ^3P^o_1$	$2p^4\ ^1S_0$	998 650	2 193 340		6.3−3	6.0+9	E	65*
82.11^C	$2s2p^3\ ^5S^o_2$	$2p^4\ ^3P_2$	534 760	1 752 580		1.0−2	2.1+9	E	65*
75.14^C	2	1	534 760	1 865 530		8.5−4	3.3+8	E	65*
82.06^C	$2s^22p^2\ ^3P_2$	$2s2p^3\ ^1P^o_1$	138 250	1 356 870		1.1−3	3.6+8	E	65*
78.98	1	1	90 730	1 356 870		1.7−2	6.2+9	E	43°,65*

Co XXIII (B sequence) Ionization Energy = 15 820 000 cm^{-1} (1962 eV)

λ (Å)	Classification		Energy Levels (cm^{-1})		Int.	gf	A (s^{-1})	Acc.	References
717.9^C	$2s^22p\ ^2P^o_{1/2}$	$2s^22p\ ^2P^o_{3/2}$	0	139 290		M1	2.42+4	B	65*
365.23^C	$2s2p^2\ ^2P_{3/2}$	$2p^3\ ^4S^o_{3/2}$	1 064 960	1 338 760		3.0−3	3.7+7	E	65*
229.62^C	1/2	3/2	903 260	1 338 760		6.4−3	2.0+8	E	65*
347.34^C	$2s2p^2\ ^2S_{1/2}$	$2p^3\ ^4S^o_{3/2}$	1 050 860	1 338 760		1.1−3	1.5+7	E	65*
342.15^C	$2s^22p\ ^2P^o_{3/2}$	$2s2p^2\ ^4P_{1/2}$	139 290	431 560		6.0−4	1.7+7	E	65*
277.79^C	3/2	3/2	139 290	499 270		4.8−4	1.0+7	E	65*
237.83^C	3/2	5/2	139 290	559 760		5.2−3	1.0+8	E	65*
231.72^C	1/2	1/2	0	431 560		2.0−3	1.2+8	E	65*
237.31^C	$2s2p^2\ ^2P_{3/2}$	$2p^3\ ^2D^o_{3/2}$	1 064 960	1 486 350		1.5−3	4.5+7	E	65*
218.25^C	3/2	5/2	1 064 960	1 523 150		1.52−1	3.56+9	C	65*
171.50	1/2	3/2	903 260	1 486 350		1.4−1	7.7+9	C	43°,65*
229.63^C	$2s2p^2\ ^2S_{1/2}$	$2p^3\ ^2D^o_{3/2}$	1 050 860	1 486 350		2.32−2	7.3+8	C	65*
181.74^C	$2s2p^2\ ^2D_{3/2}$	$2p^3\ ^4S^o_{3/2}$	788 520	1 338 760		4.4−3	2.2+8	E	65*
164.70^C	$2s2p^2\ ^2P_{3/2}$	$2p^3\ ^2P^o_{1/2}$	1 064 960	1 672 130		1.8−2	2.2+9	D	65*
146.86	3/2	3/2	1 064 960	1 745 870		3.0−1	2.3+10	C	43°,65*
130.06	1/2	1/2	903 260	1 672 130		1.7−2	3.4+9	D	43°,65*
118.68	1/2	3/2	903 260	1 745 870		3.12−2	3.69+9	C	43°,65*
160.97	$2s2p^2\ ^2S_{1/2}$	$2p^3\ ^2P^o_{1/2}$	1 050 860	1 672 130		9.50−2	1.22+10	C	43°,65*
143.89	1/2	3/2	1 050 860	1 745 870		2.80−2	2.26+9	C	43°,65*
154.03^C	$2s^22p\ ^2P^o_{3/2}$	$2s2p^2\ ^2D_{3/2}$	139 290	788 520		1.7−4	1.2+7	E	65*
147.09	3/2	5/2	139 290	819 150		1.31−1	6.7+9	C	43°,65*
126.82	1/2	3/2	0	788 520		1.2−1	1.3+10	C	43°,65*
149.88	$2s2p^2\ ^2D_{5/2}$	$2p^3\ ^2D^o_{3/2}$	819 150	1 486 350		7.44−2	5.5+9	C	43°,65*
143.30	3/2	3/2	788 520	1 486 350		9.60−2	7.8+9	C	43°,65*
142.05	5/2	5/2	819 150	1 523 150		2.47−1	1.36+10	C	43°,65*
136.12	3/2	5/2	788 520	1 523 150		7.12−2	4.27+9	C	43°,65*
130.90^C	$2s^22p\ ^2P^o_{3/2}$	$2s2p^2\ ^2P_{1/2}$	139 290	903 260		4.0−4	7.7+7	E	65*
110.71	1/2	1/2	0	903 260		1.6−1	4.3+10	C	43°,65*
108.03	3/2	3/2	139 290	1 064 960		3.4−1	4.9+10	C	43°,65*
93.90	1/2	3/2	0	1 064 960		3.42−2	6.5+9	C	43°,65*

Co XXIII (B sequence) Ionization Energy = 15 820 000 cm^{-1} (1962 eV) – Continued

λ (Å)	Classification		Energy Levels (cm^{-1})		Int.	gf	A (s^{-1})	Acc.	References
128.37	$2s2p^2$ $^4P_{5/2}$	$2p^3$ $^4S^o_{3/2}$	559 760	1 338 760		2.04−1	2.06+10	C	43°,65*
119.12	3/2	3/2	499 270	1 338 760		1.35−1	1.59+10	C	43°,65*
110.23	1/2	3/2	431 560	1 338 760		8.44−2	1.16+10	C	43°,65*
113.17	$2s2p^2$ $^2D_{3/2}$	$2p^3$ $^2P^o_{1/2}$	788 520	1 672 130		1.26−1	3.29+10	C	43°,65*
107.91	5/2	3/2	819 150	1 745 870		1.06−1	1.52+10	C	43°,65*
104.45	3/2	3/2	788 520	1 745 870		3.6−2	5.6+9	D	43°,65*
109.70	$2s^22p$ $^2P^o_{3/2}$	$2s2p^2$ $^2S_{1/2}$	139 290	1 050 860		1.38−1	3.84+10	C	43°,65*
95.16	1/2	1/2	0	1 050 860		6.4−3	2.4+9	D	43°,65*
107.92^C	$2s2p^2$ $^4P_{5/2}$	$2p^3$ $^2D^o_{3/2}$	559 760	1 486 350		2.8−3	4.0+8	E	65*
103.80^T	5/2	5/2	559 760	1 523 150		2.6−2	2.7+9	E	43°,65*
101.31^C	3/2	3/2	499 270	1 486 350		2.1−2	3.4+9	E	65*
97.67^C	3/2	5/2	499 270	1 523 150		5.6−4	6.5+7	E	65*
94.81^C	1/2	3/2	431 560	1 486 350		4.2−4	7.8+7	E	65*
84.31^C	$2s2p^2$ $^4P_{5/2}$	$2p^3$ $^2P^o_{3/2}$	559 760	1 745 870		7.2−4	1.7+8	E	65*
80.61^C	1/2	1/2	431 560	1 672 130		5.4−4	2.8+8	E	65*
80.22^C	3/2	3/2	499 270	1 745 870		1.4−3	3.5+8	E	65*
11.197^T	$2s2p^2$ $^2D_{3/2}$	$2s2p(^3P^o)3d$ $^2D^o_{5/2}$	788 520	9 720 000?					8
11.173^T	$2s2p^2$ $^2S_{1/2}$	$2s2p(^1P^o)3d$ $^2D^o_{3/2}$	1 050 860	10 000 000?					8
11.105^T	$2s2p^2$ $^2D_{5/2}$	$2s2p(^3P^o)3d$ $^2F^o_{5/2}$	819 150	9 832 000?					8
11.064^T	5/2	7/2	819 150	9 858 000?					8
11.048^T	3/2	5/2	788 520	9 832 000?					8
11.105^T	$2s2p^2$ $^2P_{3/2}$	$2s2p(^1P^o)3d$ $^2D^o_{5/2}$	1 064 960	10 070 000?					8
11.070^T	$2s2p^2$ $^2P_{3/2}$	$2s2p(^1P^o)3d$ $^2P^o_{3/2}$	1 064 960	10 100 000?					8
11.010^T	$2s2p^2$ $^4P_{5/2}$	$2s2p(^3P^o)3d$ $^4F^o_{7/2}$	559 760	9 640 000?					8
10.933^T	$2s2p^2$ $^4P_{3/2}$	$2s2p(^3P^o)3d$ $^4P^o_{5/2}$	499 270	9 646 000?					8
10.868^T	5/2	3/2	559 760	9 761 000?					8
10.799^T	3/2	1/2	499 270	9 759 000?					8
10.799^T	3/2	3/2	499 270	9 761 000?					8
10.901^T	$2s2p^2$ $^4P_{5/2}$	$2s2p(^3P^o)3d$ $^4D^o_{5/2}$	559 760	9 710 000?					8
10.889^T	3/2	5/2	499 270	9 710 000?					8
10.885^T	5/2	7/2	559 760	9 747 000?					8
10.847^T	1/2	3/2	431 560	9 651 000?					8
10.835^T	1/2	1/2	431 560	9 661 000?					8
10.847^T	$2s2p^2$ $^2D_{5/2}$	$2s2p(^1P^o)3d$ $^2F^o_{7/2}$	819 150	10 040 000?					8
10.809^T	3/2	5/2	788 520	10 040 000?					8

Co XXIV (Be sequence) Ionization Energy = 17 090 000 cm^{-1} (2119 eV)

λ (Å)	Classification		Energy Levels (cm^{-1})		Int.	gf	A (s^{-1})	Acc.	References
2809.^{C}	$2s2p$ $^3P^o_0$	$2s2p$ $^3P^o_1$	363 130	398 720		M1	7.18+2	C+	65*
905.06^C	1	2	398 720	509 210		M1	1.66+4	C+	65*
492.61^C	$2s2p$ $^1P^o_1$	$2p^2$ $^3P_0$	799 040	1 002 040		9.0−4	2.5+7	E	65*
344.65^C	1	1	799 040	1 089 190		5.4−4	1.0+7	E	65*
294.90^C	1	2	799 040	1 138 140		3.0−2	4.6+8	D	65*
345.03^C	$2s2p$ $^3P^o_2$	$2s2p$ $^1P^o_1$	509 210	799 040		M1	1.6+4	D	65*
249.80^C	1	1	398 720	799 040		M1	2.6+4	D	65*
229.41^C	0	1	363 130	799 040		M1	4.4+4	D	65*

Co XXIV (Be sequence) Ionization Energy = 17 090 000 cm^{-1} (2119 eV) – Continued

λ (Å)	Classification		Energy Levels (cm^{-1})		Int.	gf	A (s^{-1})	Acc.	References
204.10	$2s2p\ ^1P^o_1$	$2p^2\ ^1D_2$	799 040	1 289 000		1.63 − 1	5.20 + 9	B	43°,65*
172.42	$2s2p\ ^3P^o_2$	$2p^2\ ^3P_1$	509 210	1 089 190		6.20 − 2	4.64 + 9	B	43°,65*
165.75	1	0	398 720	1 002 040		5.37 − 2	1.3 + 10	B	43°,65*
159.00	2	2	509 210	1 138 140		1.45 − 1	7.65 + 9	B	43°,65*
144.83	1	1	398 720	1 089 190		4.35 − 2	4.61 + 9	B	43°,65*
137.73	0	1	363 130	1 089 190		6.33 − 2	7.42 + 9	B	43°,65*
135.24	1	2	398 720	1 138 140		8.43 − 2	6.15 + 9	B	43°,65*
139.80	$2s2p\ ^1P^o_1$	$2p^2\ ^1S_0$	799 040	1 514 350		1.06 − 1	3.6 + 10	B	43°,65*
128.24	$2s2p\ ^3P^o_2$	$2p^2\ ^1D_2$	509 210	1 289 000		7.55 − 2	6.12 + 9	C	43°,65*
125.15	$2s^2\ ^1S_0$	$2s2p\ ^1P^o_1$	0	799 040		1.52 − 1	2.16 + 10	B	43°,65*
11.430	$2p^2\ ^1S_0$	$2p3s\ ^1P^o_1$	1 514 350	10 264 000		5.4 − 2	9.2 + 11	D	5°,65*
11.141	$2p^2\ ^1D_2$	$2p3s\ ^1P^o_1$	1 289 000	10 264 000		1.3 − 1	2.4 + 12	D	5°,65*
11.141	$2p^2\ ^3P_1$	$2p3s\ ^3P^o_0$	1 089 190	10 065 000		4.8 − 2	2.6 + 12	D	5°,65*
10.933	$2p^2\ ^1S_0$	$2p3d\ ^1P^o_1$	1 514 350	10 661 000		1.28	2.38 + 13	C−	5°,65*
10.933	$2s2p\ ^3P^o_2$	$2s3s\ ^3S_1$	509 210	9 653 000		1.3 − 1	2.4 + 12	D	5°,65*
10.811	1	1	398 720	9 653 000		7.8 − 2	1.5 + 12	D	5°,65*
10.764[C]	0	1	363 130	9 653 000		2.7 − 2	5.2 + 11	D	65*
10.811	$2p^2\ ^1D_2$	$2p3d\ ^1D^o_2$	1 289 000	10 539 000		2.2 − 1	2.6 + 12	C−	5°,65*
10.800	$2s2p\ ^1P^o_1$	$2s3d\ ^1D_2$	799 040	10 058 000		1.82	2.08 + 13	C	5°,65*
10.760	$2p^2\ ^1D_2$	$2p3d\ ^3P^o_2$	1 289 000	10 578 000		8.5 − 1	9.8 + 12	C−	5°,65*
10.760	$2p^2\ ^3P_2$	$2p3d\ ^3D^o_2$	1 138 140	10 430 000		1.5 − 1	1.8 + 12	D	5°,65*
10.743	2	1	1 138 140	10 449 000		1.5 − 2	2.9 + 11	D	5°,65*
10.709	1	2	1 089 190	10 430 000		1.43	1.67 + 13	C−	5°,65*
10.674	1	1	1 089 190	10 449 000		2.6 − 1	5.1 + 12	C−	5°,65*
10.593	0	1	1 002 040	10 449 000		1.30	2.58 + 13	C−	5°,65*
10.674	$2p^2\ ^1D_2$	$2p3d\ ^1F^o_3$	1 289 000	10 658 000		5.0	4.18 + 13	C−	5°,65*
10.674	$2p^2\ ^1D_2$	$2p3d\ ^1P^o_1$	1 289 000	10 661 000		7.5 − 2	1.5 + 12	D	4°,65*
10.593	$2p^2\ ^3P_2$	$2p3d\ ^3P^o_1$	1 138 140	10 578 000		3.3 − 1	6.6 + 12	C−	5°,65*
10.593	2	2	1 138 140	10 578 000		1.05	1.25 + 13	C−	5°,65*
10.543	1	1	1 089 190	10 578 000		7.5 − 1	1.5 + 13	C−	5°,65*
10.543	1	2	1 089 190	10 578 000		1.9 − 1	2.3 + 12	D	5°,65*
10.543	1	0	1 089 190	10 578 000		3.3 − 1	2.0 + 13	C−	5°,65*
10.443[C]	0	1	1 002 040	10 578 000		1.5 − 3	3.1 + 10	C−	65*
10.587[C]	$2s2p\ ^1P^o_1$	$2p3p\ ^3D_1$	799 040	10 245 000		8.1 − 2	1.6 + 12	D	65*
10.571	$2s2p\ ^3P^o_2$	$2s3d\ ^3D_1$	509 210	9 965 000		3.6 − 2	7.2 + 11	C−	5°,65*
10.571	2	2	509 210	9 971 000		5.5 − 1	6.6 + 12	C−	5°,65*
10.552	2	3	509 210	9 986 000		2.98	2.55 + 13	C−	5°,65*
10.445	1	1	398 720	9 965 000		5.4 − 1	1.1 + 13	C−	4°,65*
10.445	1	2	398 720	9 971 000		1.64	2.01 + 13	C−	5°,65*
10.428	0	1	363 130	9 965 000		7.5 − 1	1.5 + 13	C−	5°,65*
10.503	$2p^2\ ^3P_2$	$2p3d\ ^1F^o_3$	1 138 140	10 658 000	2				5
10.503	$2s2p\ ^1P^o_1$	$2p3p\ ^1P_1$	799 040	10 320 000		8.7 − 2	1.8 + 12	D	5°,65*
10.389[C]	$2s2p\ ^1P^o_1$	$2p3p\ ^3P_2$	799 040	10 425 000		2.2 − 1	2.7 + 12	D	5°,65*
10.389[C]	1	1	799 040	10 425 000		2.1 − 1	4.3 + 12	C−	5°,65*
10.265	$2s2p\ ^1P^o_1$	$2p3p\ ^1D_2$	799 040	10 541 000		6.0 − 1	7.6 + 12	C−	5°,65*

Co XXIV (Be sequence) Ionization Energy = 17 090 000 cm^{-1} (2119 eV) — Continued

λ (Å)	Classification		Energy Levels (cm^{-1})		Int.	*gf*	*A* (s^{-1})	Acc.	References
10.182	$2s2p\ ^1P^o_1$	$2s3s\ ^1S_0$	799 040	106 200 00?		3.3−2	2.1+12	D	5°,65*
10.179[C]	$2s2p\ ^3P^o_2$	$2p3p\ ^3D_2$	509 210	10 333 000		1.3−2	1.7+11	E	5°,65*
10.156	1	1	398 720	10 245 000		1.6−1	3.4+12	E	5°,65*
10.115	0	1	363 130	10 245 000		8.4−2	1.8+12	E	5°,65*
10.066	1	2	398 720	10 333 000		4.8−1	6.3+12	C−	5°,65*
10.066	2	3	509 210	10 444 000		7.5−1	7.0+12	C−	5°,65*
10.115	$2s^2\ ^1S_0$	$2s3p\ ^3P^o_1$	0	9 886 000		2.7−1	5.9+12	C−	5°,65*
10.085[C]	$2s2p\ ^3P^o_2$	$2p3p\ ^3P_2$	509 210	10 425 000		4.6−1	6.0+12	C−	65*
10.066	1	0	398 720	10 333 000		1.2−1	7.9+12	D	5°,65*
9.974	1	1	398 720	10 425 000	1				5
9.974	1	2	398 720	10 425 000		1.4−2	1.9+11	D	5°,65*
10.053	$2s2p\ ^3P^o_0$	$2p3p\ ^1P_1$	363 130	10 320 000	3				5
10.053	$2s2p\ ^3P^o_2$	$2p3p\ ^3S_1$	509 210	10 456 000	3				5
9.974	$2s2p\ ^3P^o_2$	$2p3p\ ^1D_2$	509 210	10 541 000	1				5

Co XXV (Li sequence) Ionization Energy = 17 897 000 cm^{-1} (2219.0 eV)

λ (Å)	Classification		Energy Levels (cm^{-1})		Int.	*gf*	*A* (s^{-1})	Acc.	References
244.185[P]	$2s\ ^2S_{1/2}$	$2p\ ^2P^o_{1/2}$	0	409 520		3.40−2	1.92+9	B+	21°,65*
178.197[P]	1/2	3/2	0	561 180		9.48−2	4.99+9	B+	21°,65*
10.539	$2p\ ^2P^o_{3/2}$	$3s\ ^2S_{1/2}$	561 180	10 055 000		7.2−2	2.2+12	C	8°,65*
10.366	1/2	1/2	409 520	10 055 000		3.4−2	1.1+12	D	8°,65*
10.316	$2p\ ^2P^o_{3/2}$	$3d\ ^2D_{3/2}$	561 180	10 253 000		2.7−1	4.3+12	C	8°,65*
10.295	3/2	5/2	561 180	10 267 000		2.43	2.56+13	C+	8°,65*
10.157	1/2	3/2	409 520	10 253 000		1.36	2.19+13	C+	8°,65*
9.836	$2s\ ^2S_{1/2}$	$3p\ ^2P^o_{1/2}$	0	10 165 000		2.58−1	8.89+12	B+	8°,65*
9.795	1/2	3/2	0	10 209 000		4.94−1	8.58+12	B+	8°,65*

Co XXVI (He sequence) Ionization Energy = 76 979 000 cm^{-1} (9544.1 eV)

λ (Å)	Classification		Energy Levels (cm^{-1})		Int.	*gf*	*A* (s^{-1})	Acc.	References
6367.7[C]	$1s5s\ ^3S_1$	$1s5p\ ^3P^o_1$	73 971 200	73 986 900		8.1−2	4.4+6	E	65*
5433.3[C]	$1s5s\ ^1S_0$	$1s5p\ ^1P^o_1$	73 986 200	74 004 600		1.0−1	7.5+6	E	65*
3267.0[C]	$1s4s\ ^3S_1$	$1s4p\ ^3P^o_1$	72 265 200	72 295 800		7.5−2	1.6+7	E	65*
2792.5[C]	$1s4s\ ^1S_0$	$1s4p\ ^1P^o_1$	72 294 700	72 330 500		6.9−2	2.0+7	D	65*
1379.7[C]	$1s3s\ ^3S_1$	$1s3p\ ^3P^o_1$	68 559 422	68 631 900		4.8−2	5.6+7	C	65*
1177.7[C]	$1s3s\ ^1S_0$	$1s3p\ ^1P^o_1$	68 629 950	68 714 862		5.7−2	9.1+7	C	65*
408.48[C]	$1s2s\ ^3S_1$	$1s2p\ ^3P^o_0$	57 857 196	58 102 005		1.01−2	4.04+8	B	65*
381.28[C]	1	1	57 857 196	58 119 468		2.94−2	4.50+8	B	65*
247.71[C]	1	2	57 857 196	58 260 893		8.34−2	1.82+9	B	65*

Co XXVI (He sequence) Ionization Energy = 76 979 000 cm^{-1} (9544.1 eV) – Continued

λ (Å)	Classification		Energy Levels (cm^{-1})		Int.	gf	A (s^{-1})	Acc.	References
346.38^C	$1s2s\ ^1S_0$	$1s2p\ ^1P^\circ_1$	58 122 567	58 411 271		3.35–2	6.21+8	B	65*
180.48^C	$1s2s\ ^3S_1$	$1s2p\ ^1P^\circ_1$	57 857 196	58 411 271		6.78–3	4.62+8	B	65*
60.397^C	$1s4p\ ^1P^\circ_1$	$1s5s\ ^1S_0$	72 330 500	73 986 200		1.6–1	3.0+11	B	65*
59.687^C	$1s4p\ ^3P^\circ_1$	$1s5s\ ^3S_1$	72 295 800	73 971 200		1.6–1	9.7+10	B	65*
58.483^C	$1s4s\ ^1S_0$	$1s5p\ ^1P^\circ_1$	72 294 700	74 004 600		4.38–1	2.85+11	B	65*
58.082^C	$1s4s\ ^3S_1$	$1s5p\ ^3P^\circ_1$	72 265 200	73 986 900		4.50–1	2.96+11	B	65*
27.934^C	$1s3p\ ^1P^\circ_1$	$1s4s\ ^1S_0$	68 714 862	72 294 700		9.9–2	8.5+11	B	65*
27.761^C	$1s3d\ ^1D_2$	$1s4p\ ^1P^\circ_1$	68 728 333	72 330 500		5.5–2	1.6+11	C	65*
27.613^C	$1s3p\ ^1P^\circ_1$	$1s4d\ ^1D_2$	68 714 862	72 336 300		1.9	3.3+12	C	65*
27.523^C	$1s3p\ ^3P^\circ_1$	$1s4s\ ^3S_1$	68 631 900	72 265 200		9.6–2	2.8+11	B	65*
27.023^C	$1s3s\ ^1S_0$	$1s4p\ ^1P^\circ_1$	68 629 950	72 330 500		3.93–1	1.20+12	B	65*
26.764^C	$1s3s\ ^3S_1$	$1s4p\ ^3P^\circ_1$	68 559 422	72 295 800		3.99–1	1.24+12	B	65*
18.971^C	$1s3p\ ^1P^\circ_1$	$1s5s\ ^1S_0$	68 714 862	73 986 200		2.3–2	4.2+11	C	65*
18.729^C	$1s3p\ ^3P^\circ_1$	$1s5s\ ^3S_1$	68 631 900	73 971 200		2.1–2	1.3+11	C	65*
18.606^C	$1s3s\ ^1S_0$	$1s5p\ ^1P^\circ_1$	68 629 950	74 004 600		1.01–1	6.49+11	B	65*
18.425^C	$1s3s\ ^3S_1$	$1s5p\ ^3P^\circ_1$	68 559 422	73 986 900		1.0–1	6.7+11	B	65*
9.7860^C	$1s2p\ ^1P^\circ_1$	$1s3s\ ^1S_0$	58 411 271	68 629 950		4.2–2	2.9+12	B	65*
9.6927^C	$1s2p\ ^1P^\circ_1$	$1s3d\ ^1D_2$	58 411 271	68 728 333		2.1	3.0+13	C+	65*
9.5786^C	$1s2p\ ^3P^\circ_1$	$1s3s\ ^3S_1$	58 119 468	68 559 422		4.2–2	1.0+12	B	65*
9.4408^C	$1s2s\ ^1S_0$	$1s3p\ ^1P^\circ_1$	58 122 567	68 714 862		3.58–1	8.93+12	B	65*
9.2810^C	$1s2s\ ^3S_1$	$1s3p\ ^3P^\circ_1$	57 857 196	68 631 900		3.63–1	9.37+12	B	65*
7.2028^C	$1s2p\ ^1P^\circ_1$	$1s4s\ ^1S_0$	58 411 271	72 294 700		9.3–3	1.2+12	C	65*
7.1813^C	$1s2p\ ^1P^\circ_1$	$1s4d\ ^1D_2$	58 411 271	72 336 300		3.6–1	9.3+12	C	65*
7.0693^C	$1s2p\ ^3P^\circ_1$	$1s4s\ ^3S_1$	58 119 468	72 265 200		9.0–3	4.0+11	C	65*
7.0383^C	$1s2s\ ^1S_0$	$1s4p\ ^1P^\circ_1$	58 122 567	72 330 500		8.6–2	3.9+12	B	65*
6.9259^C	$1s2s\ ^3S_1$	$1s4p\ ^3P^\circ_1$	57 857 196	72 295 800		9.3–2	4.3+12	B	65*
6.4206^C	$1s2p\ ^1P^\circ_1$	$1s5s\ ^1S_0$	58 411 271	73 986 200		3.6–3	5.8+11	C	65*
6.3085^C	$1s2p\ ^3P^\circ_1$	$1s5s\ ^3S_1$	58 119 468	73 971 200		3.6–3	2.0+11	C	65*
6.2964^C	$1s2s\ ^1S_0$	$1s5p\ ^1P^\circ_1$	58 122 567	74 004 600		3.5–2	2.0+12	B	65*
6.1997^C	$1s2s\ ^3S_1$	$1s5p\ ^3P^\circ_1$	57 857 196	73 986 900		3.6–2	2.1+12	B	65*
1.7284^C	$1s^2\ ^1S_0$	$1s2s\ ^3S_1$	0	57 857 196		M1	3.12+8	B	65*
1.7206^C	$1s^2\ ^1S_0$	$1s2p\ ^3P^\circ_1$	0	58 119 468		7.84–2	5.89+13	B	65*
1.7164^C	$_0$	$_2$	0	58 260 893		M2	9.05+9	D	65*
1.7120^C	$1s^2\ ^1S_0$	$1s2p\ ^1P^\circ_1$	0	58 411 271		6.93–1	5.26+14	B	65*

Co XXVI (He sequence) Ionization Energy = 76 979 000 cm^{-1} (9544.1 eV) – Continued

λ (Å)	Classification		Energy Levels (cm^{-1})		Int.	gf	A (s^{-1})	Acc.	References
1.4570^{C}	$1s^2\ ^1S_0$	$1s3p\ ^3P^\circ_1$	0	68 631 900		1.8–2	1.9+13	E	65*
1.4553^{C}	$1s^2\ ^1S_0$	$1s3p\ ^1P^\circ_1$	0	68 714 862		1.35–1	1.42+14	B	65*
1.3832^{C}	$1s^2\ ^1S_0$	$1s4p\ ^3P^\circ_1$	0	72 295 800		6.6–3	7.7+12	E	65*
1.3825^{C}	$1s^2\ ^1S_0$	$1s4p\ ^1P^\circ_1$	0	72 330 500		4.88–2	5.68+13	B	65*
1.3516^{C}	$1s^2\ ^1S_0$	$1s5p\ ^3P^\circ_1$	0	73 986 900		3.3–3	4.0+12	E	65*
1.3513^{C}	$1s^2\ ^1S_0$	$1s5p\ ^1P^\circ_1$	0	74 004 600		2.40–2	2.92+13	B	65*

Co XXVII (H sequence) Ionization Energy = 80 753 210 cm^{-1} (10 012.0 eV) – Continued

λ (Å)	Classification		Energy Levels (cm^{-1})		Int.	gf	A (s^{-1})	Acc.	References
8.9689^{C}	$2p\ ^2P^\circ_{3/2}$	$3d\ ^2D_{5/2}$	60 705 294	71 854 986		2.514	3.473+13	A	66*
8.8303^{C}	$2s\ ^2S_{1/2}$	$3p\ ^2P^\circ_{3/2}$	60 511 126	71 835 748		5.914–1	1.264+13	A	66*
6.6485^{C}	$2p\ ^2P^\circ_{3/2}$	$4d\ ^2D_{5/2}$	60 705 294	75 746 267		4.396–1	1.105+13	A	66*
6.5673^{C}	$2s\ ^2S_{1/2}$	$4p\ ^2P^\circ_{3/2}$	60 511 126	75 738 145		1.391–1	5.377+12	A	66*
5.9370^{C}	$2p\ ^2P^\circ_{3/2}$	$5d\ ^2D_{5/2}$	60 705 294	77 548 739		1.602–1	5.051+12	A	66*
5.8708^{C}	$2s\ ^2S_{1/2}$	$5p\ ^2P^\circ_{3/2}$	60 511 126	77 544 581		5.670–2	2.742+12	A	66*
1.6527^{C}	$1s\ ^2S_{1/2}$	$2p\ ^2P^\circ_{1/2}$	0	60 505 950		2.798–1	3.417+14	A	66*
1.6473^{C}	1/2	3/2	0	60 705 294		5.616–1	3.451+14	A	66*
1.3932^{C}	$1s\ ^2S_{1/2}$	$3p\ ^2P^\circ_{1/2}$	0	71 776 650		5.324–2	9.147+13	A	66*
1.3921^{C}	1/2	3/2	0	71 835 748		1.065–1	9.166+13	A	66*
1.3208^{C}	$1s\ ^2S_{1/2}$	$4p\ ^2P^\circ_{1/2}$	0	75 713 918		1.951–2	3.729+13	A	66*
1.3203^{C}	1/2	3/2	0	75 738 145		3.904–2	3.734+13	A	66*
1.2898^{C}	$1s\ ^2S_{1/2}$	$5p\ ^2P^\circ_{1/2}$	0	77 531 837		9.382–3	1.881+13	A	66*
1.2896^{C}	1/2	3/2	0	77 544 581		1.877–2	1.881+13	A	66*

5. Explanation of Grotrian Diagrams

Notations on the Diagrams generally have the same meanings as for the Tables (see Explanation of Tables).

Abscissa

Energy of the levels in cm^{-1}.

Short vertical lines

Energy levels are indicated as the vertical lines. The electronic configuration (with the parentage in parentheses) and the level energy in cm^{-1} are given to the right of the vertical line, and at the top is the J value. Energy levels with the same LS label for the upper term are grouped together. The term designation is given at the right of the diagram; the ordering is by increasing multiplicity and orbital angular momentum. For the lower level, the term is adjacent to the configuration.

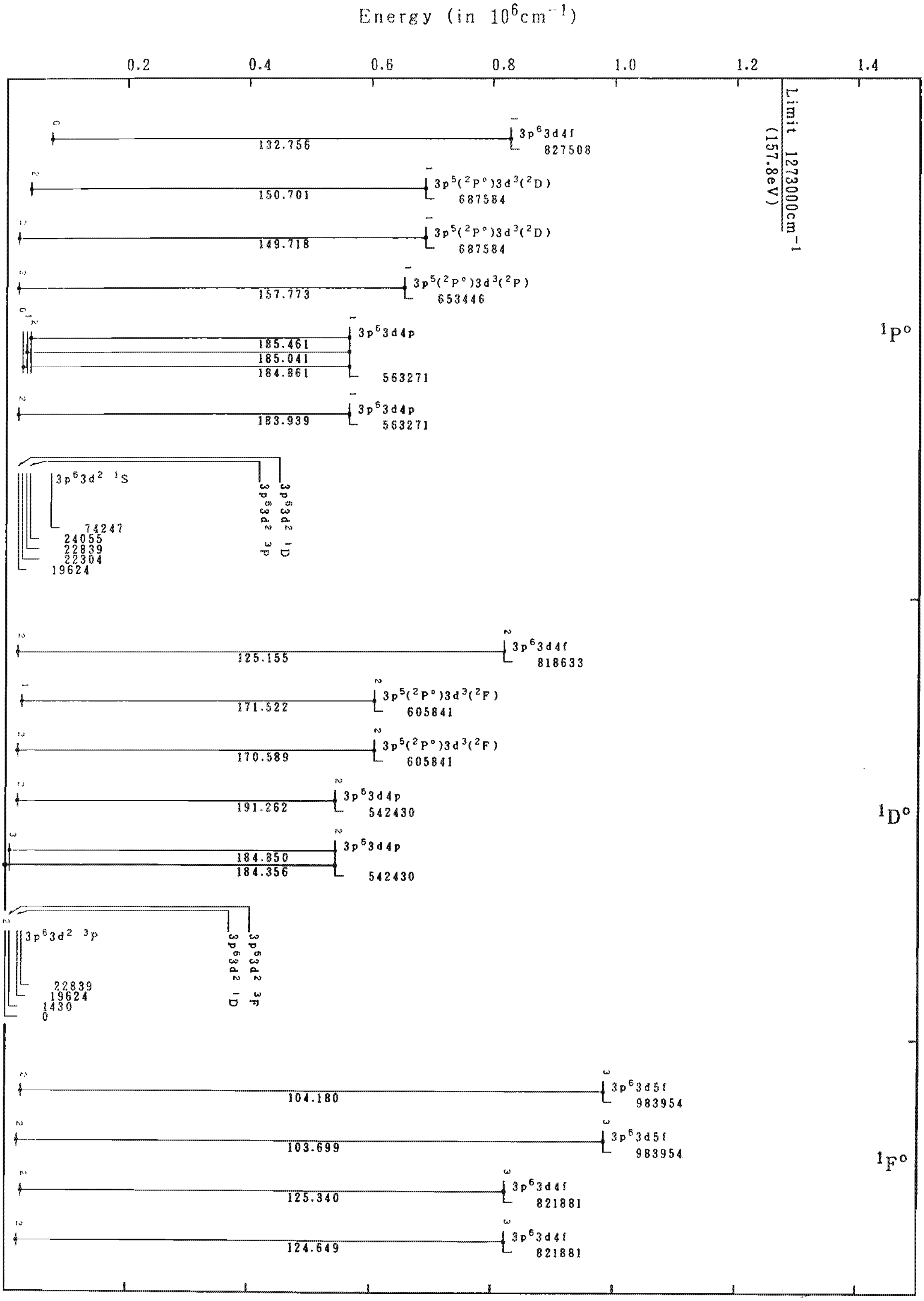
Horizontal lines

Transitions between levels. The number below each line gives the transition wavelength in Angstroms (10^{-8}cm). Heavier lines indicate resonance transitions with absorption oscillator strengths ≥ 0.01.

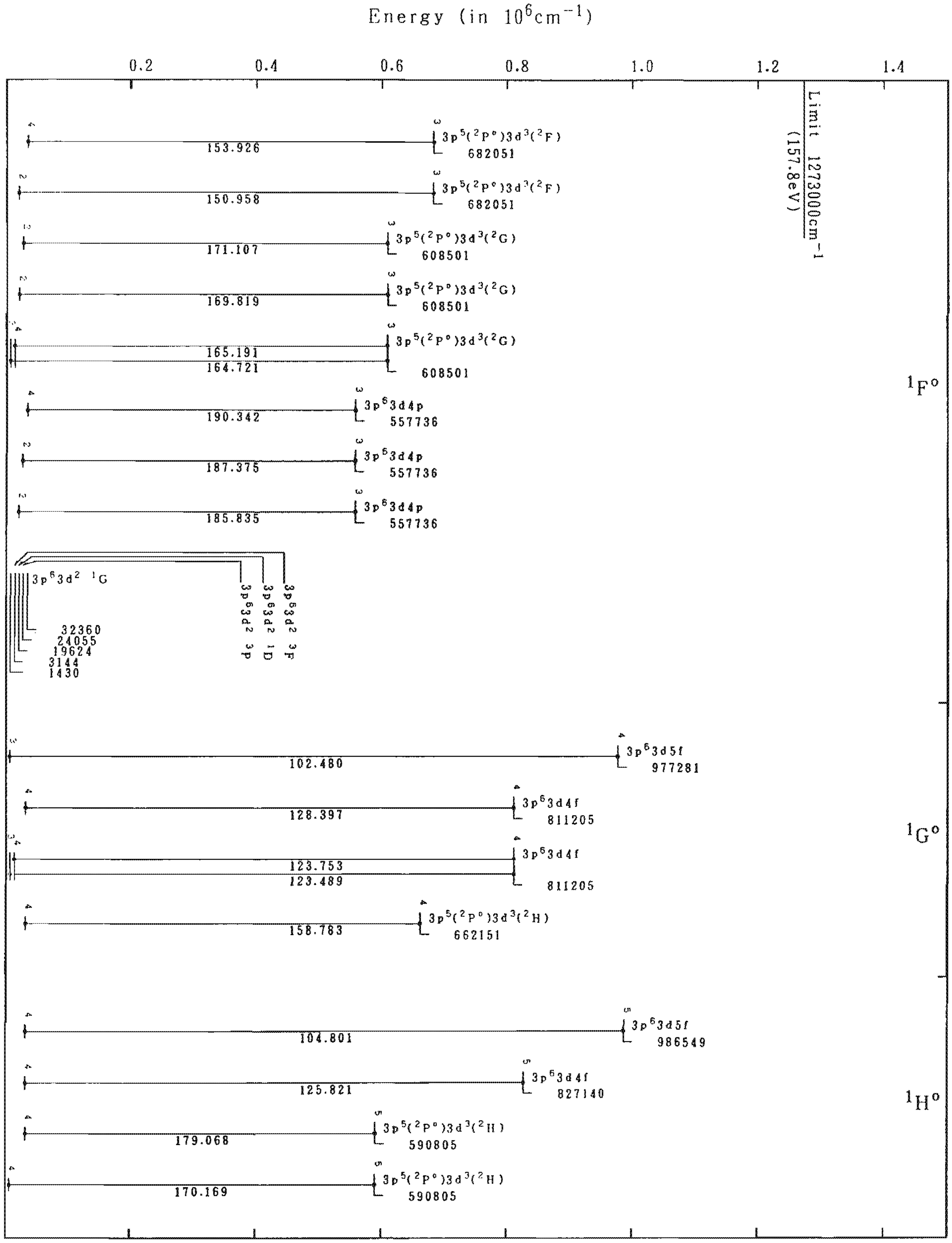
Limit

Principal ionization limit in cm^{-1} and eV.

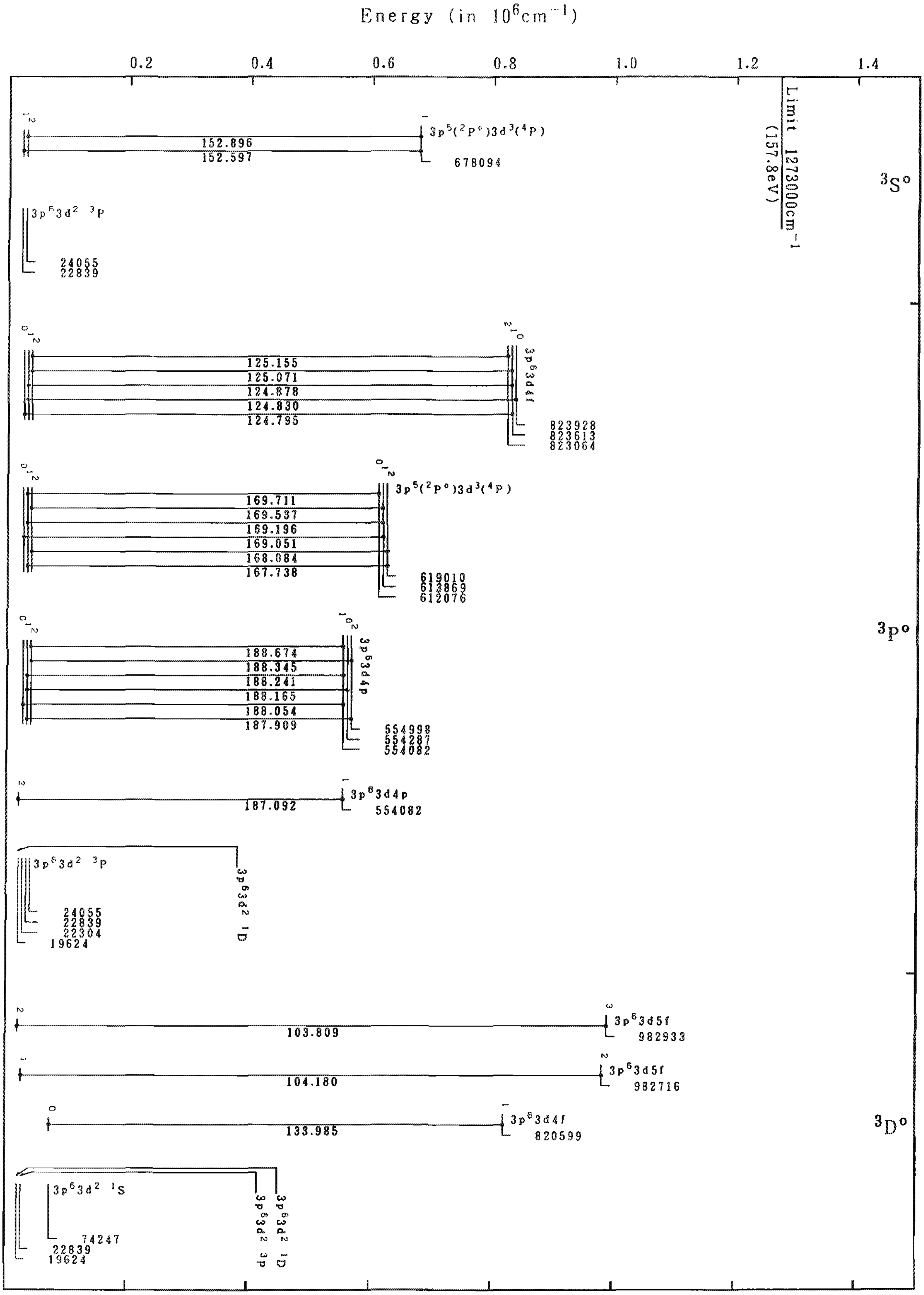
6. Diagrams for Co VIII through Co XXVII



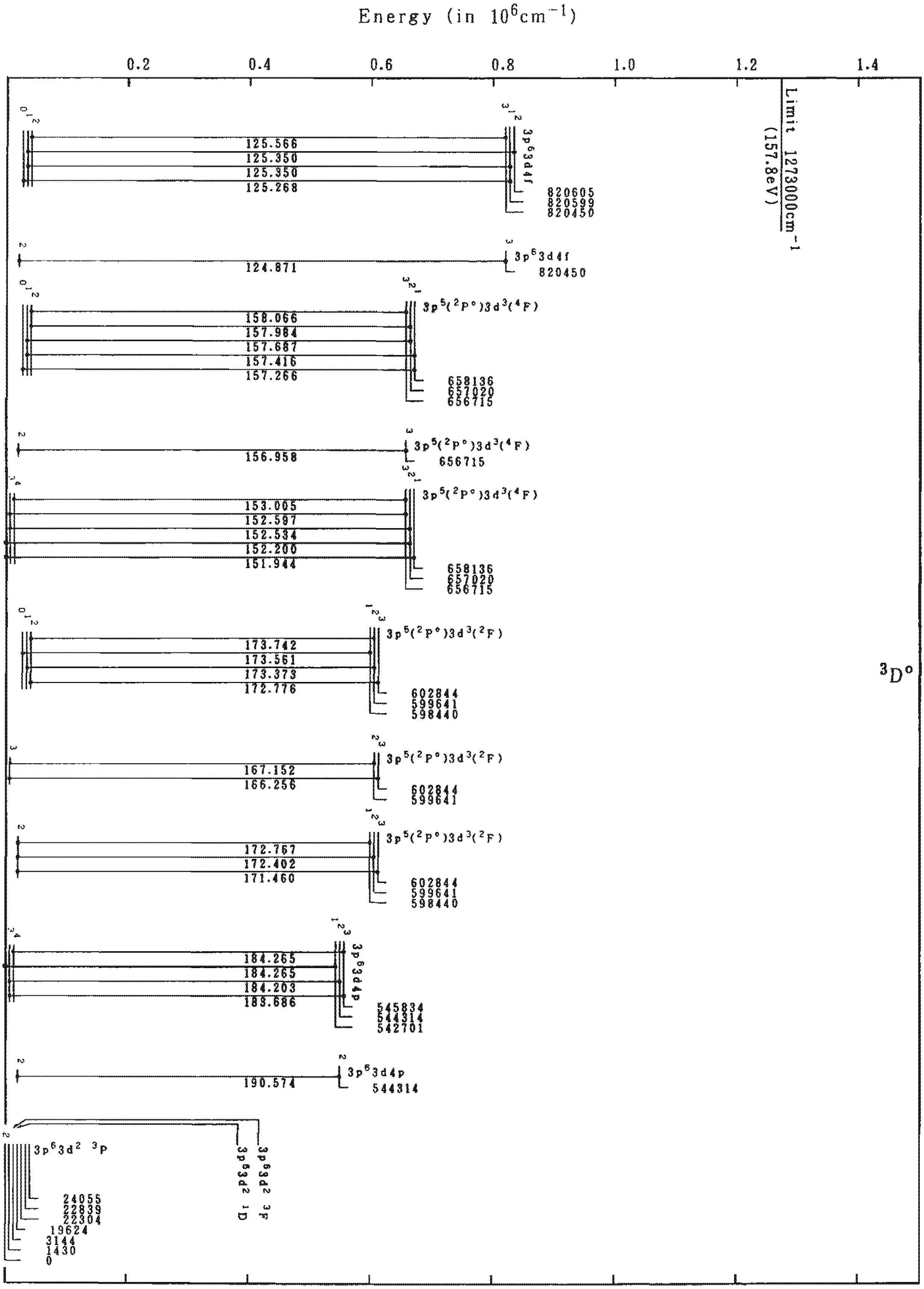
Co VIII (Ca–Sequence)



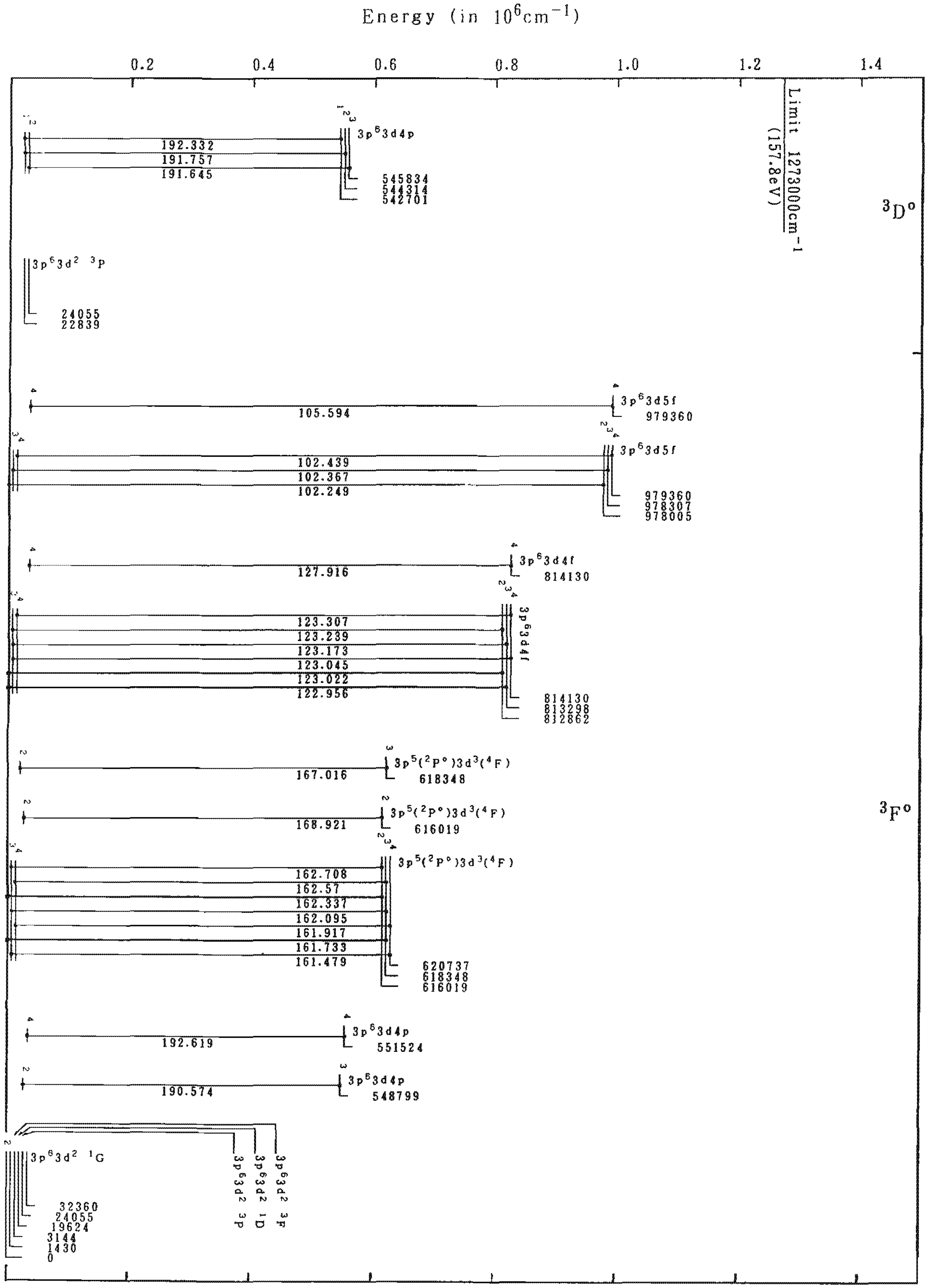
Co VIII (Ca–Sequence)



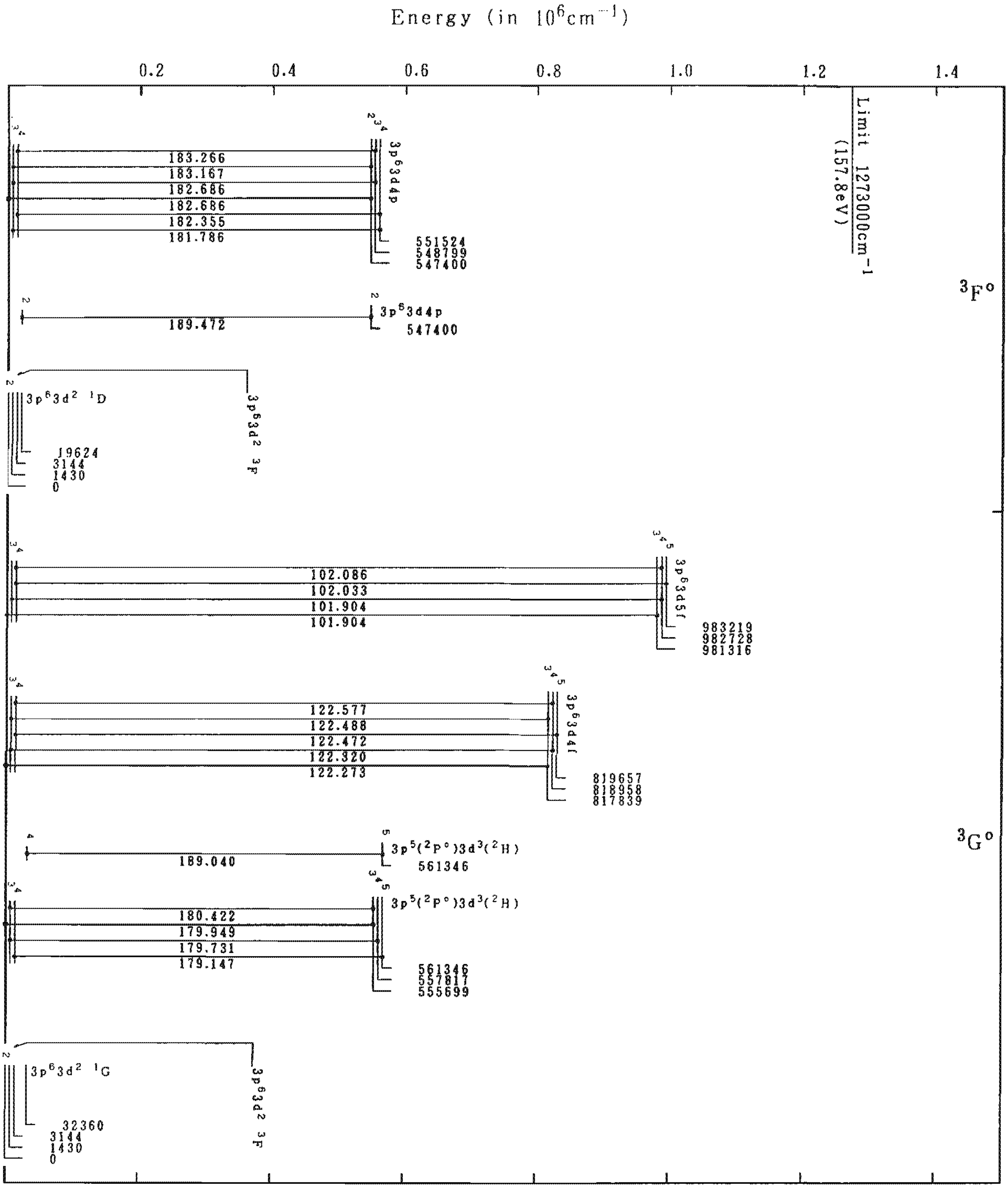
Co VIII (Ca–Sequence)



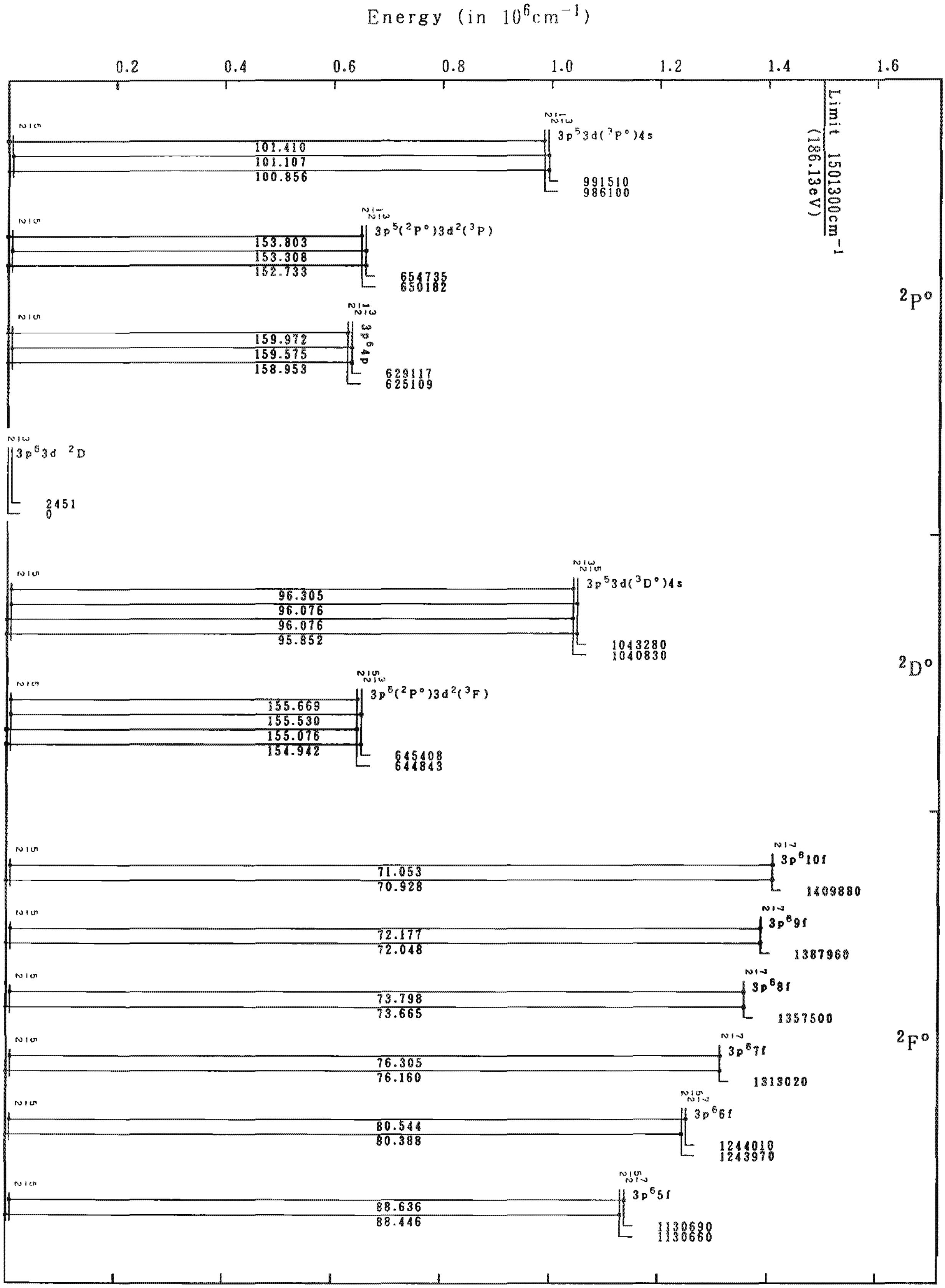
Co VIII (Ca–Sequence)



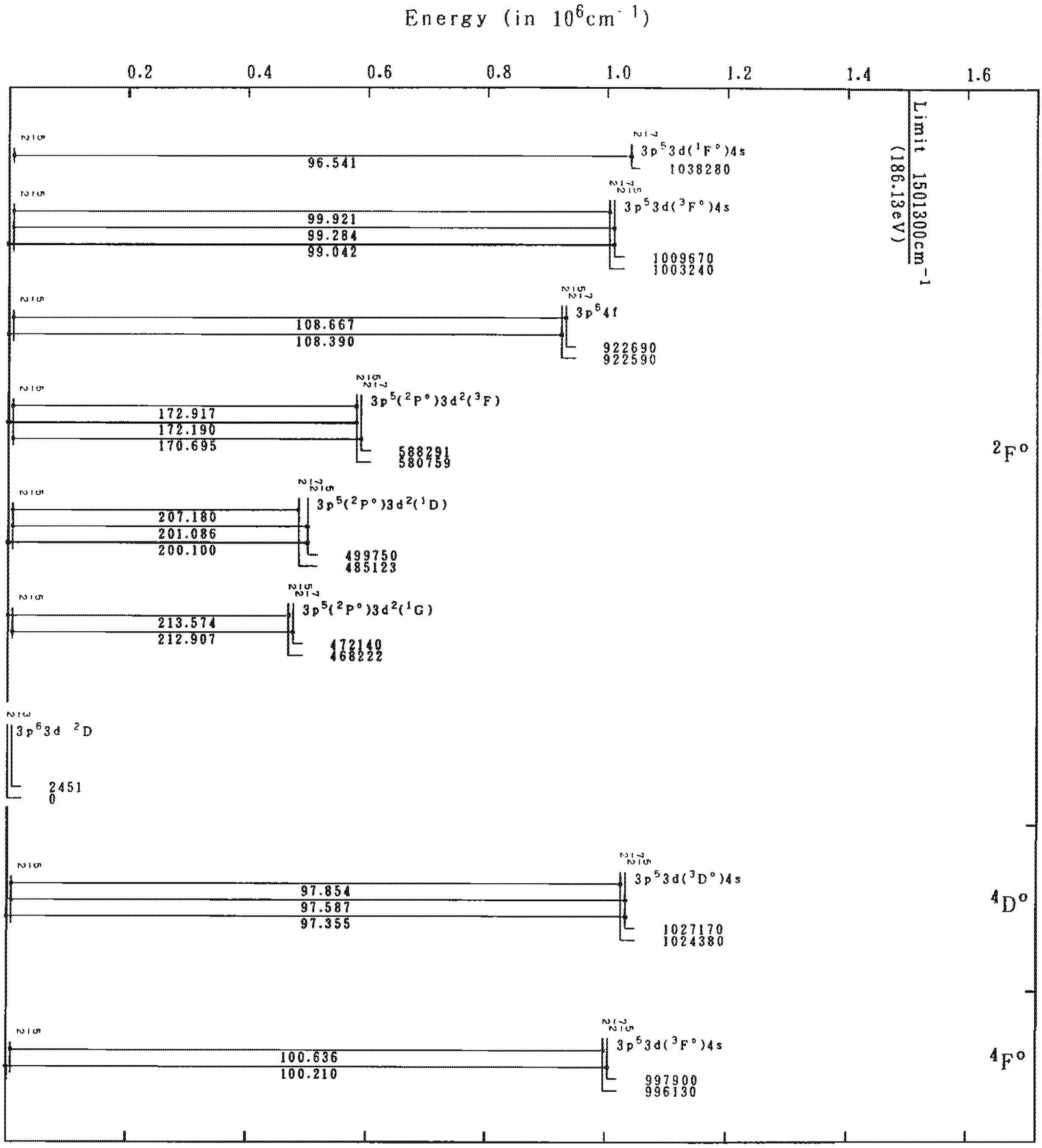
Co VIII (Ca–Sequence)



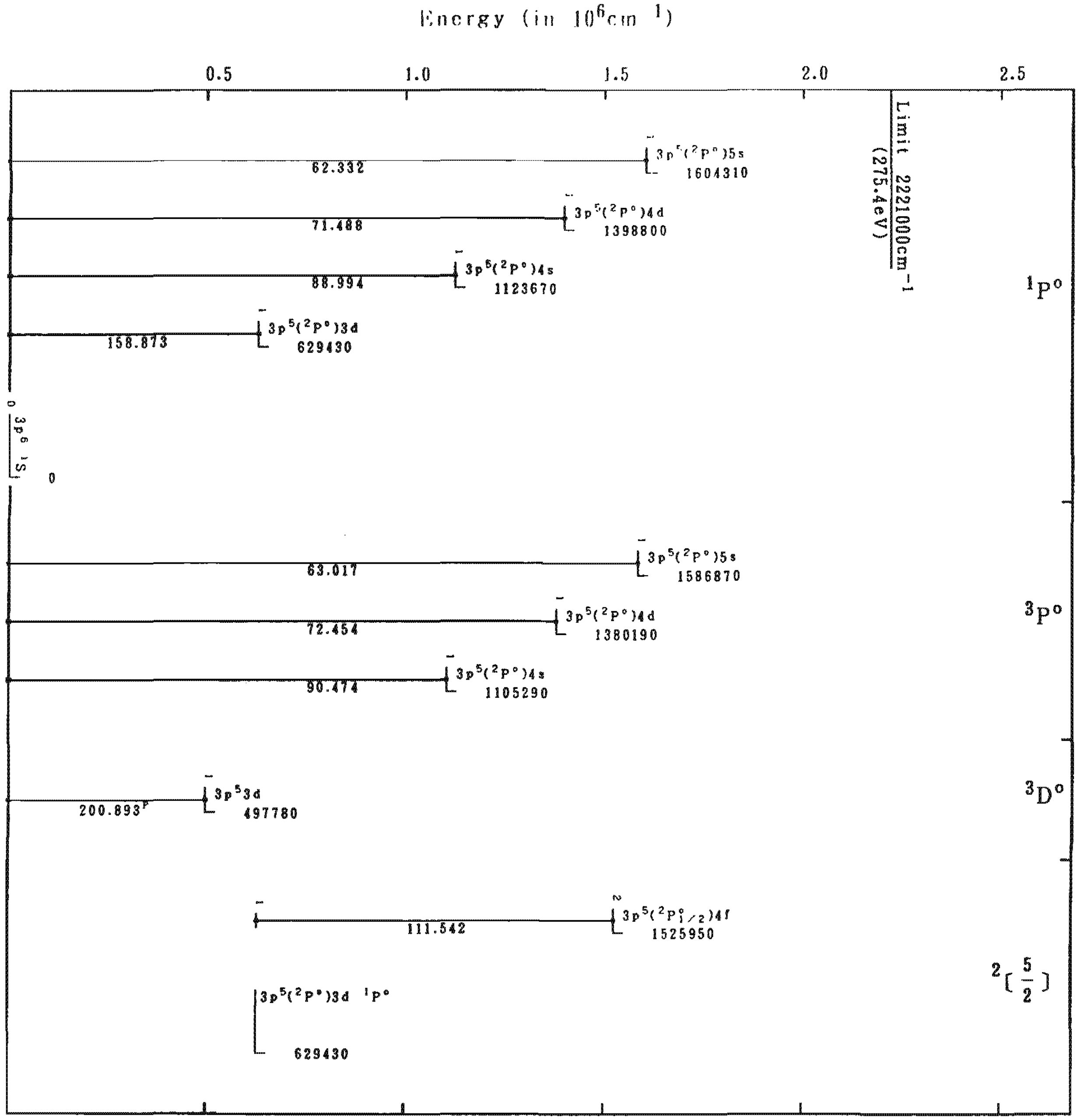
Co VIII (Ca–Sequence)



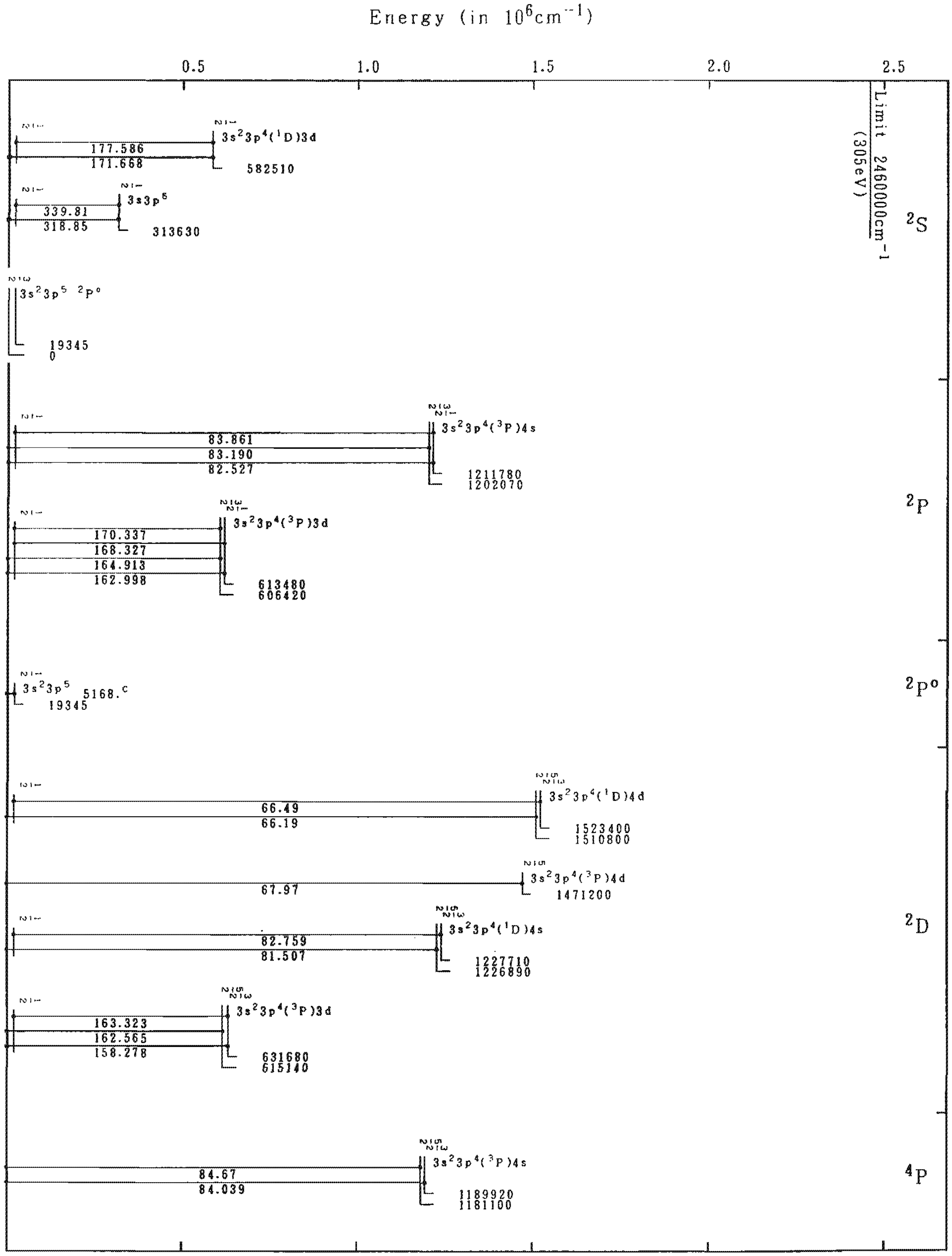
Co IX (K–Sequence)



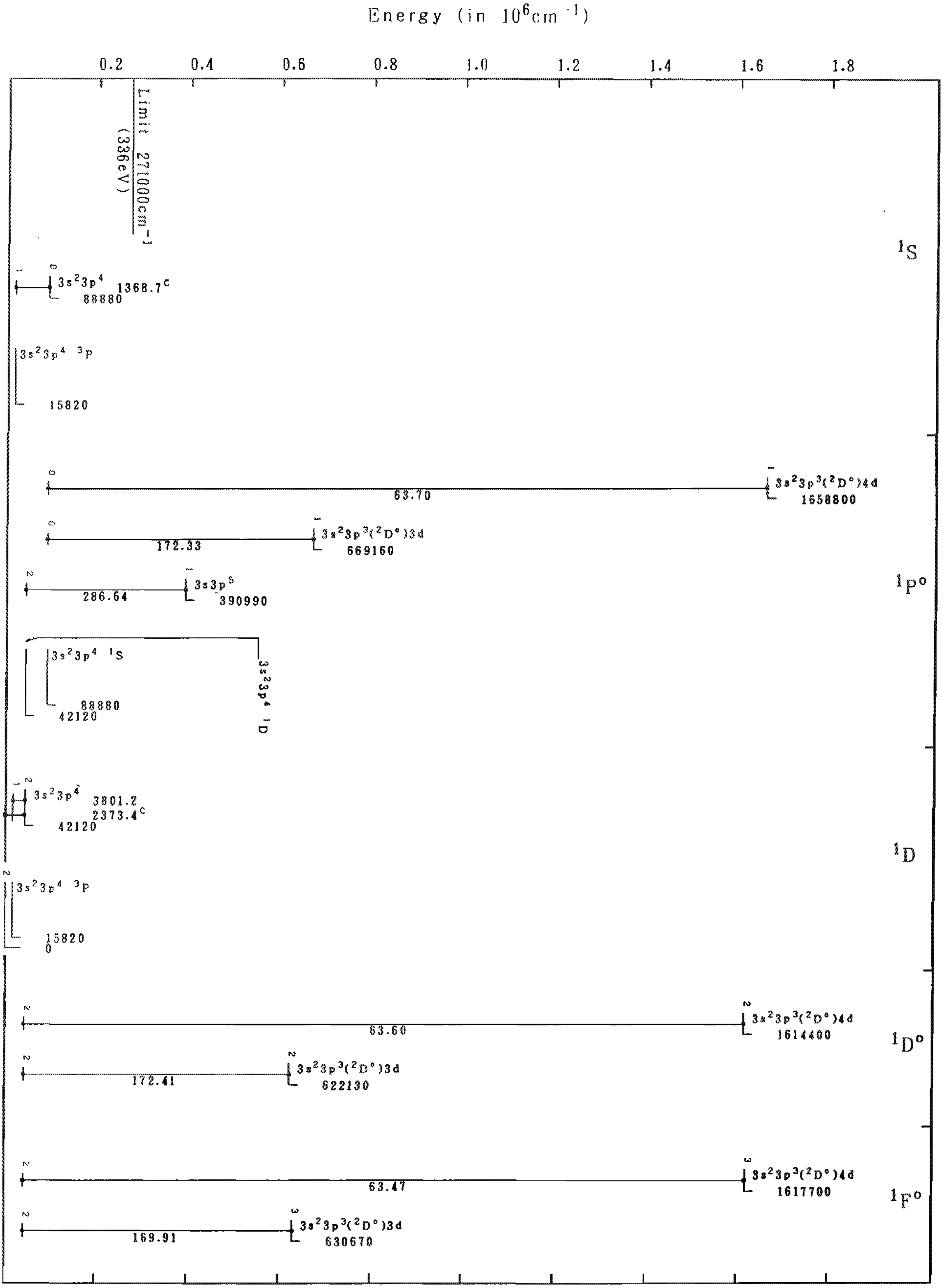
Co IX (K–Sequence)



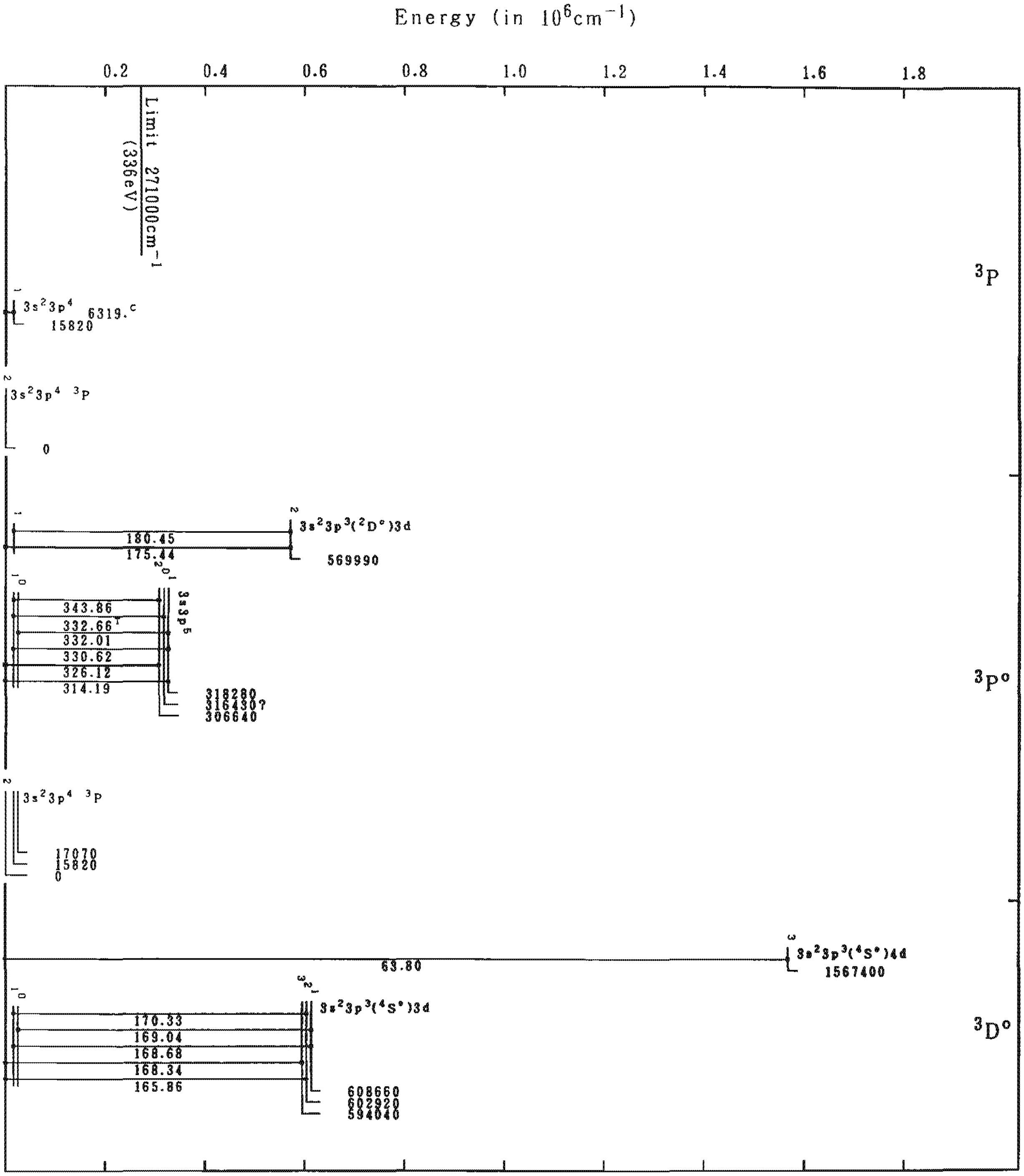
Co X (Ar–Sequence)



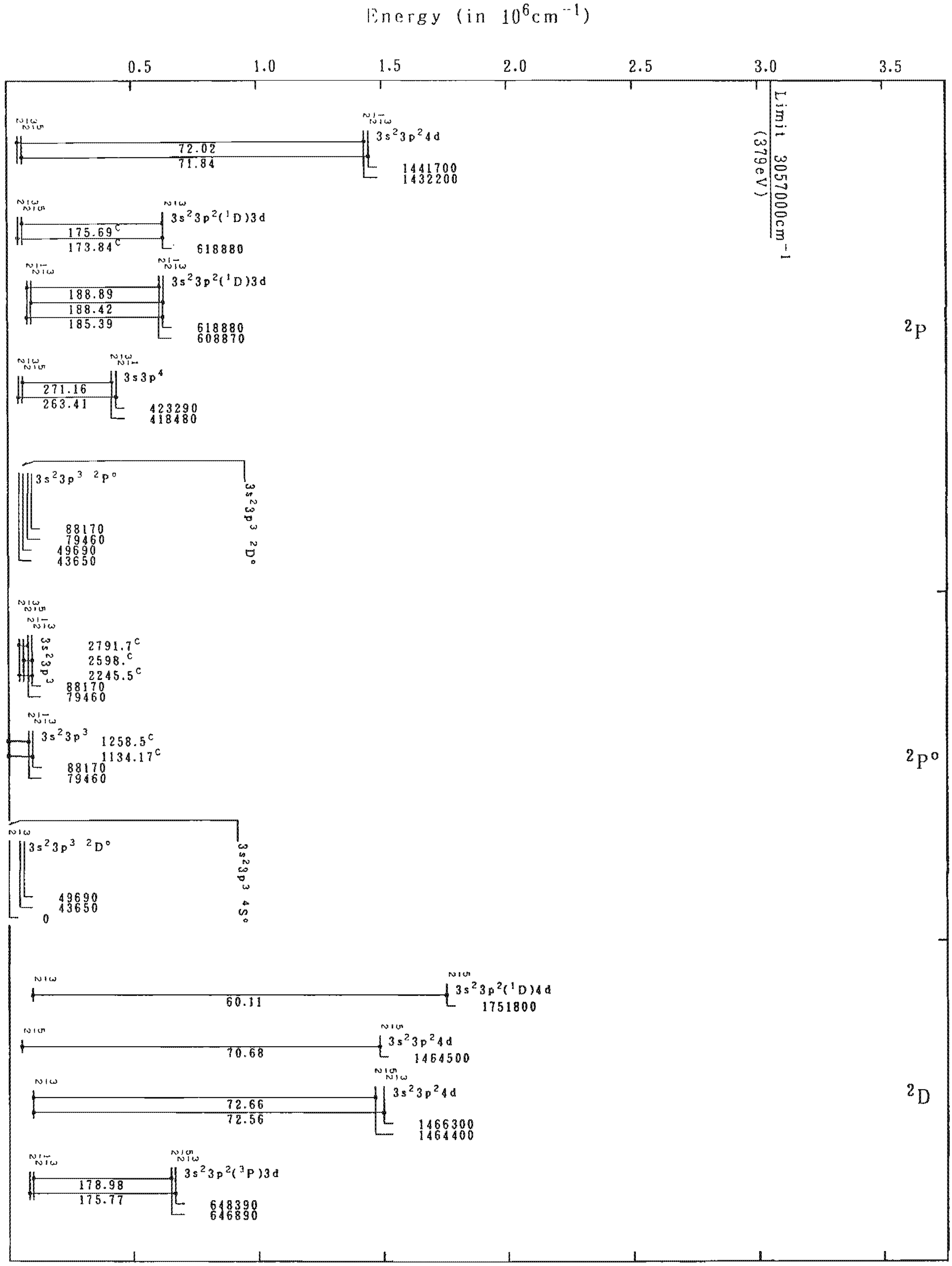
Co XI (Cl–Sequence)



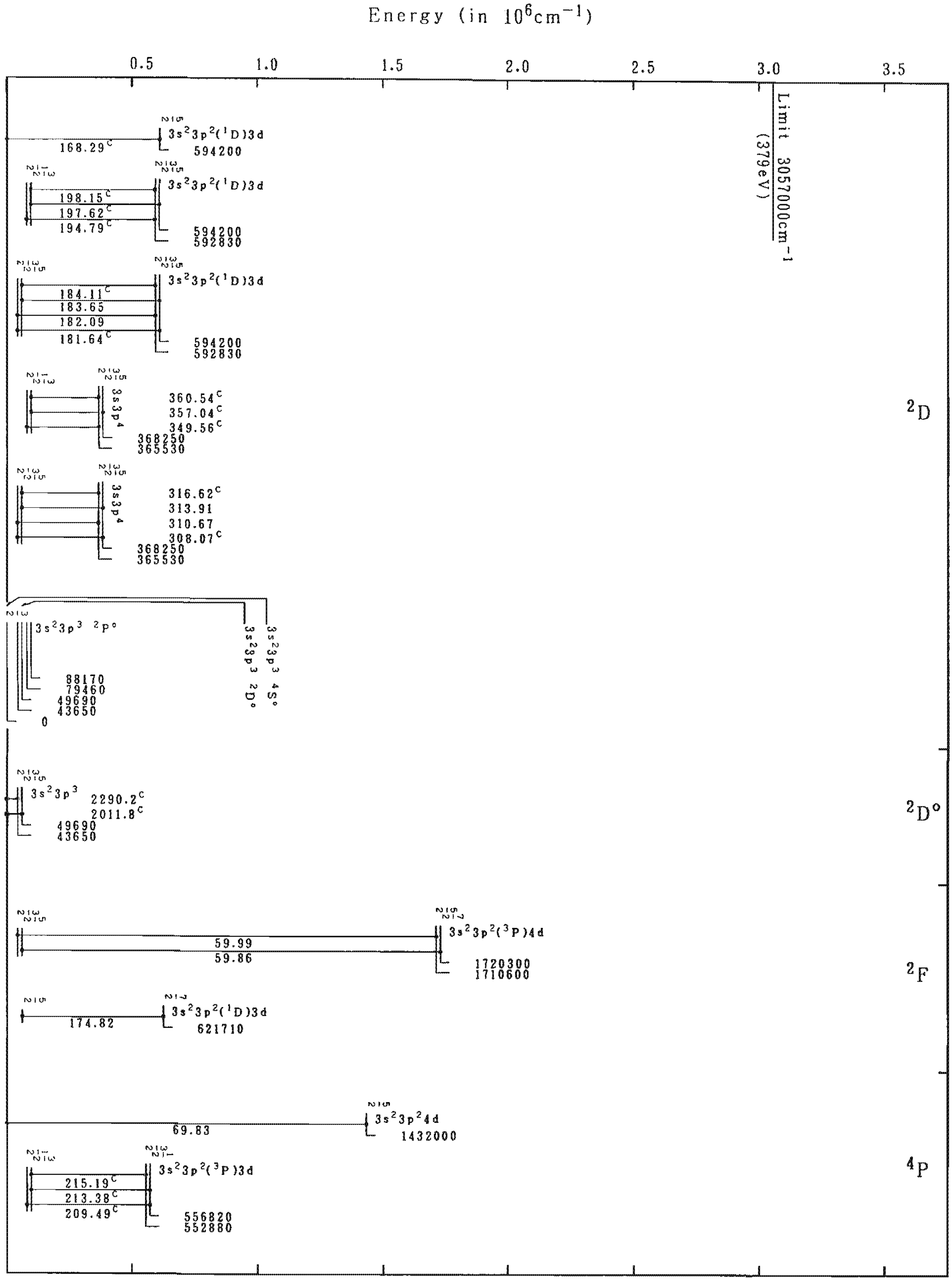
Co XII (S–Sequence)



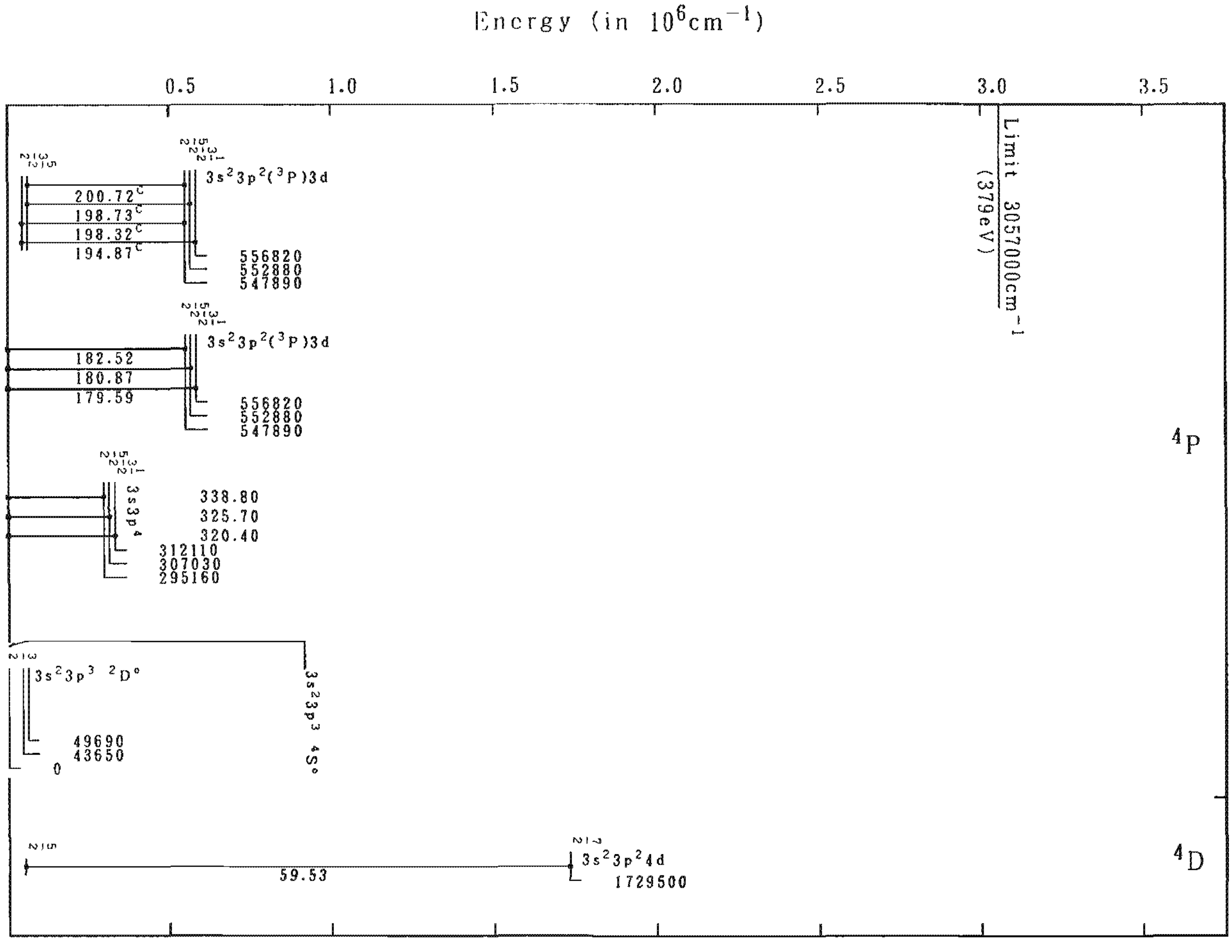
Co XII (S–Sequence)



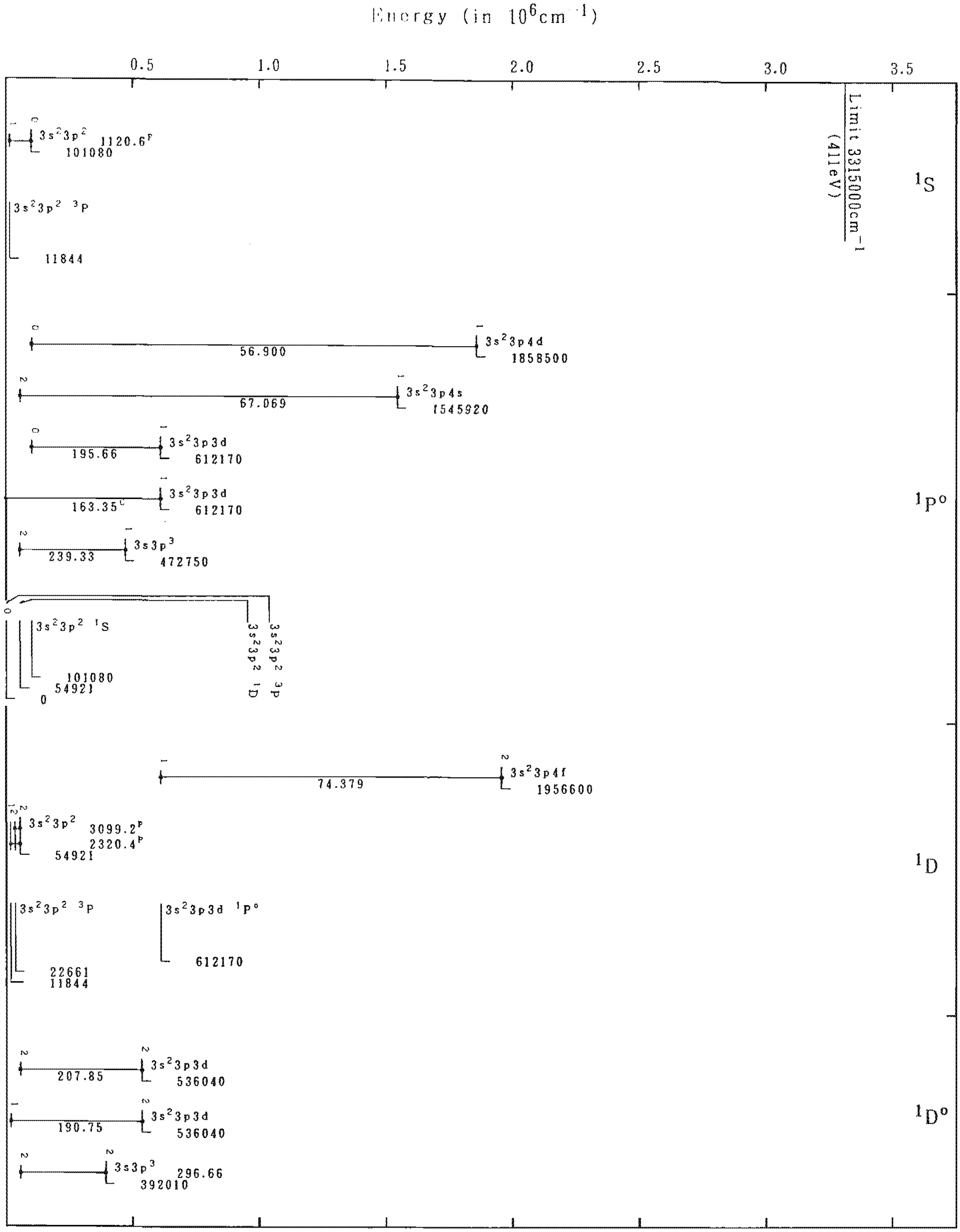
Co XIII (P–Sequence)



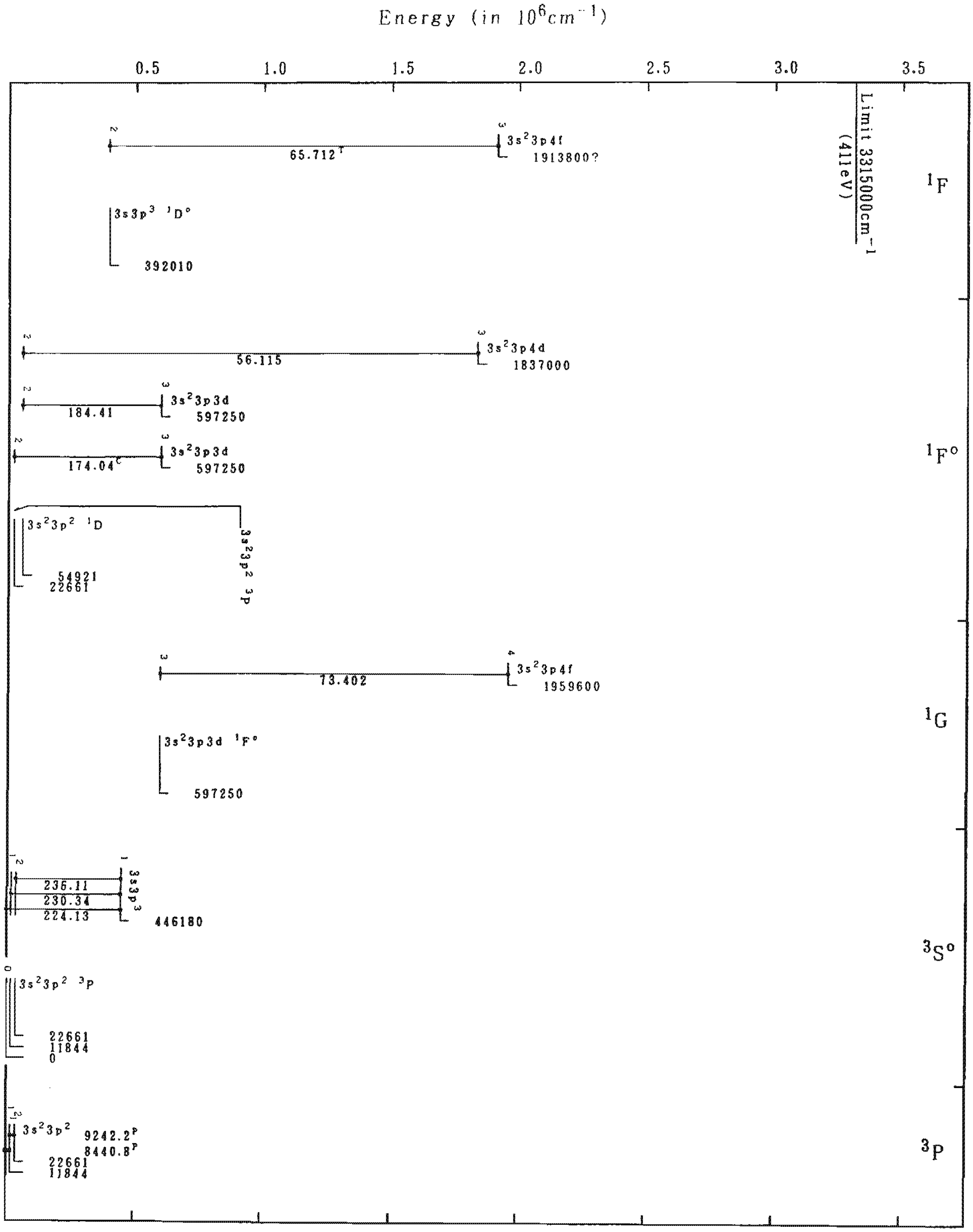
Co XIII (P–Sequence)



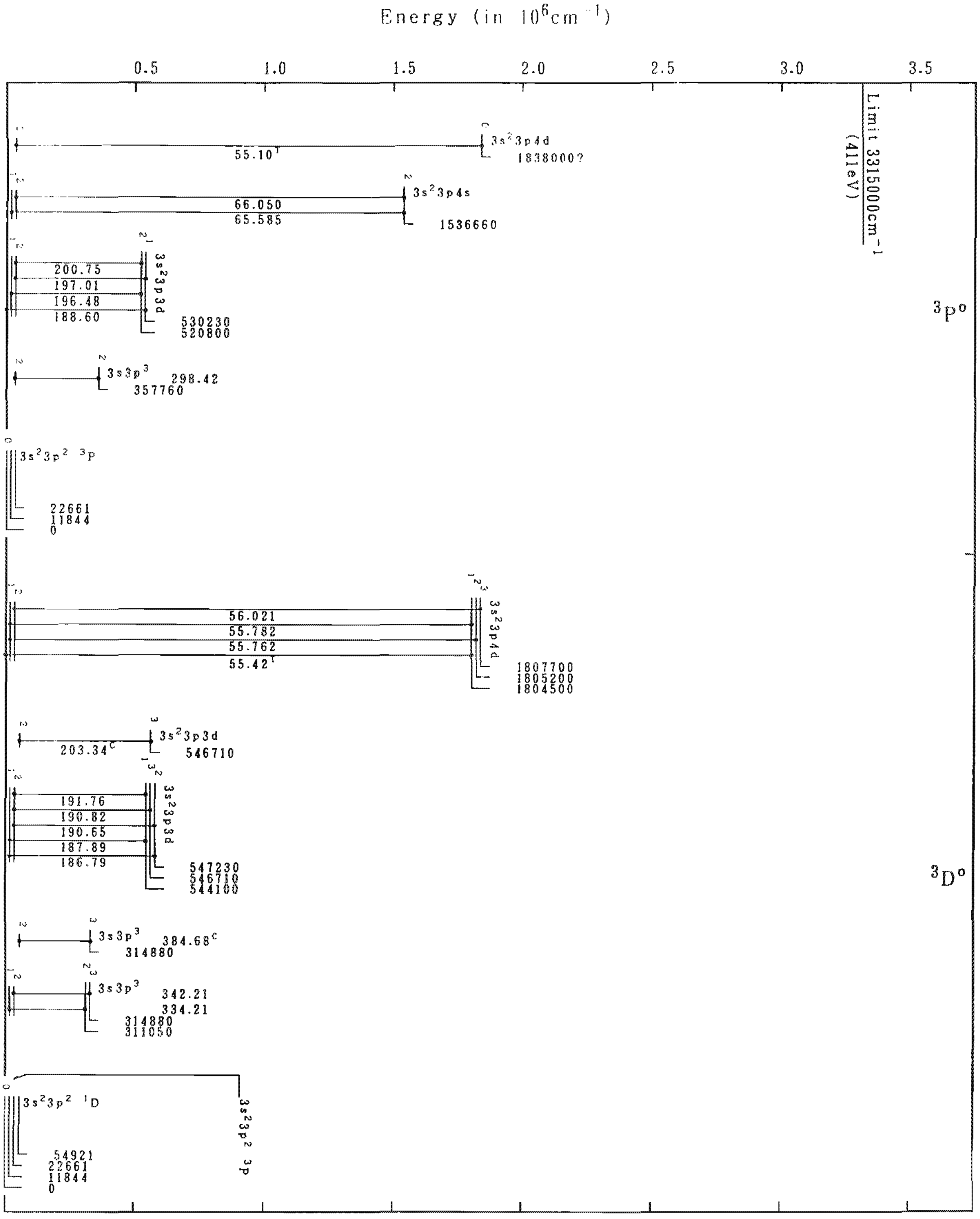
Co XIII (P–Sequence)



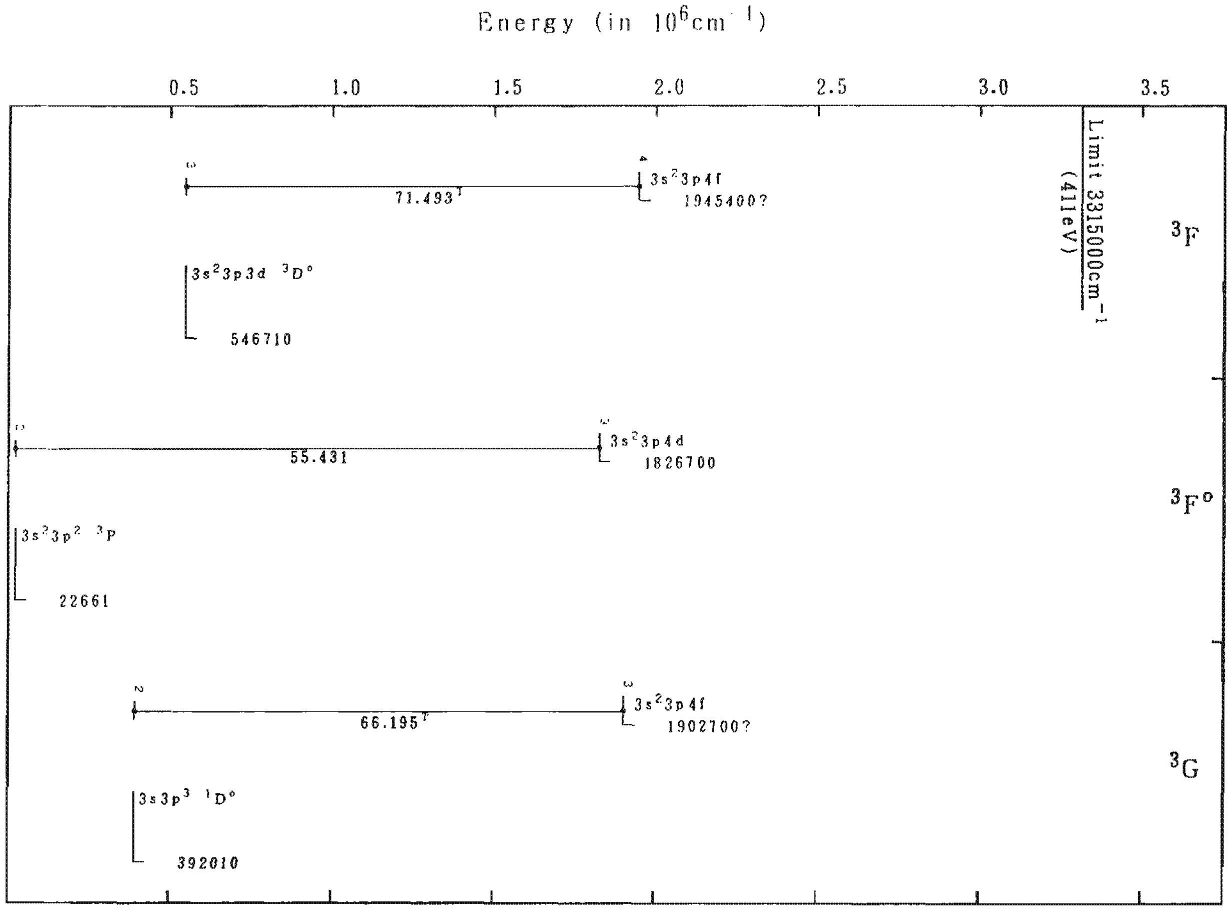
Co XIV (Si–Sequence)



Co XIV (Si–Sequence)



Co XIV (Si-Sequence)



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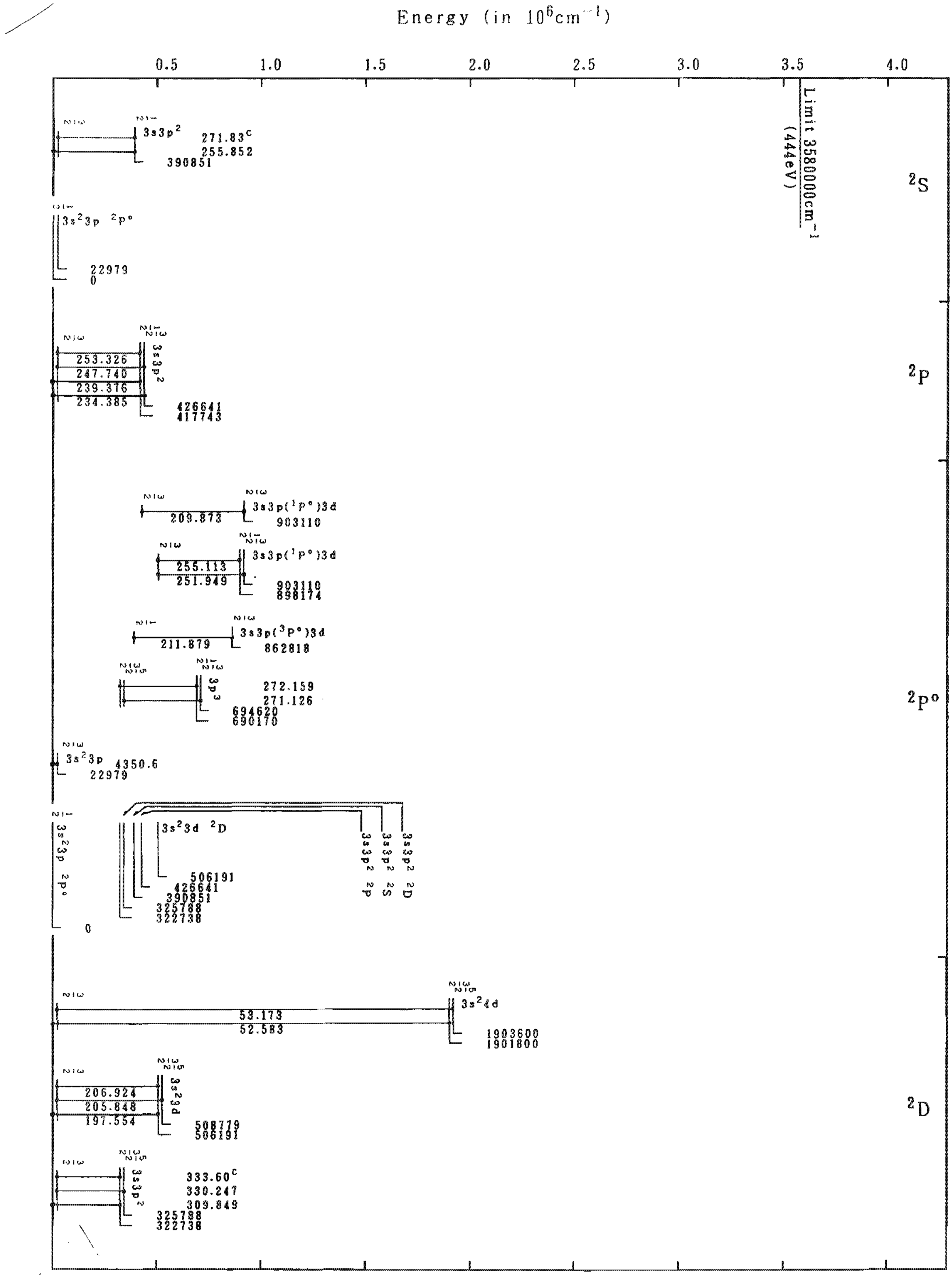
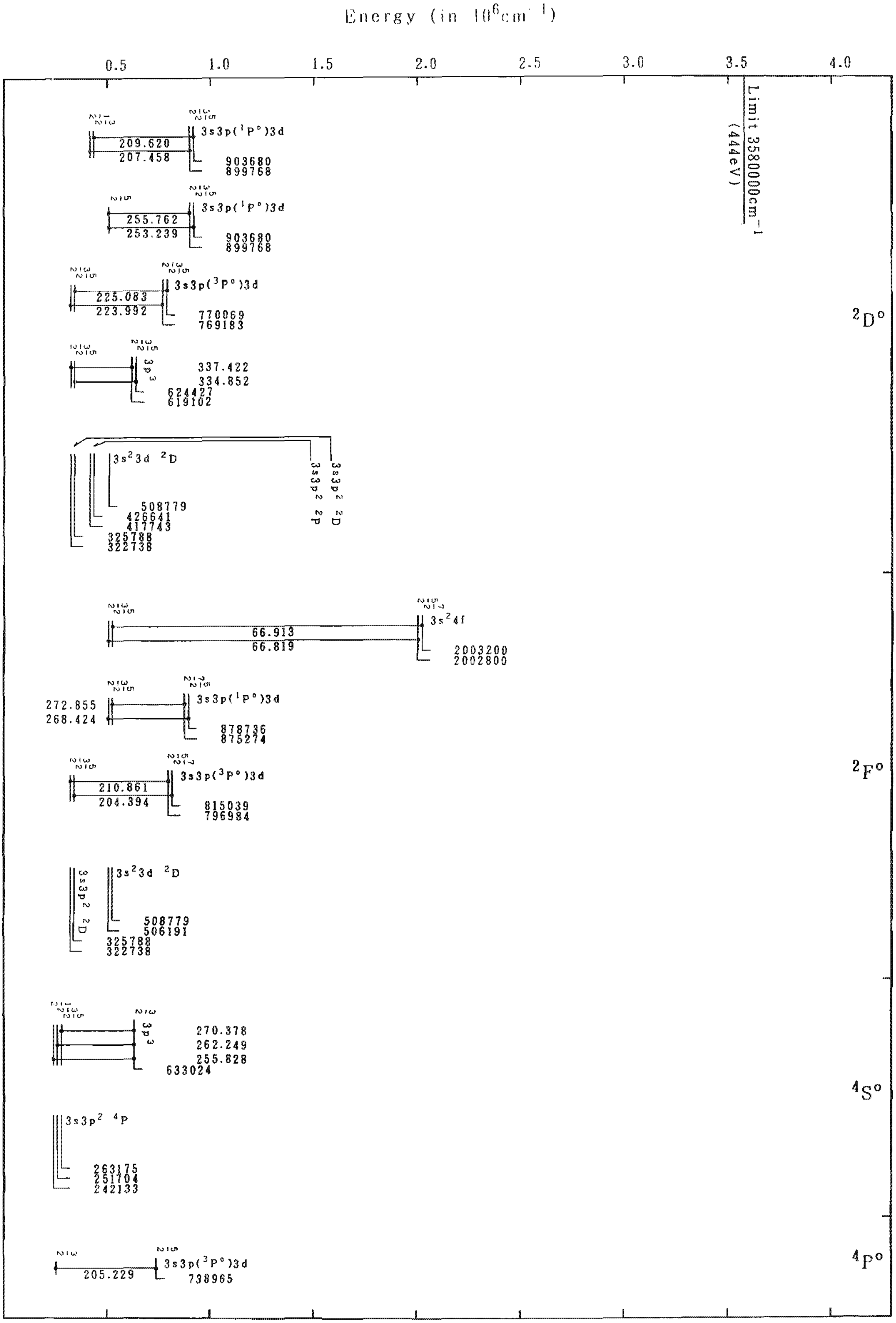


Co XV (Al–Sequence)



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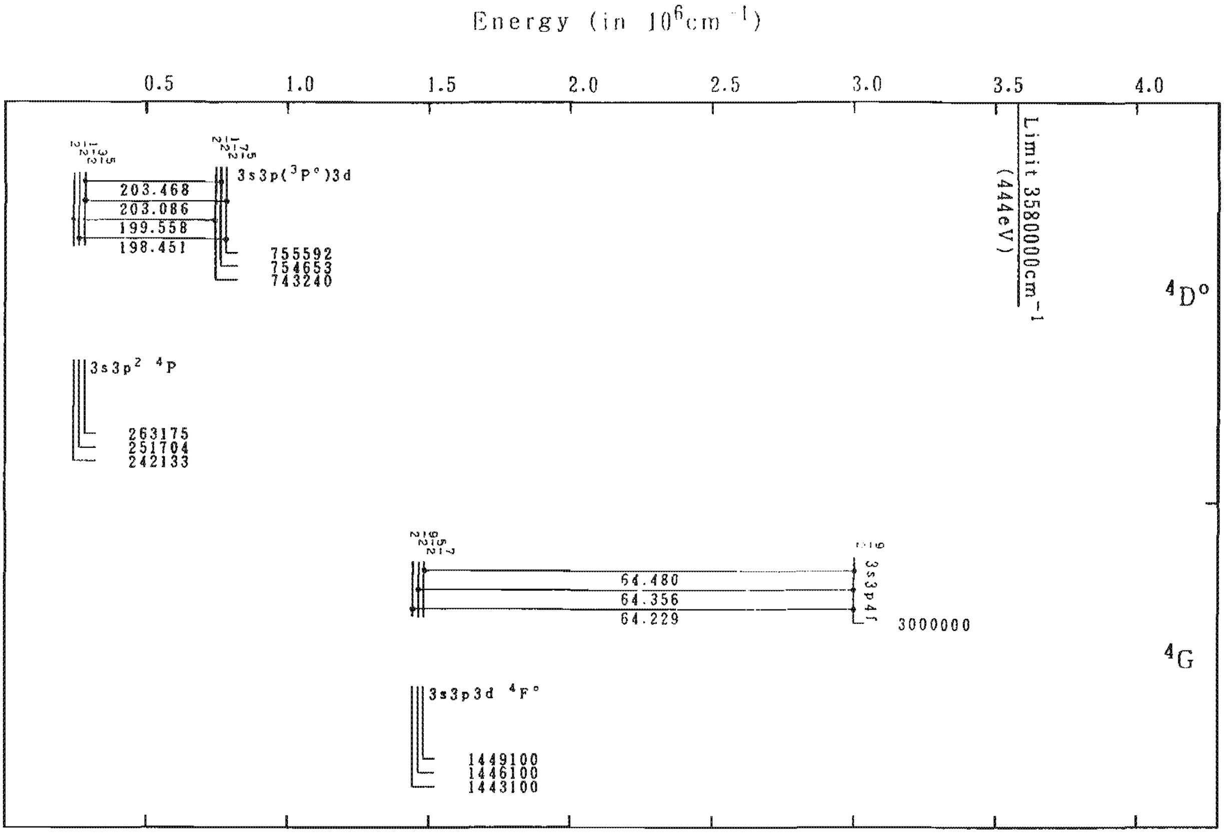

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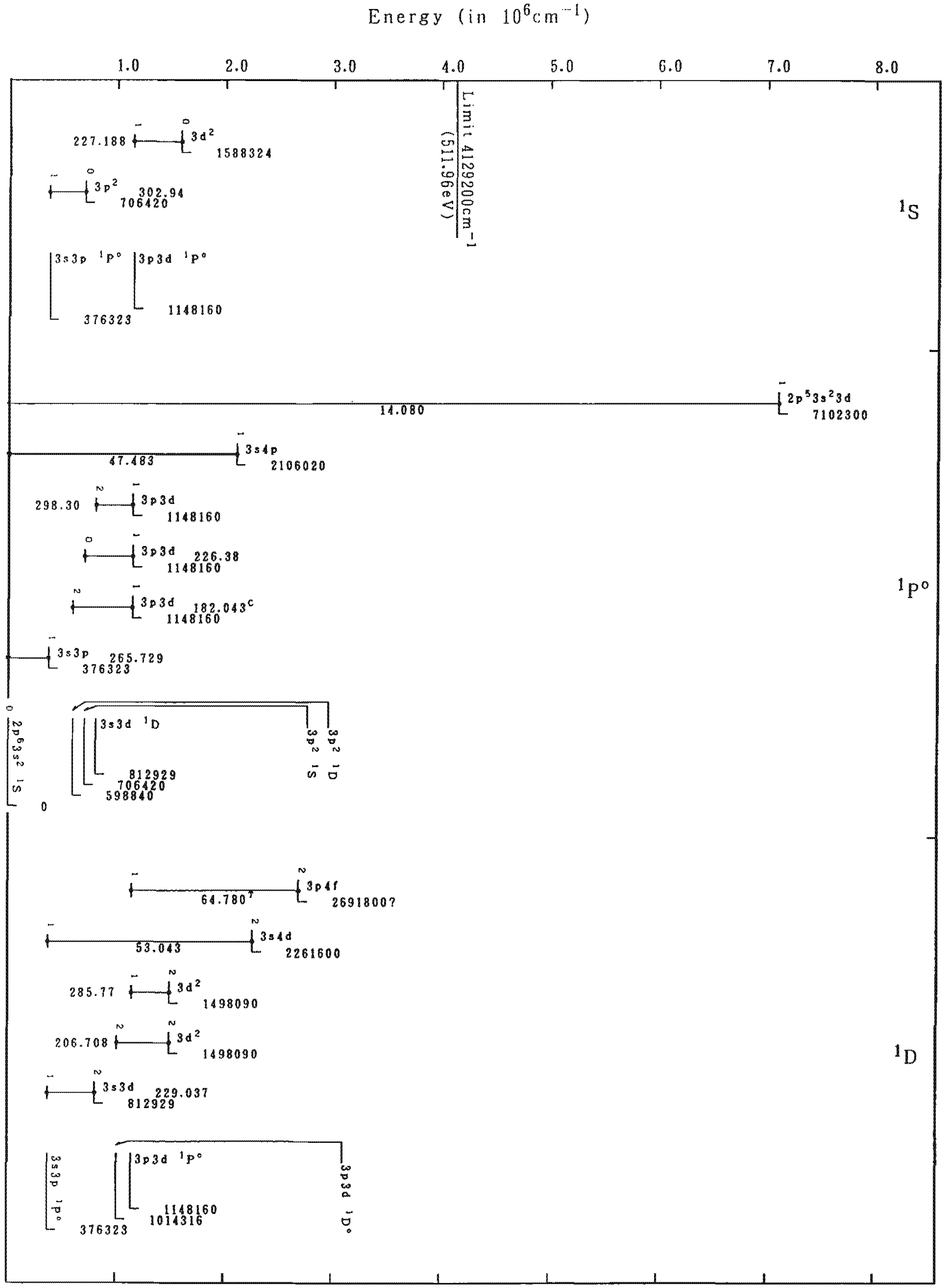

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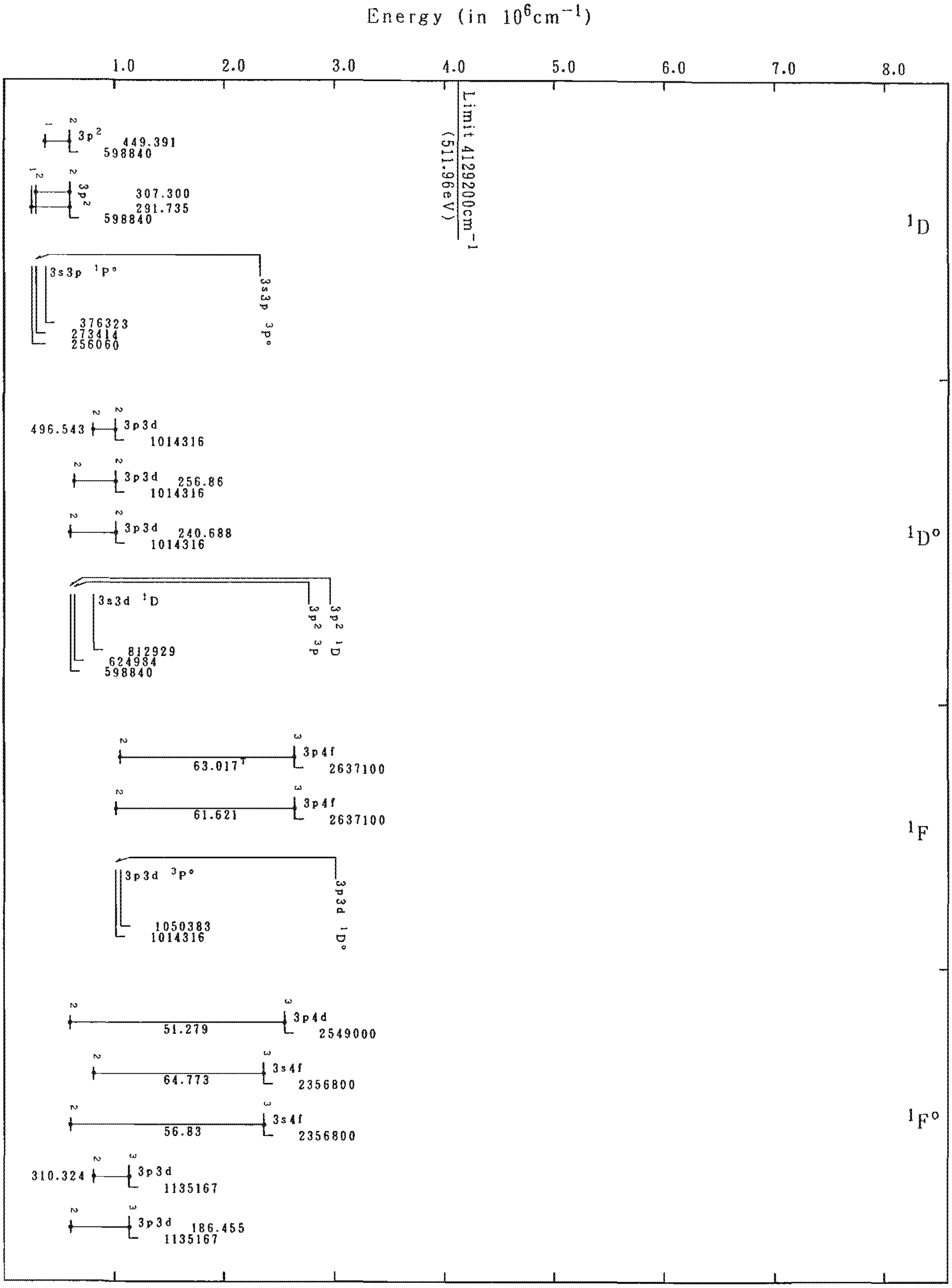

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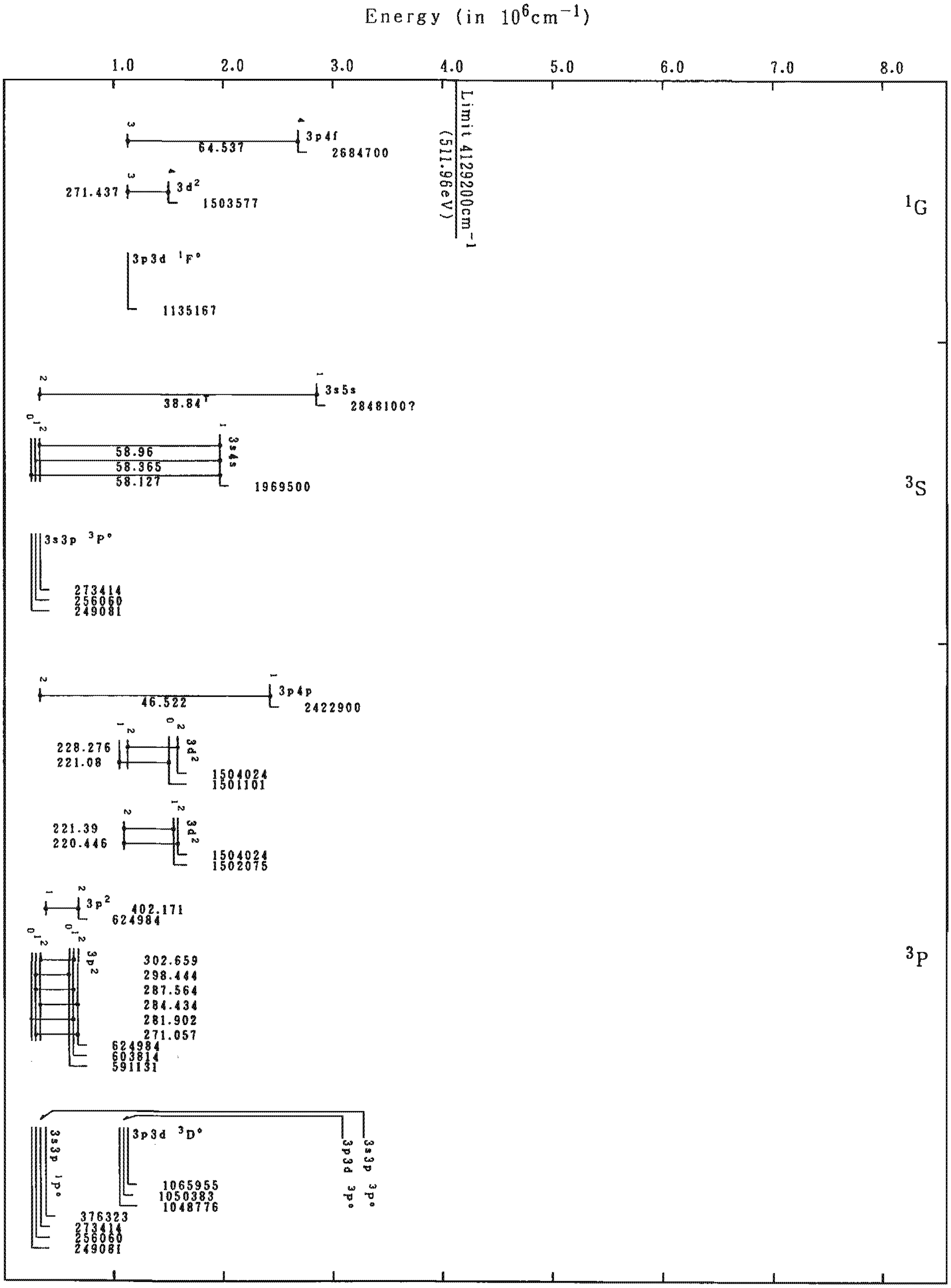

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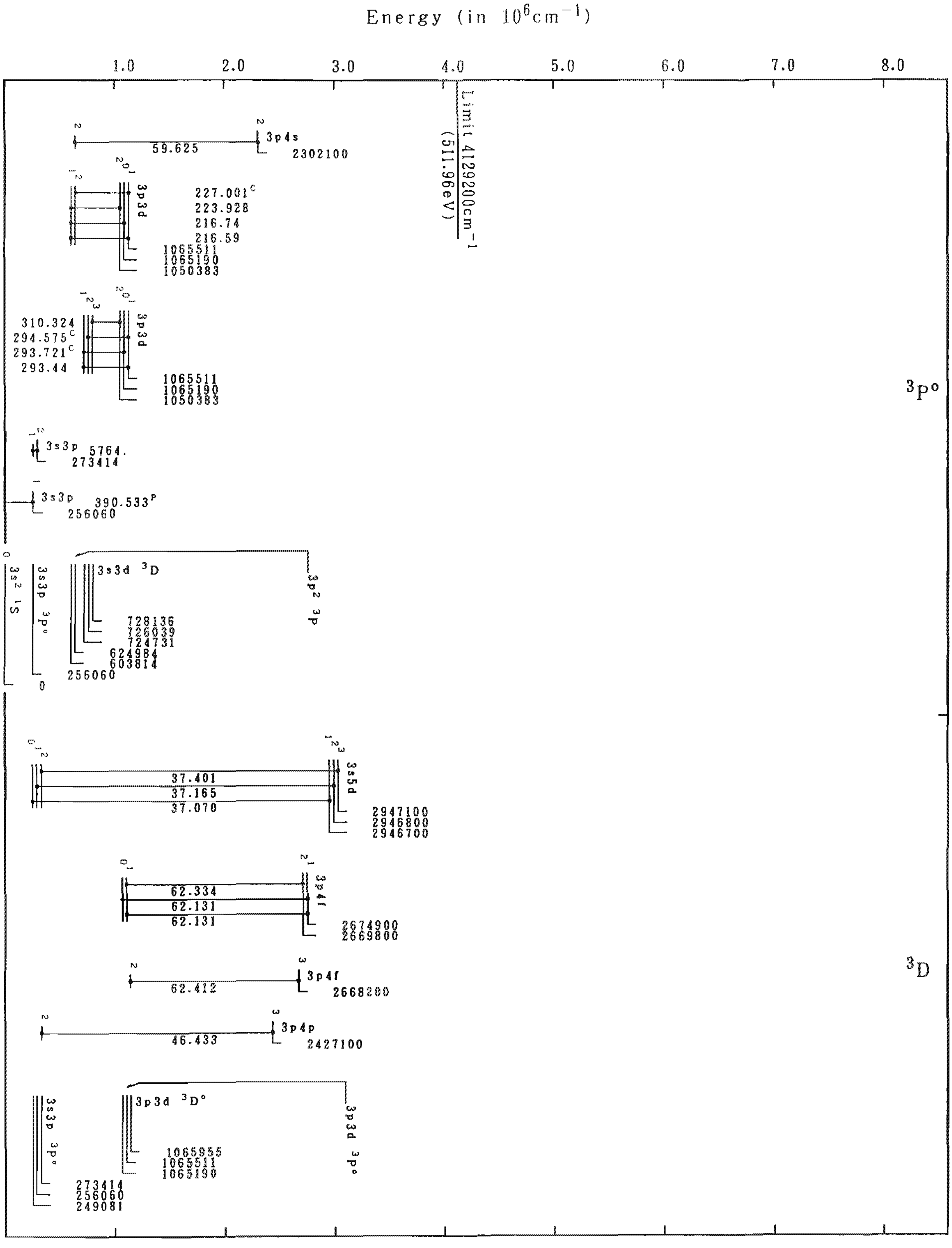

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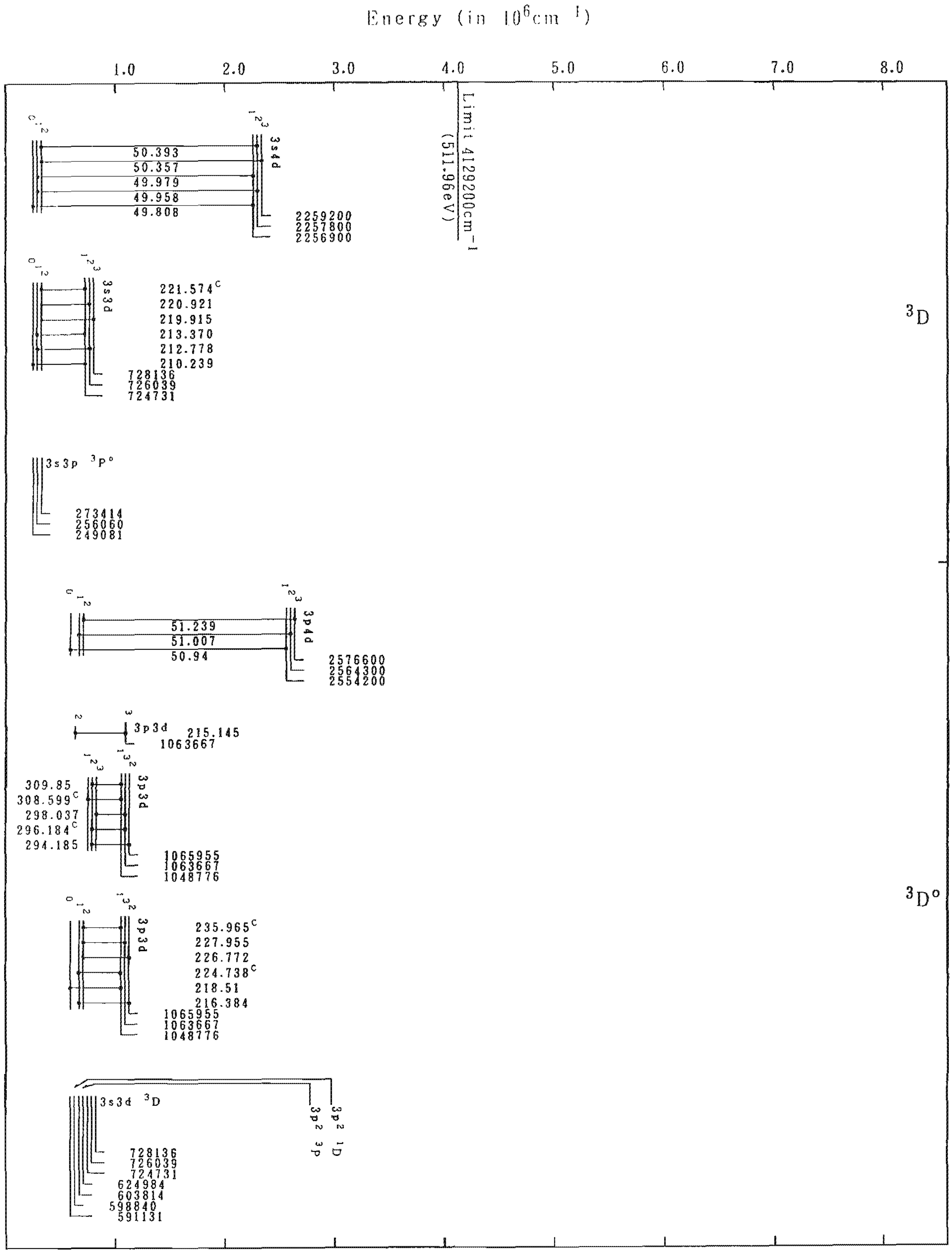

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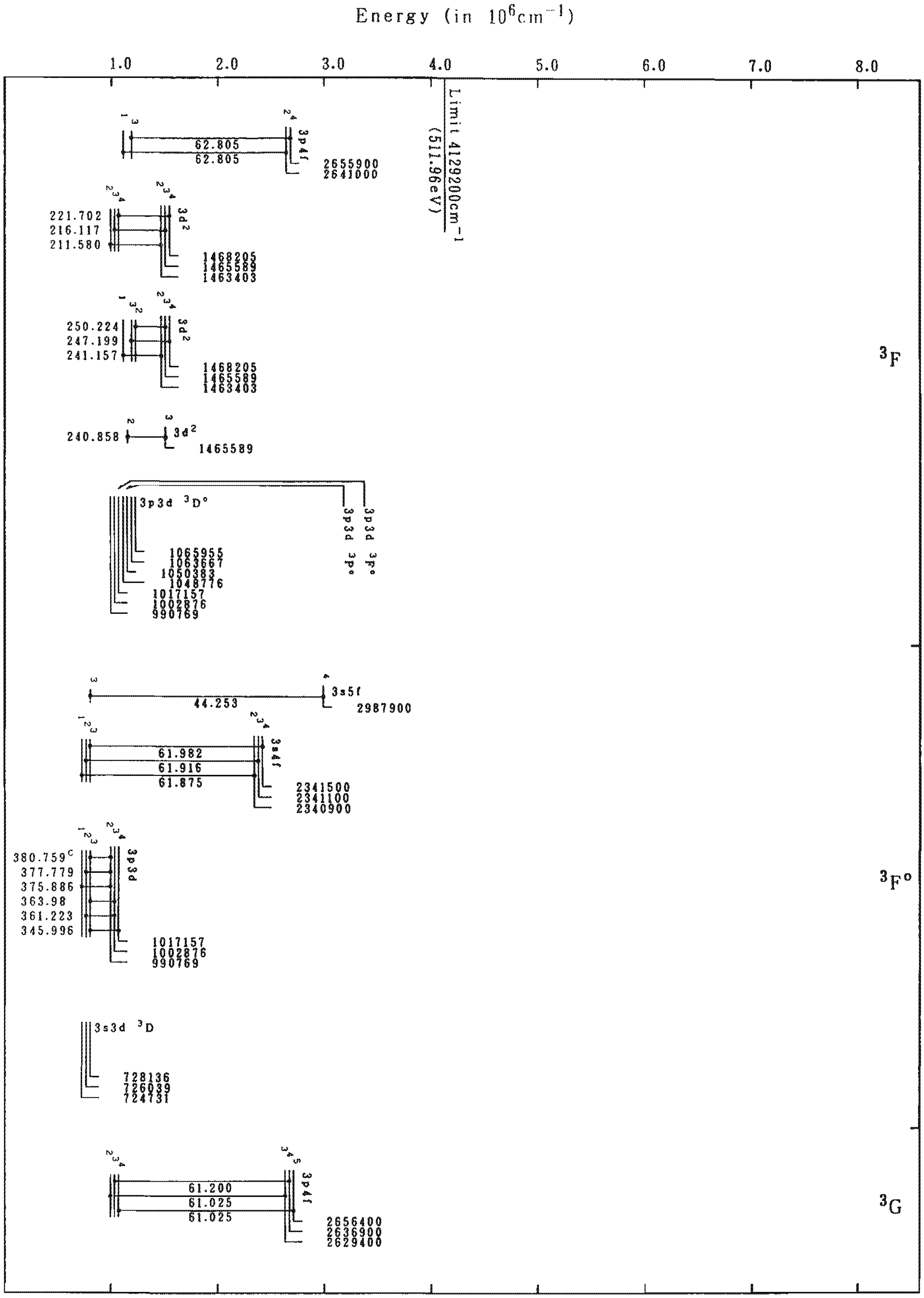

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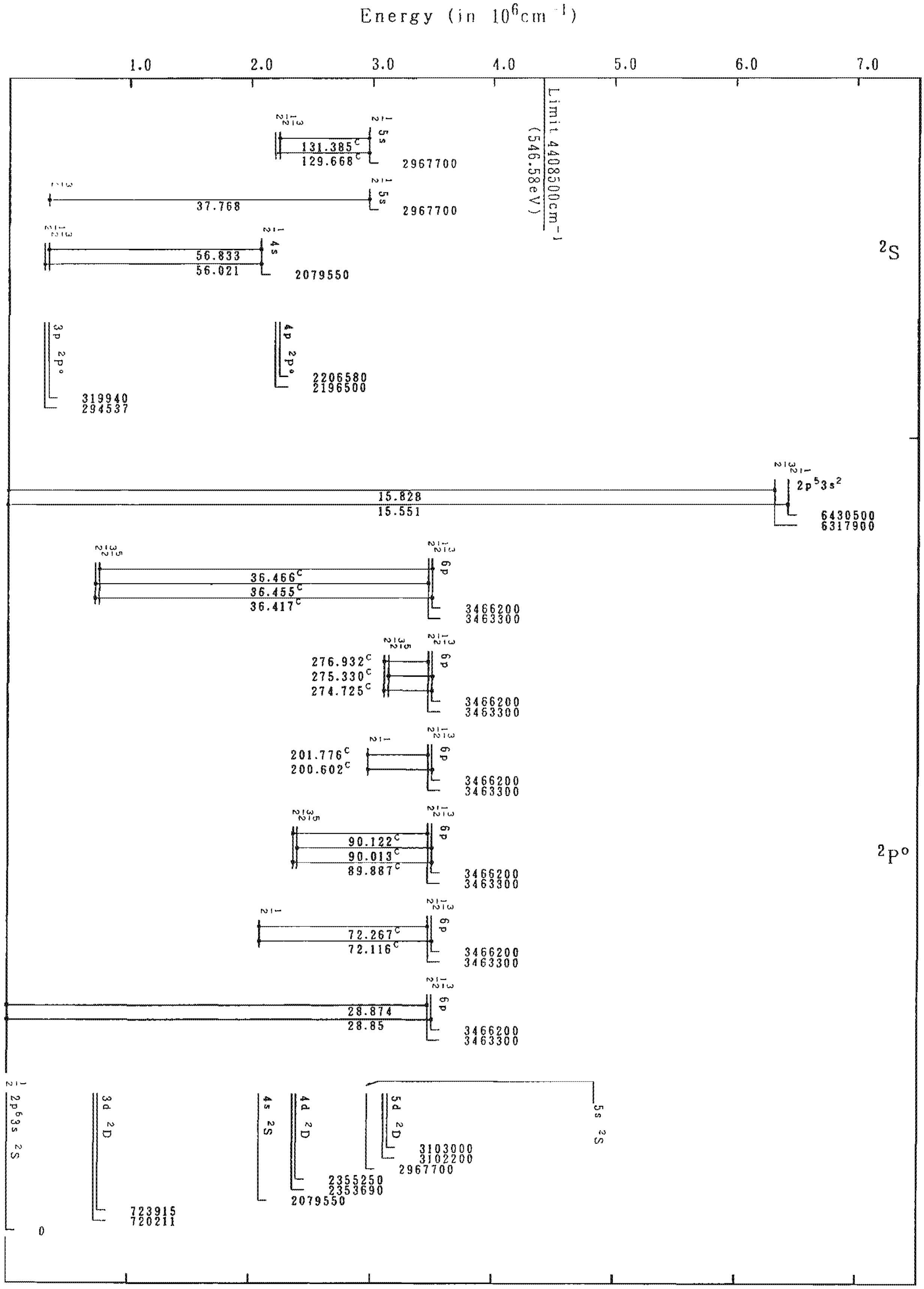

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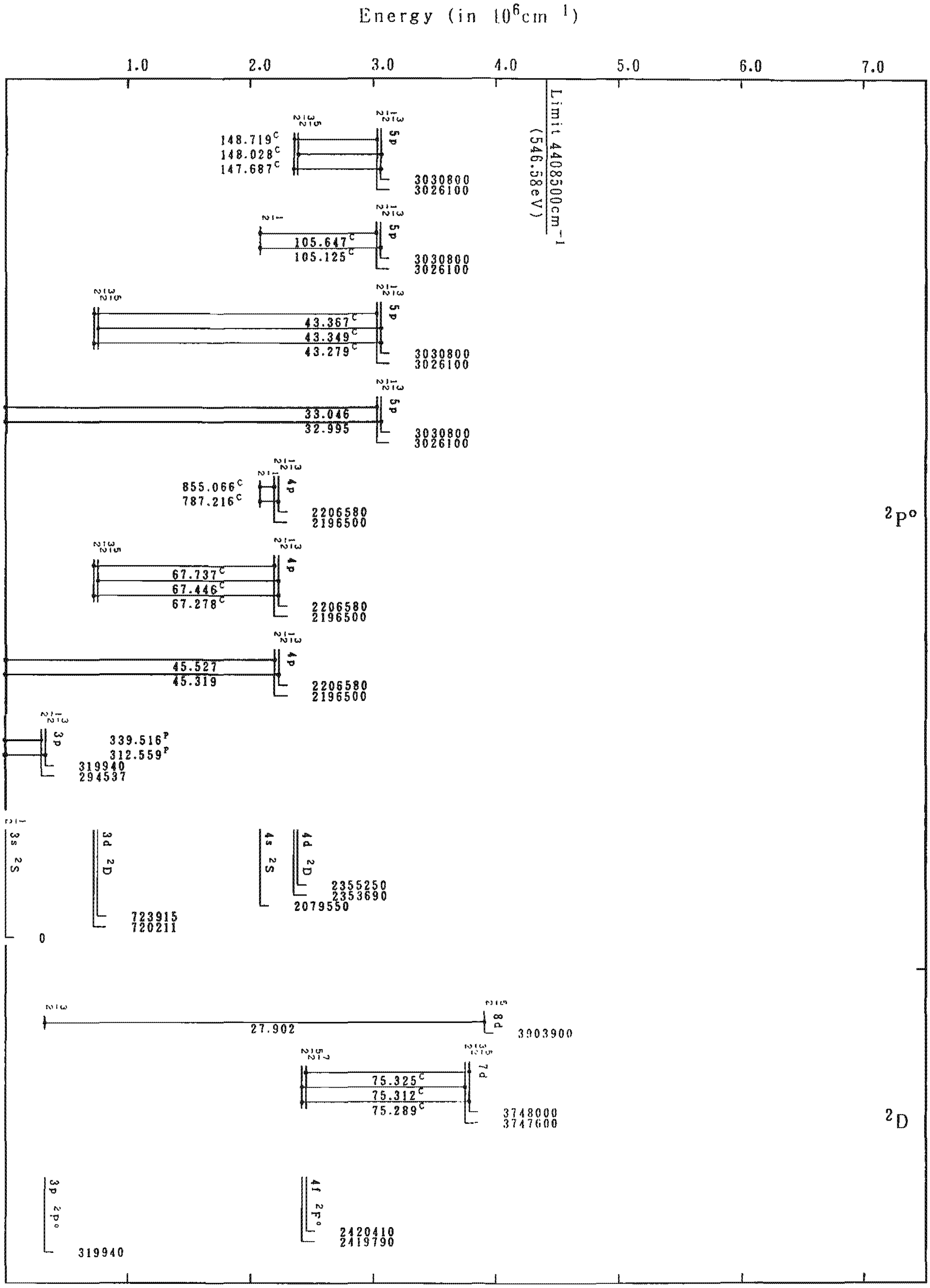

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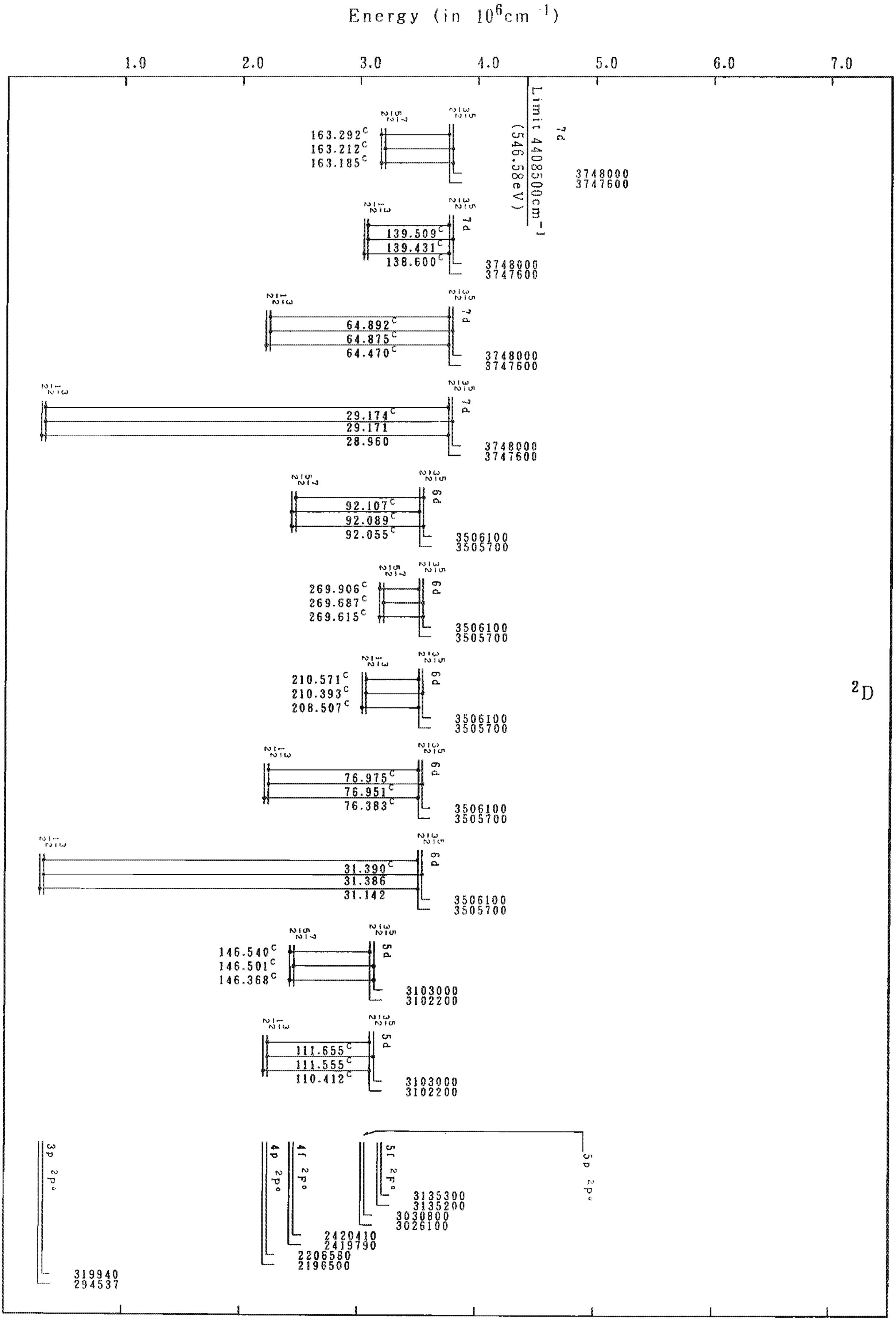

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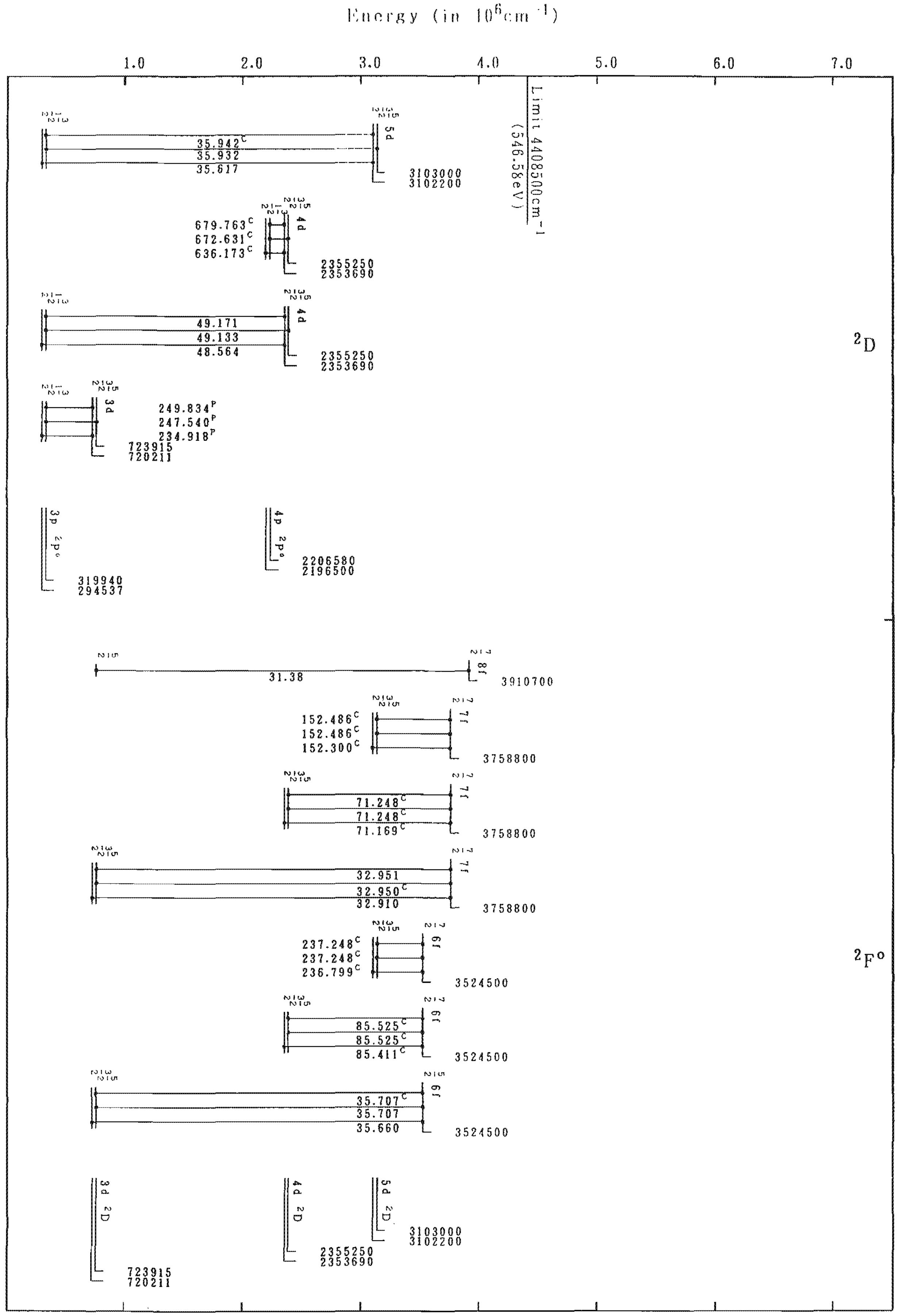

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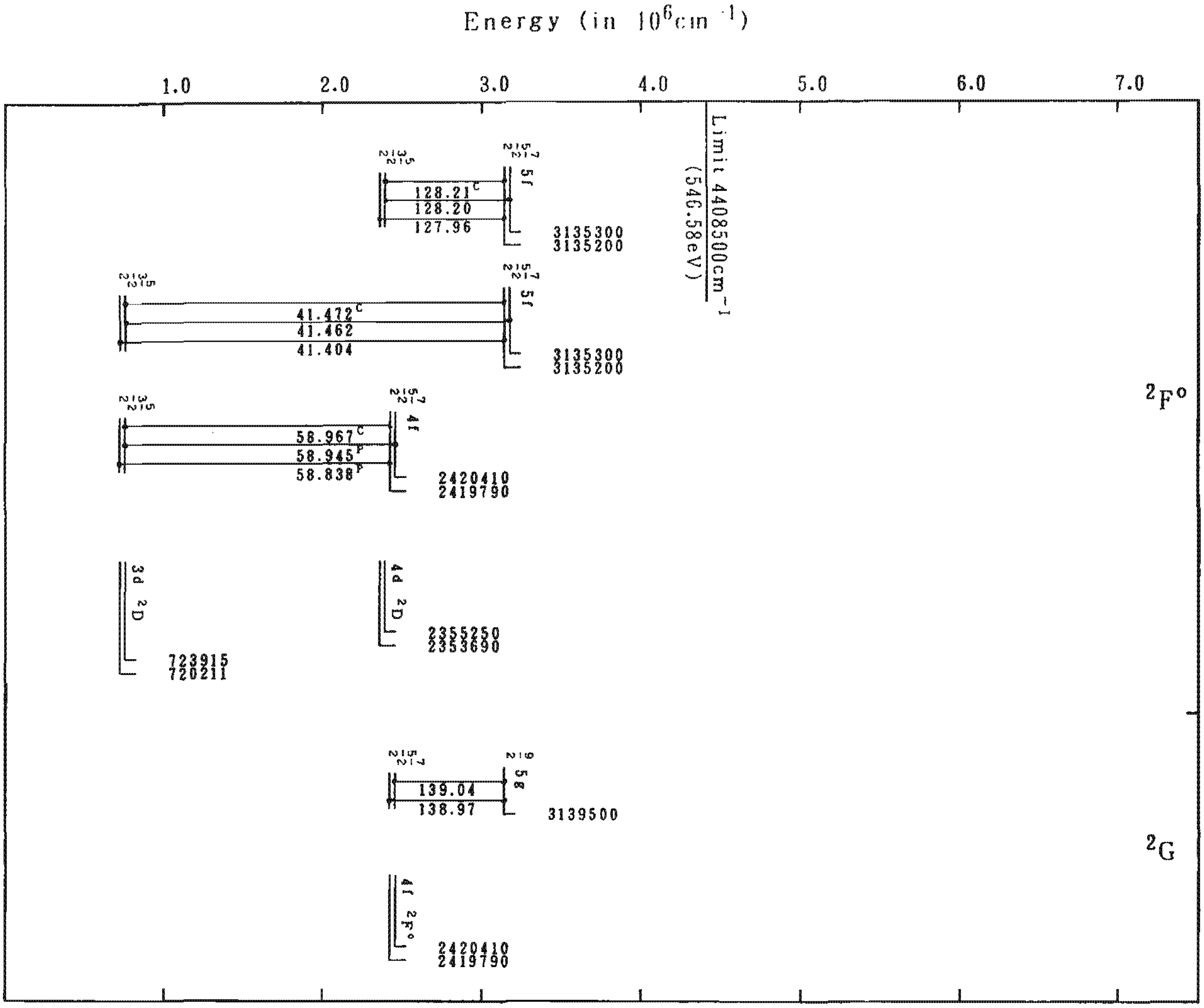

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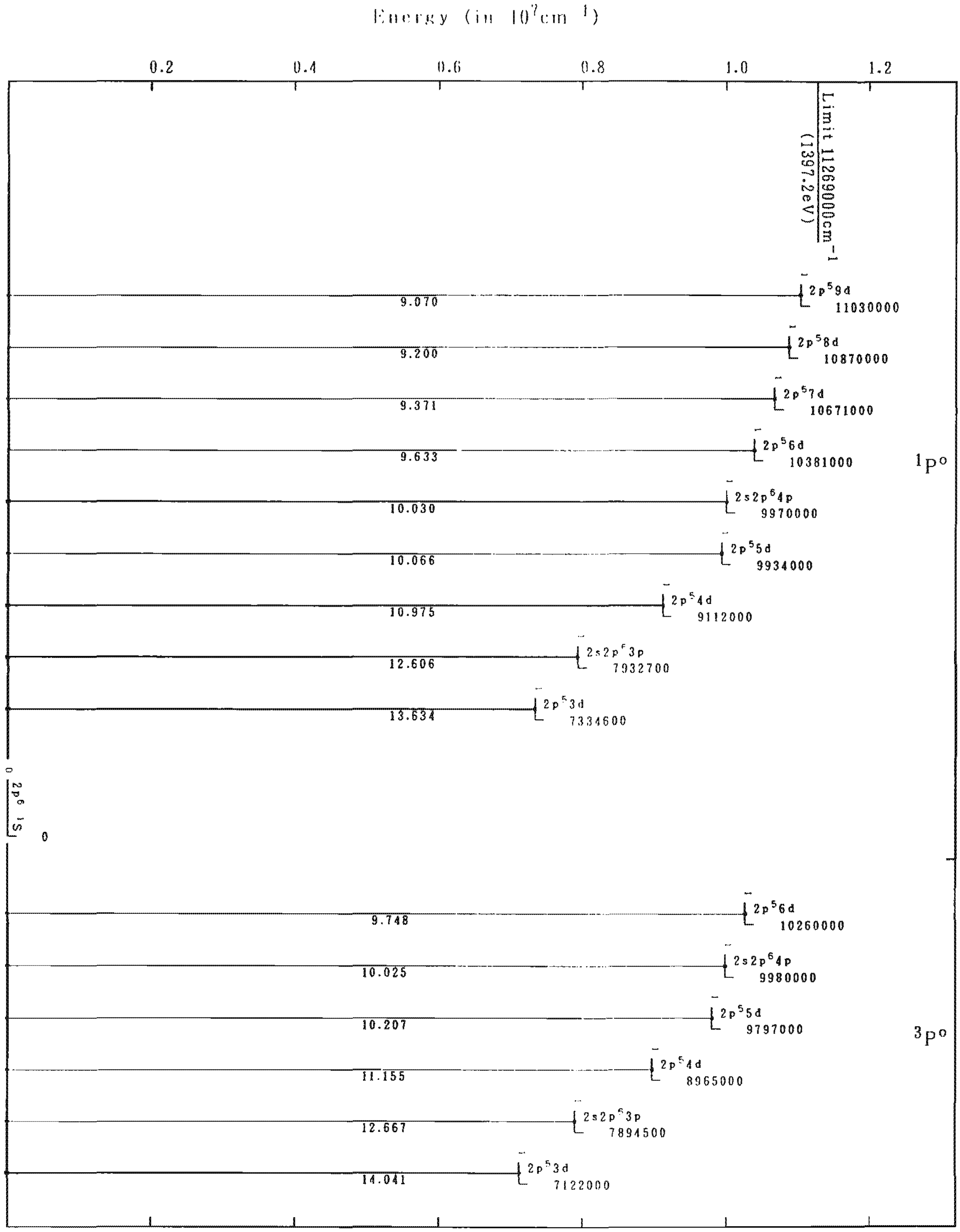

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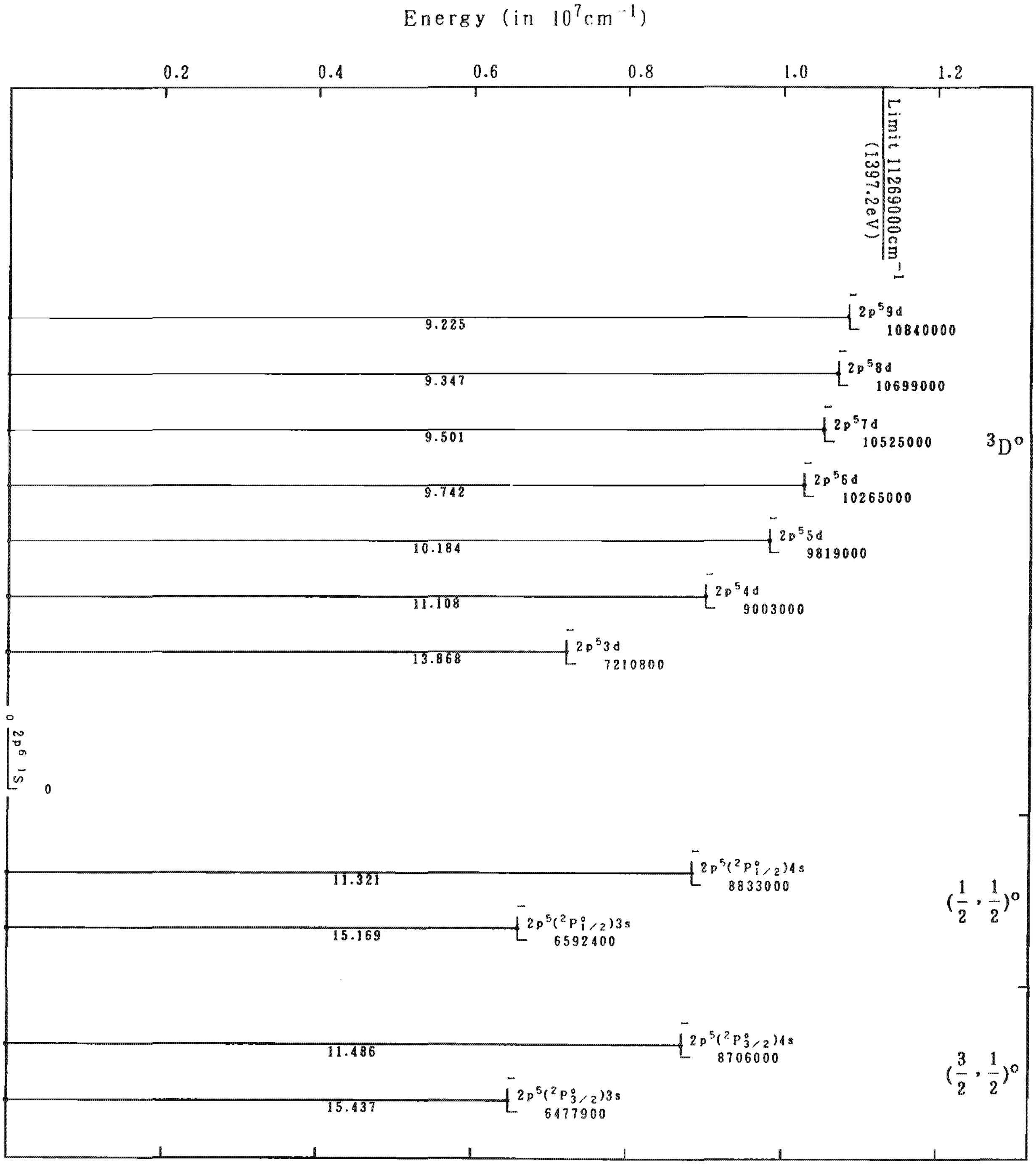

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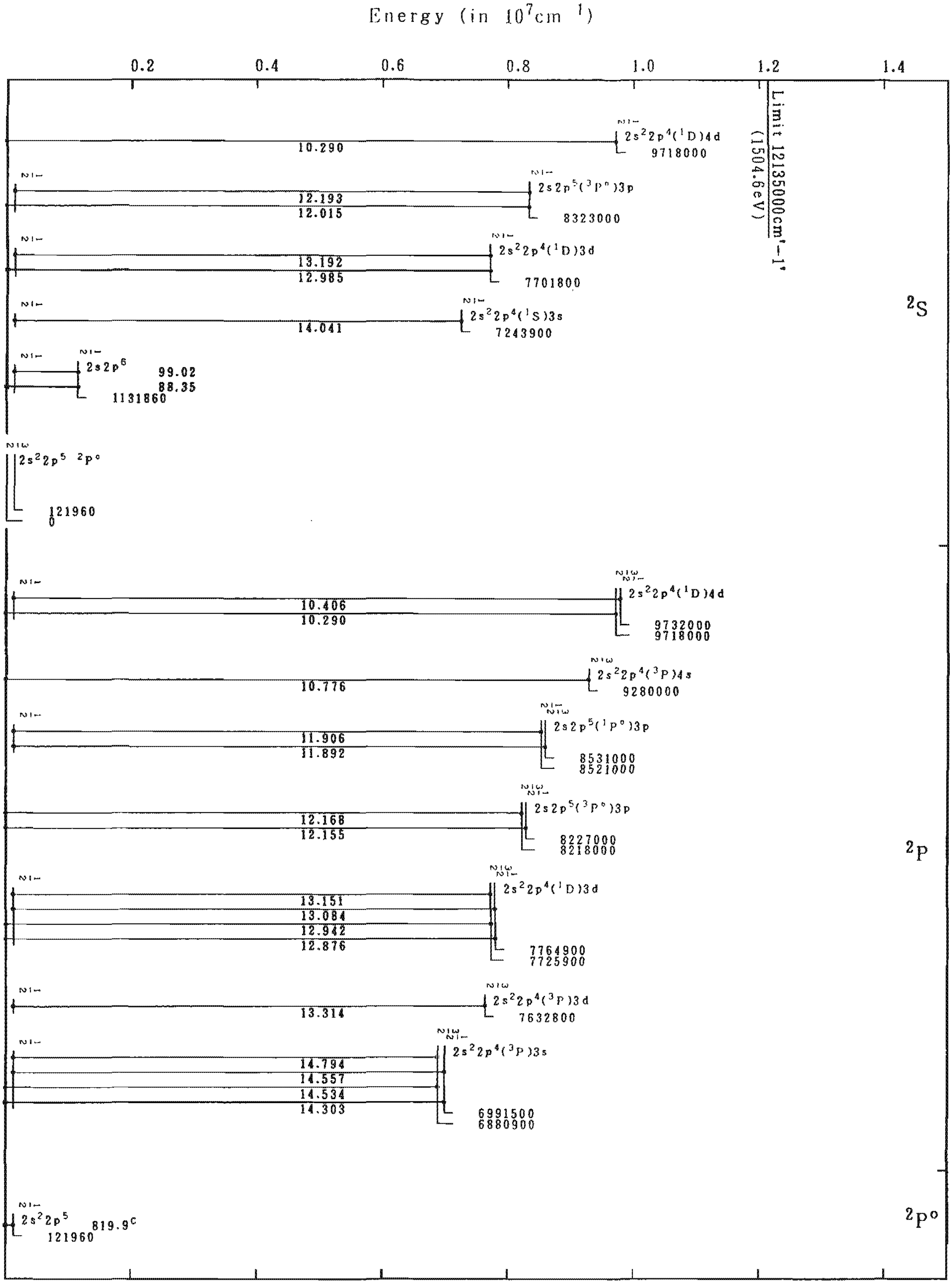

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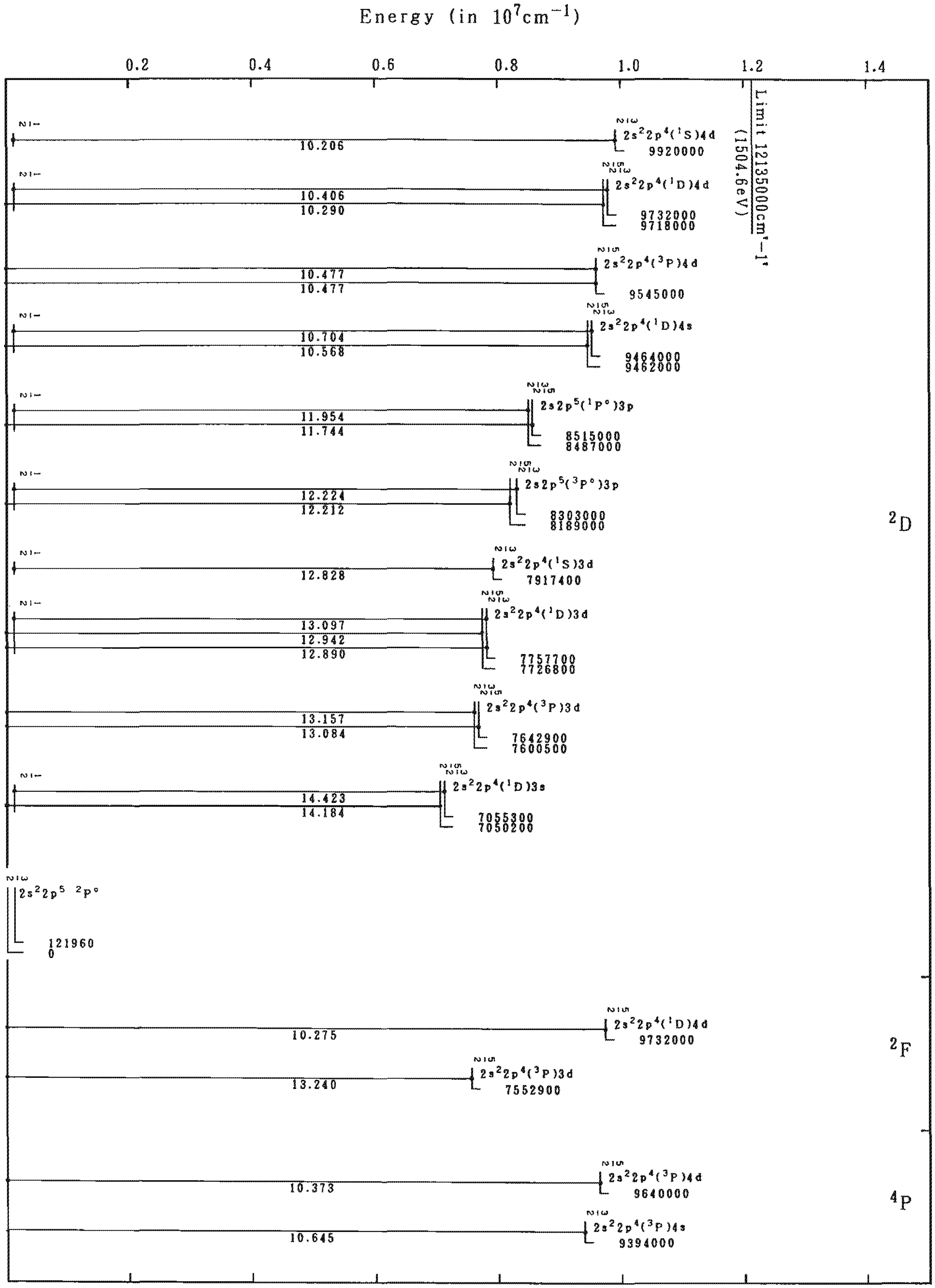

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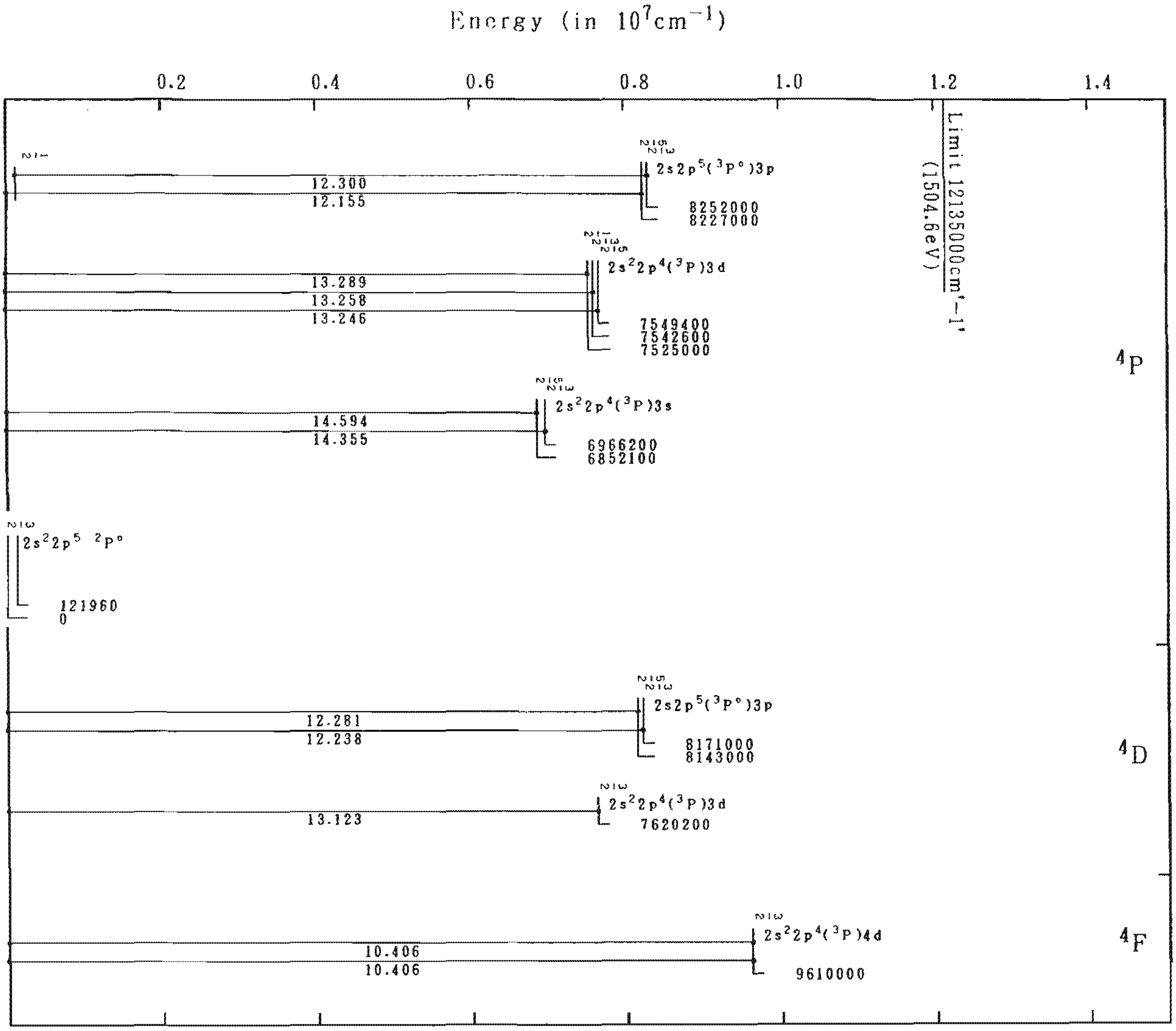

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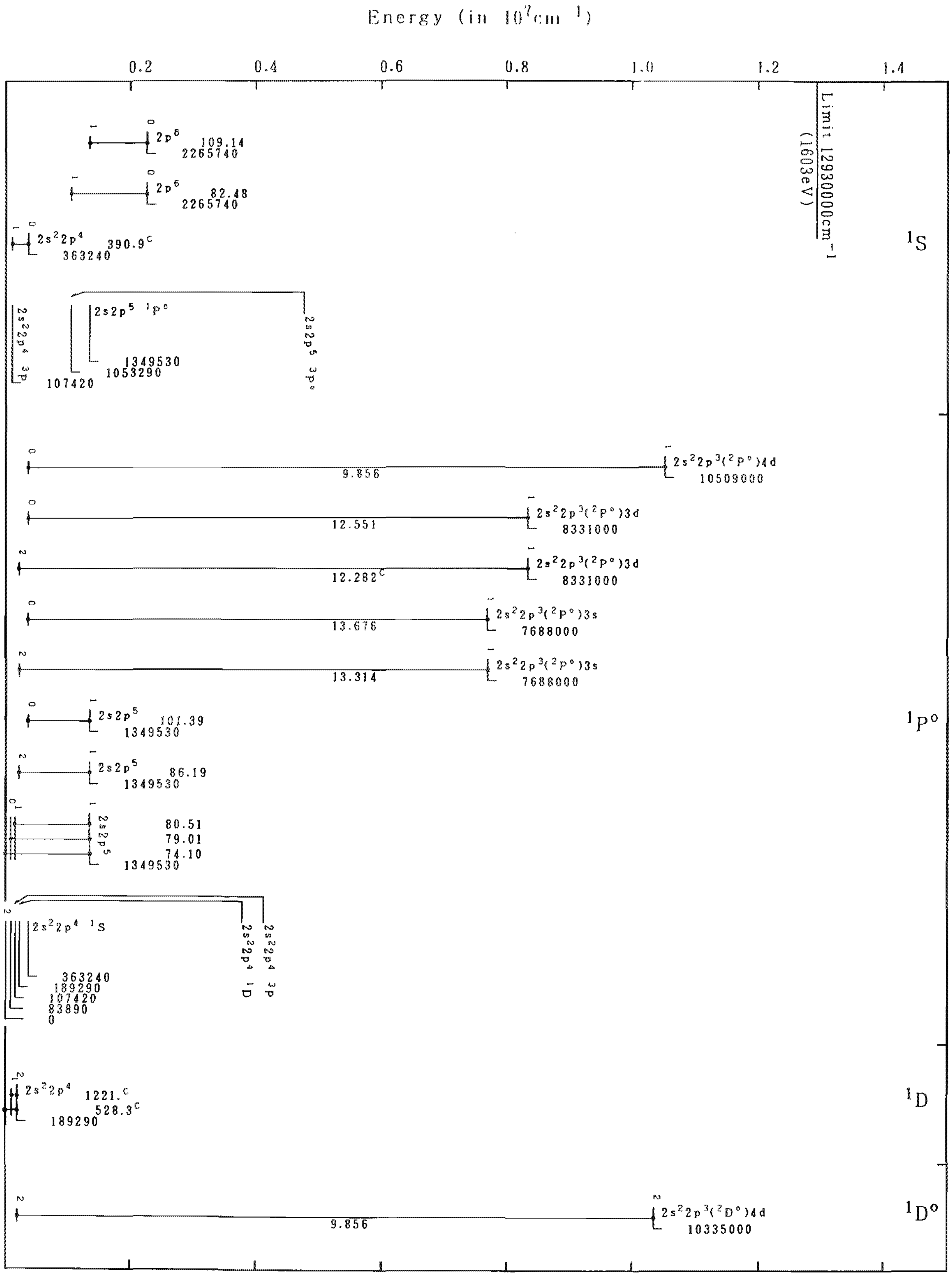

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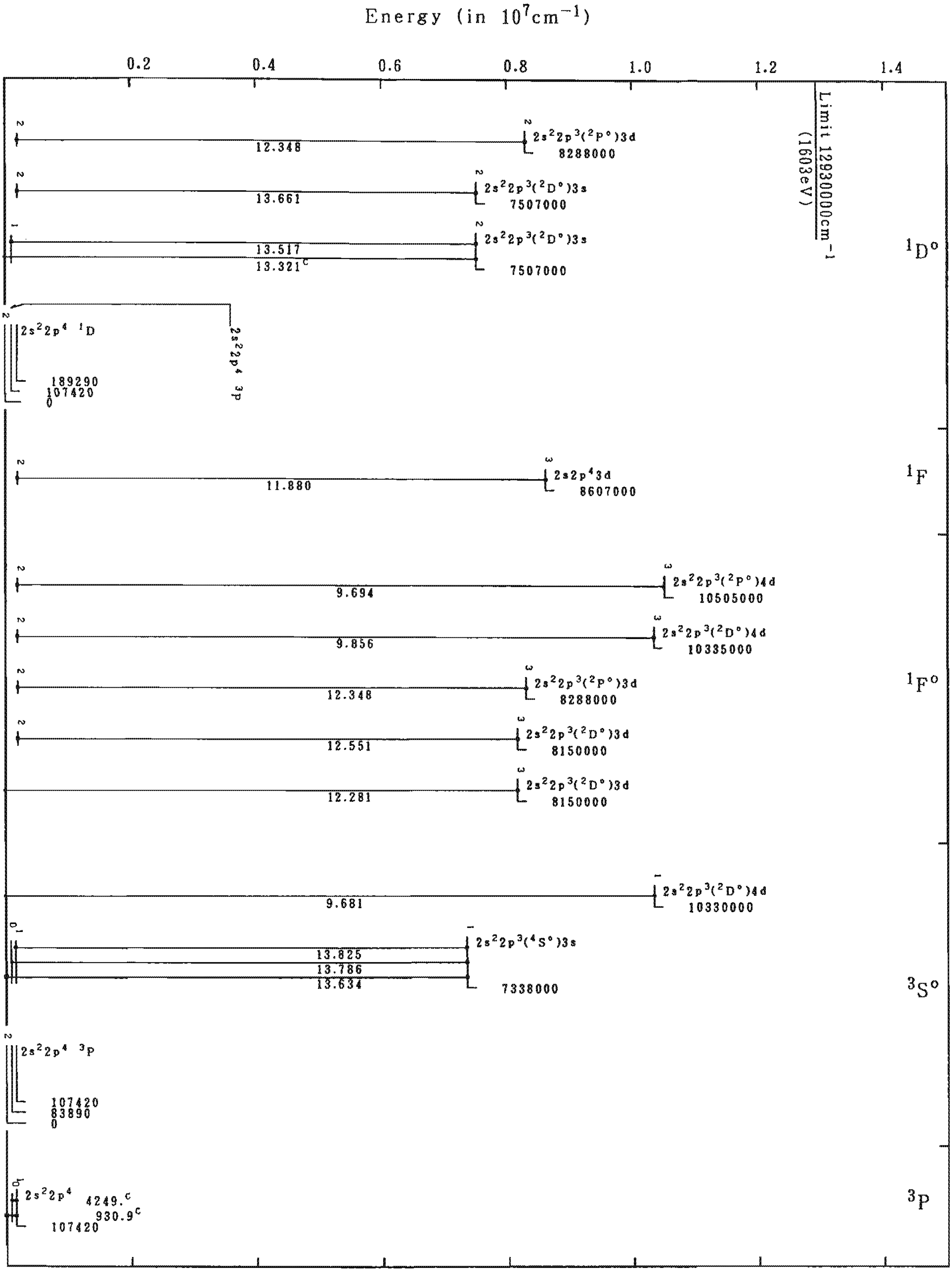

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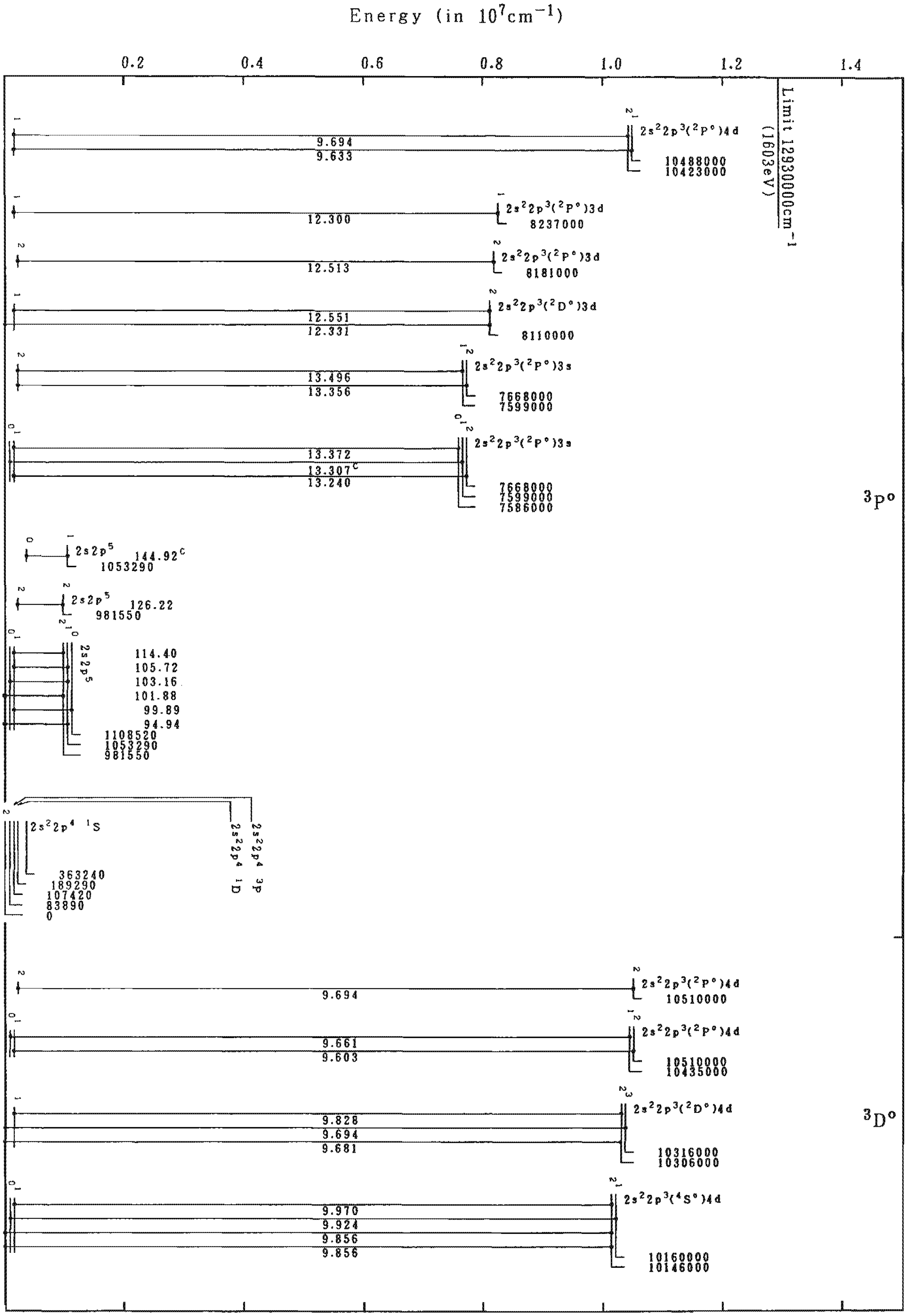

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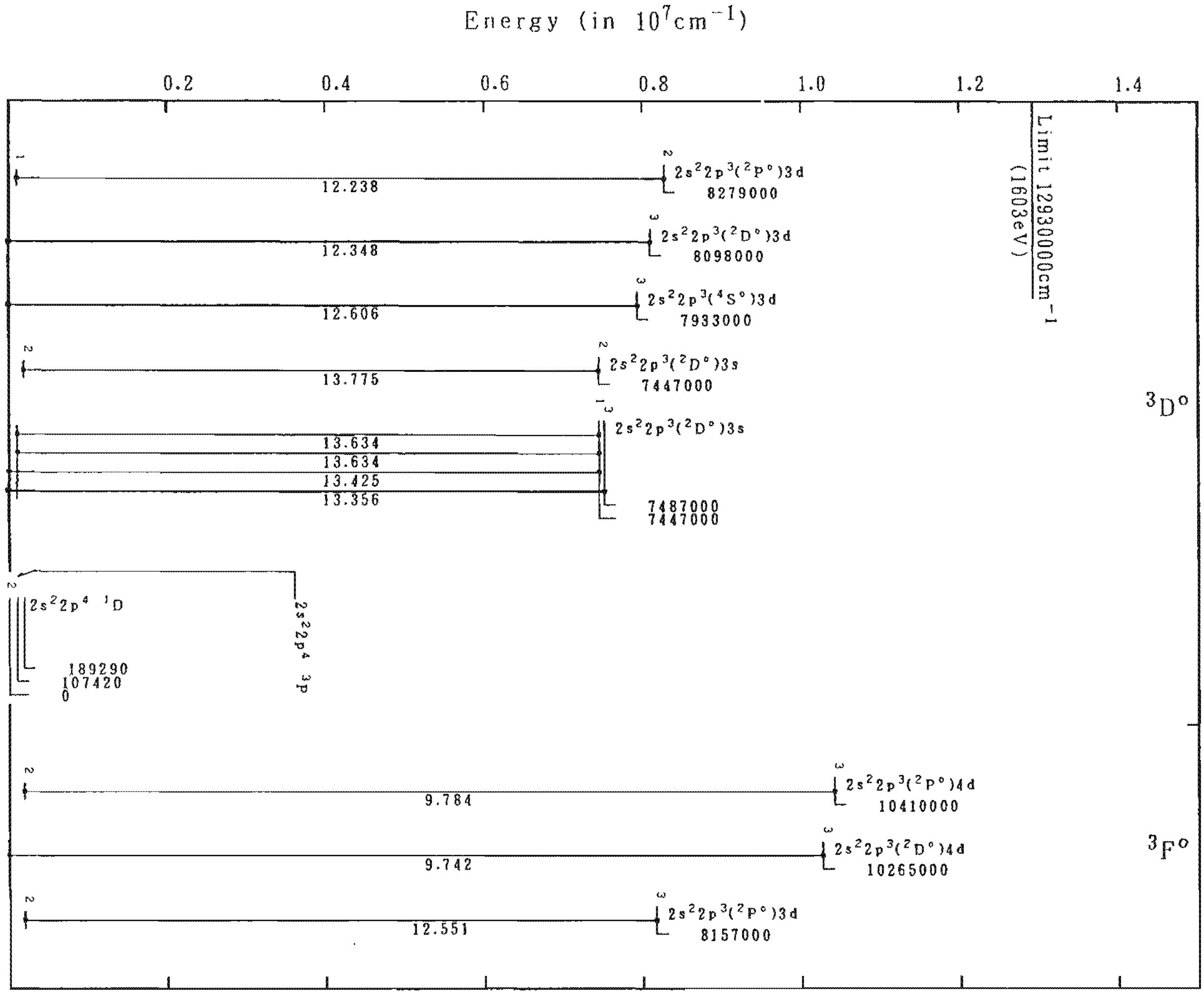

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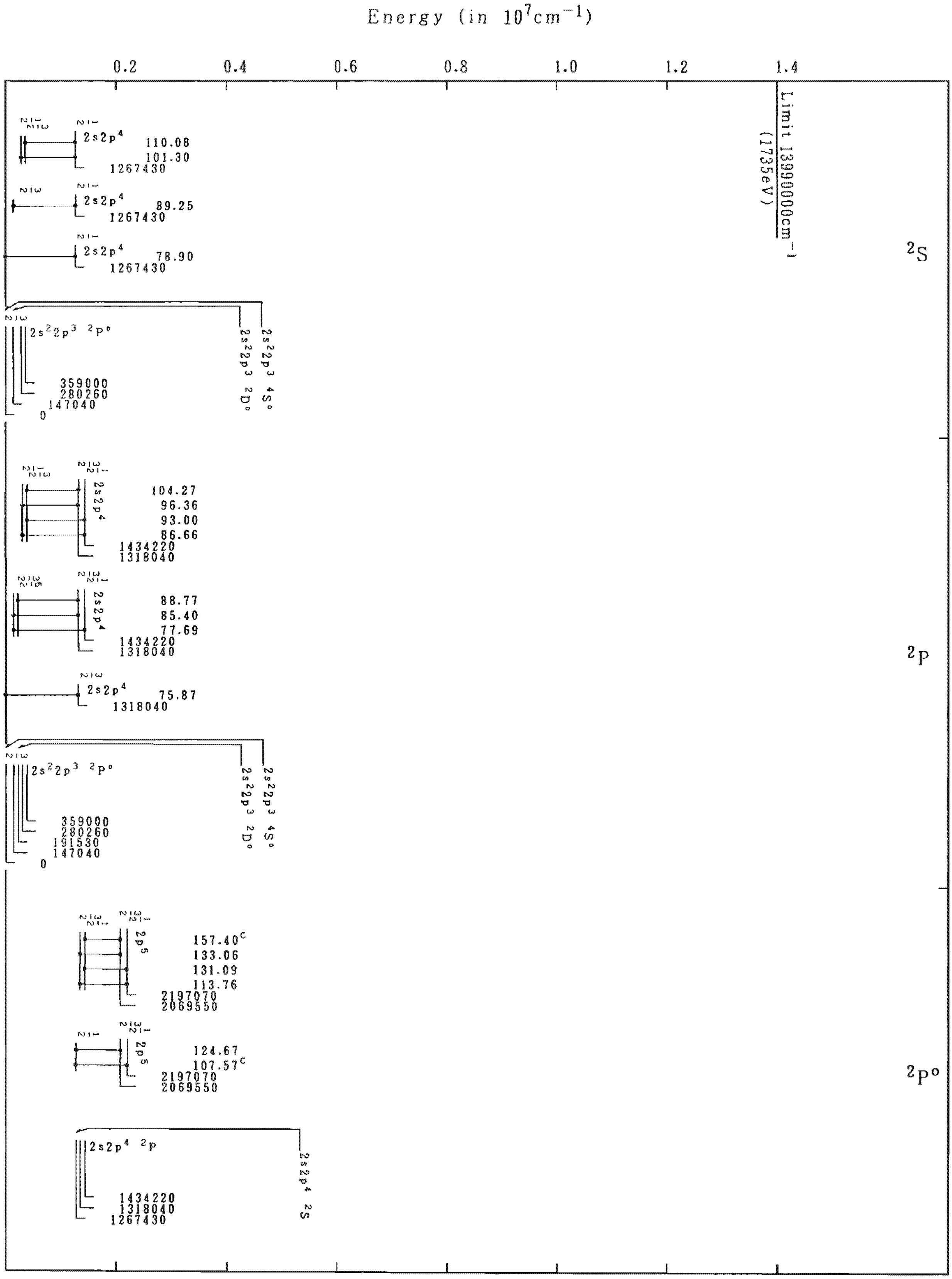
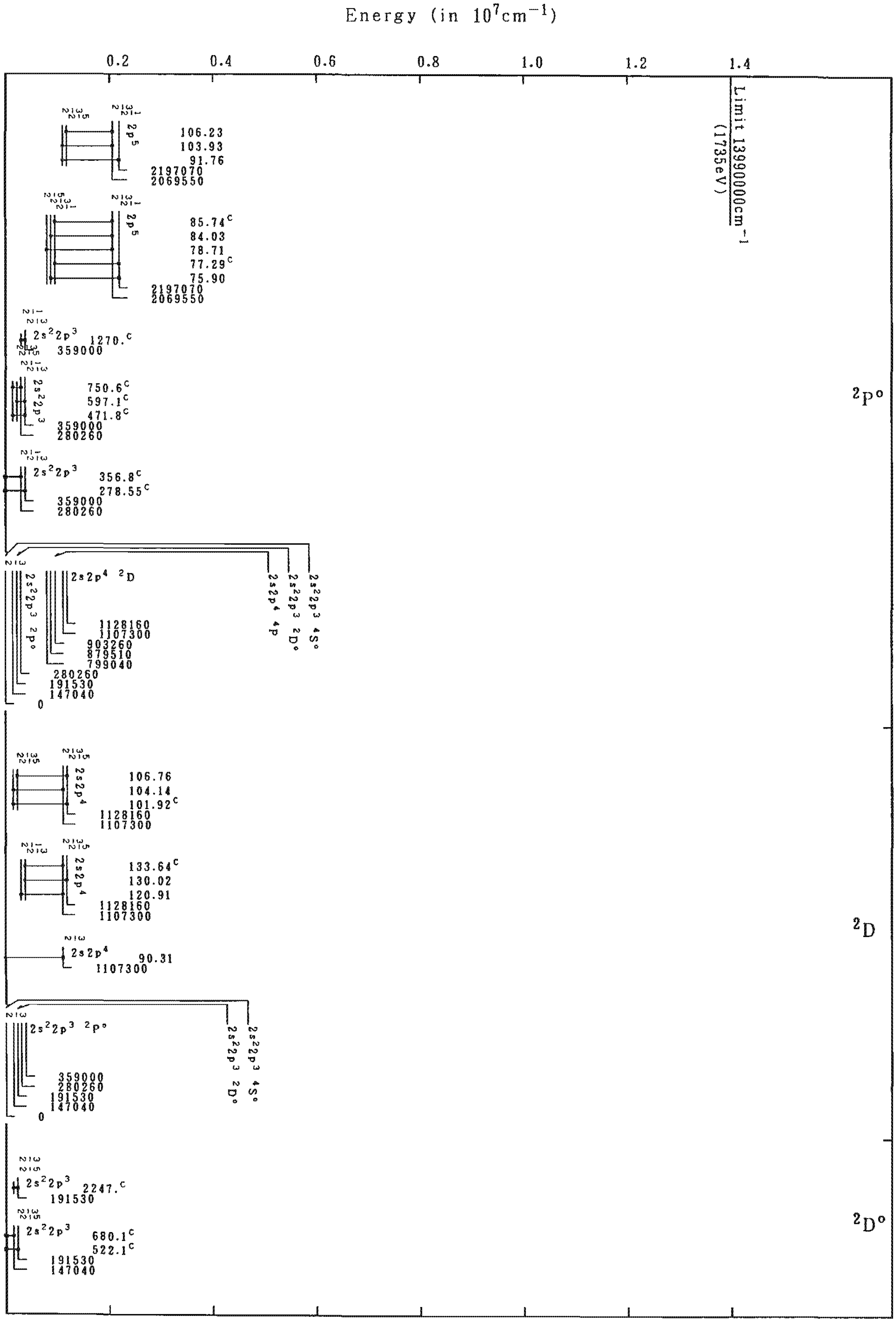


Co XXI (N–Sequence)



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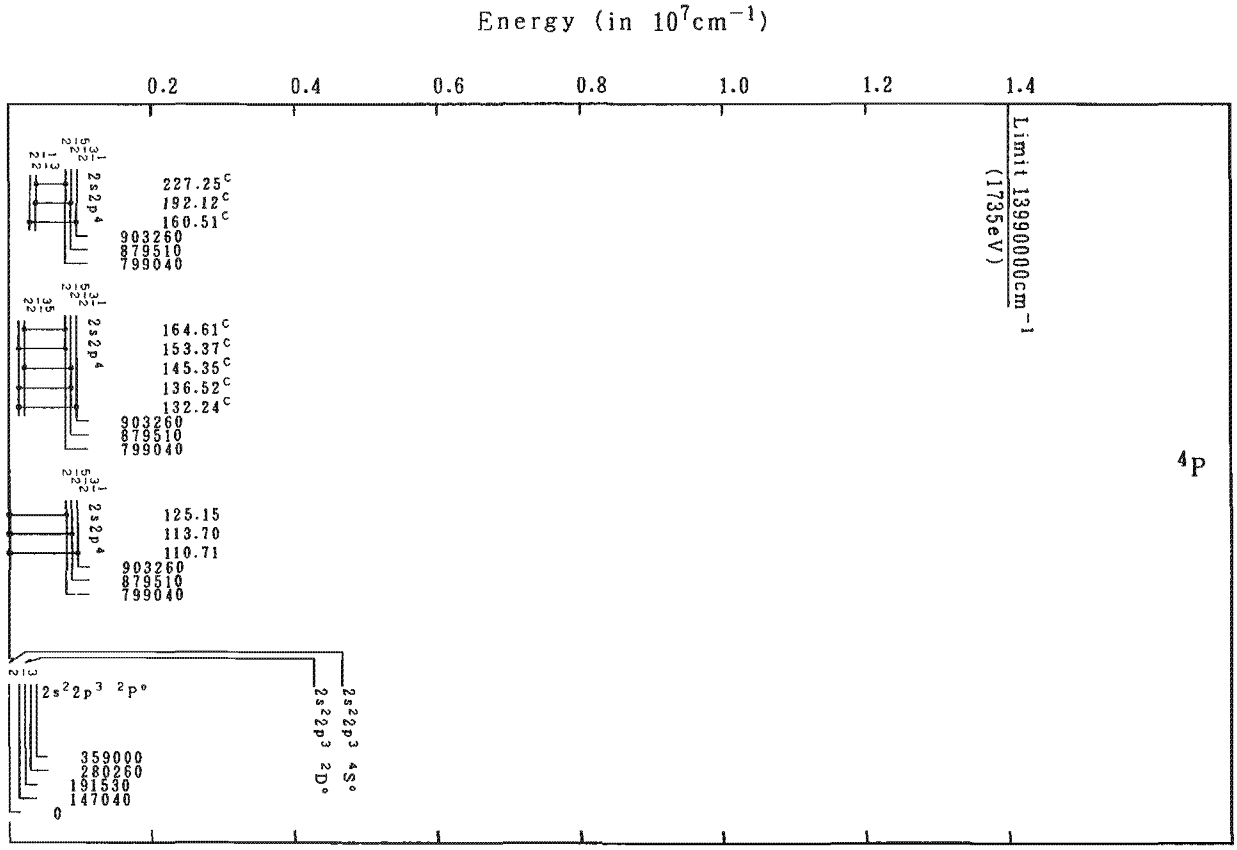

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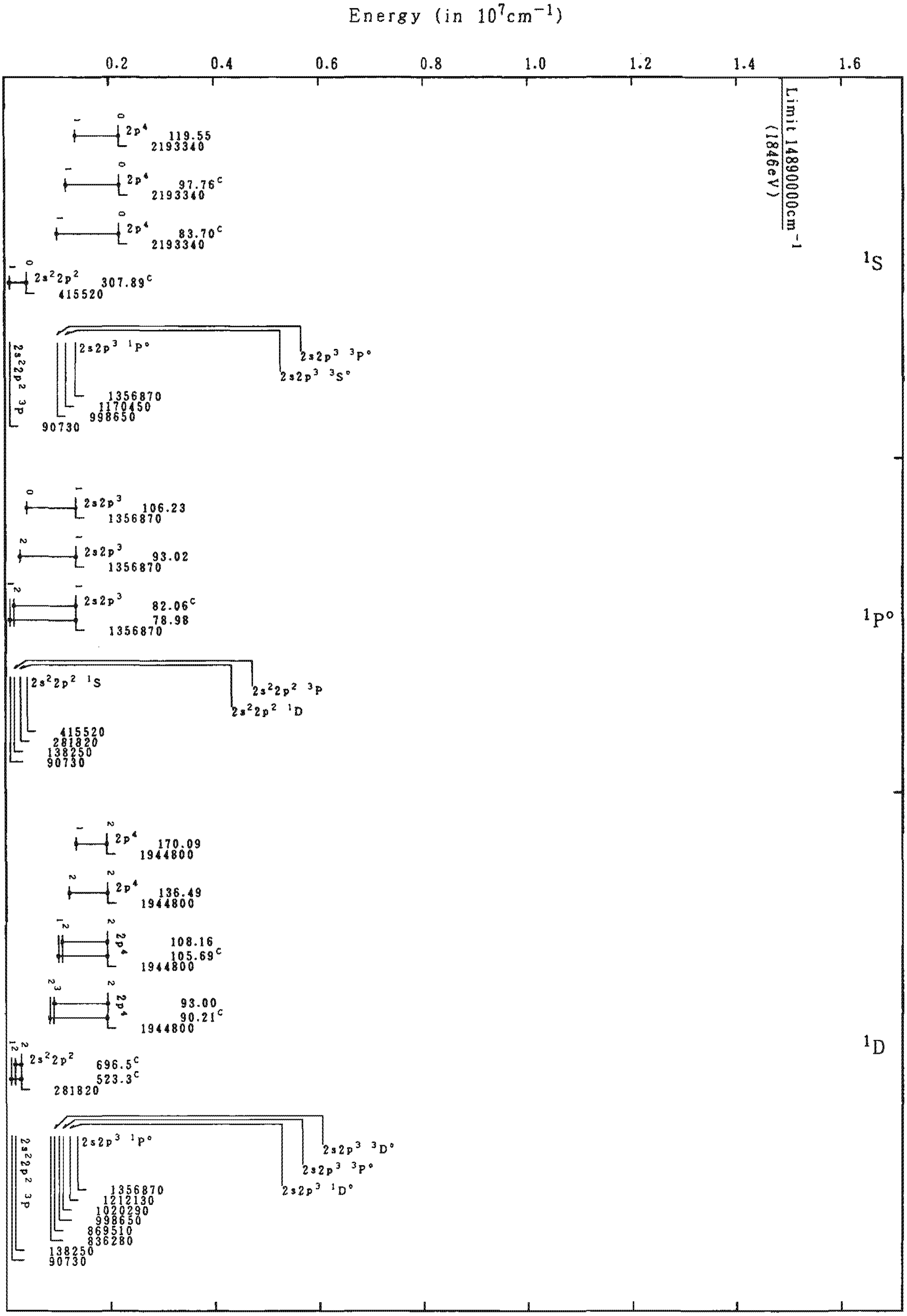

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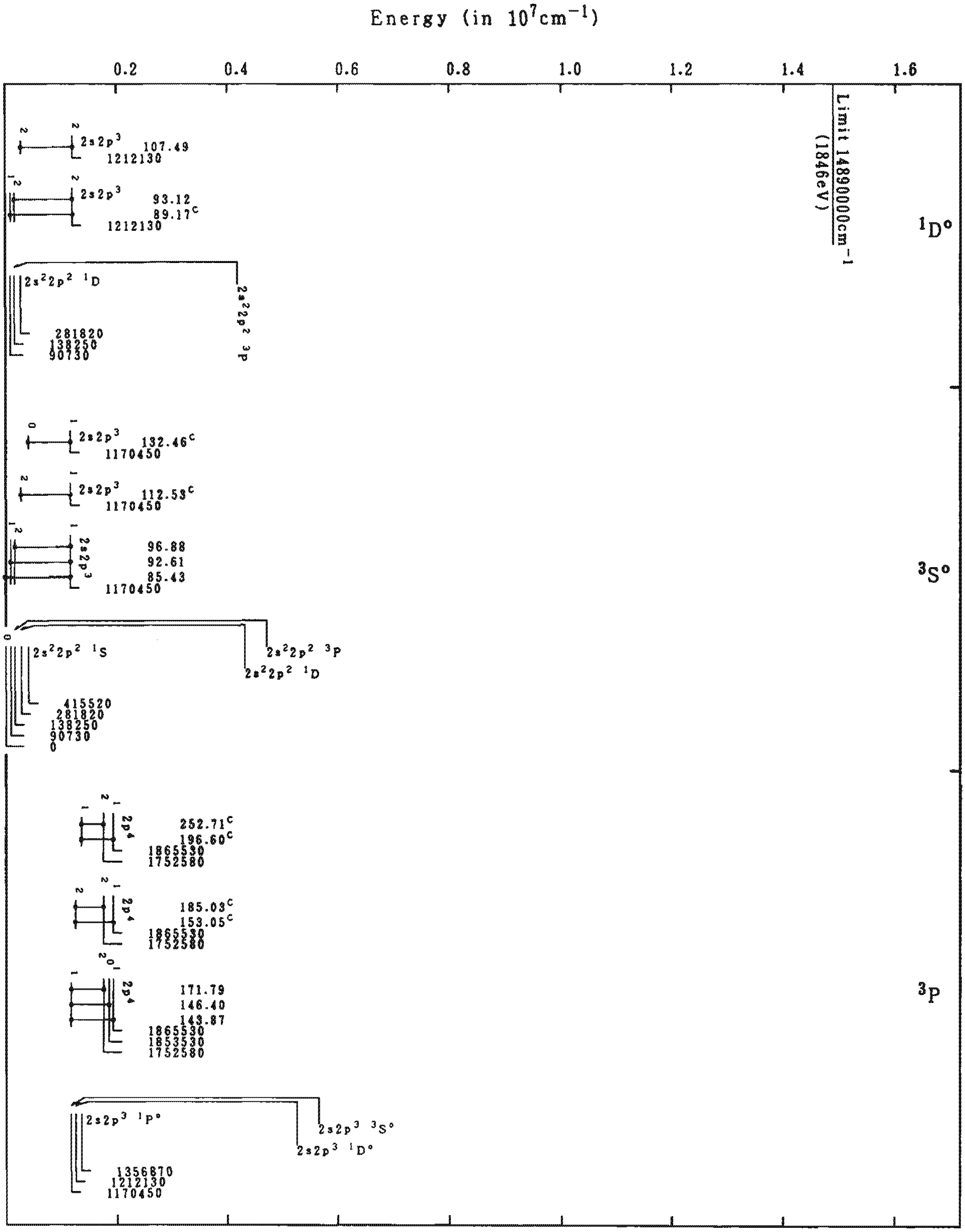

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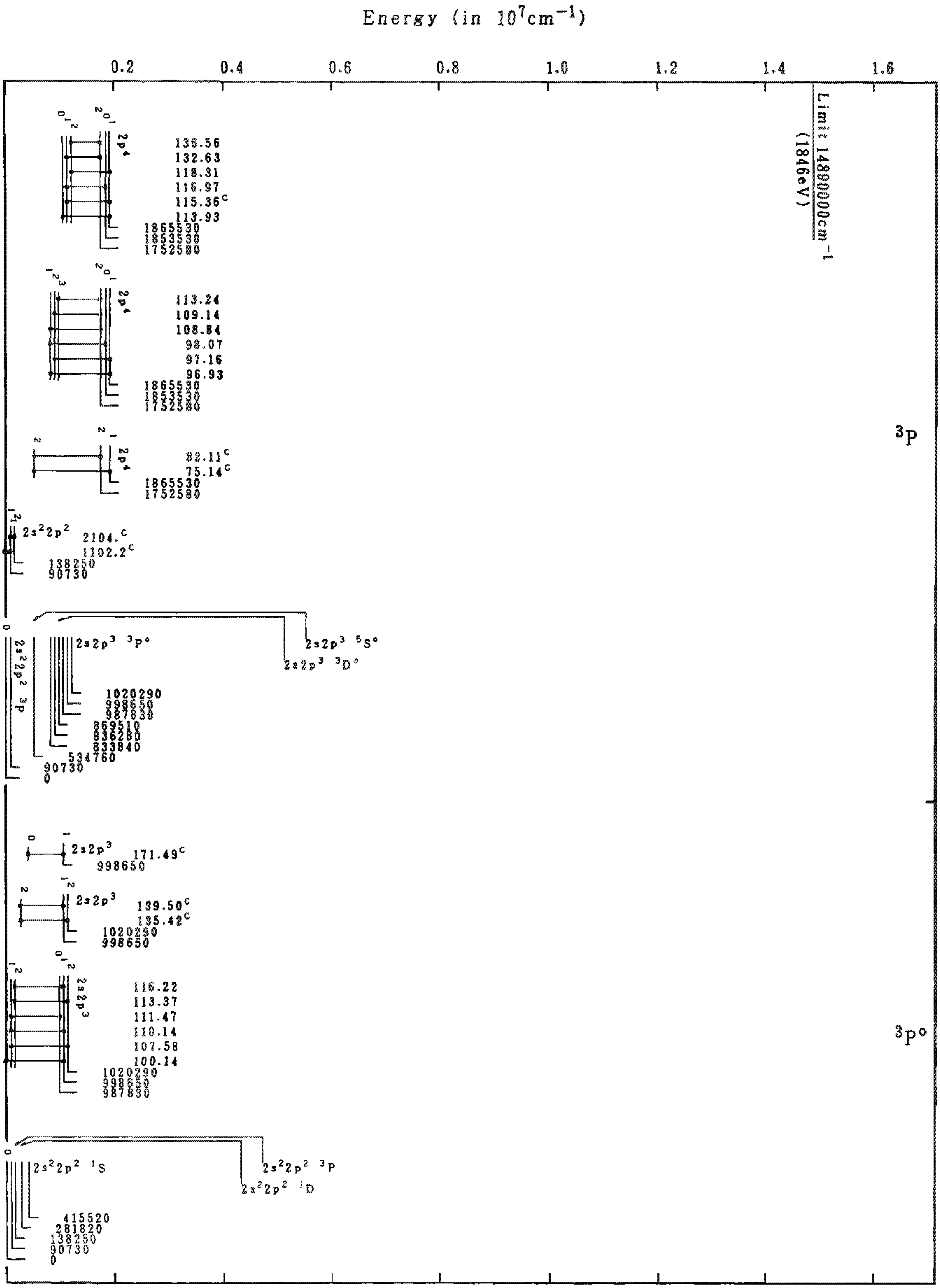

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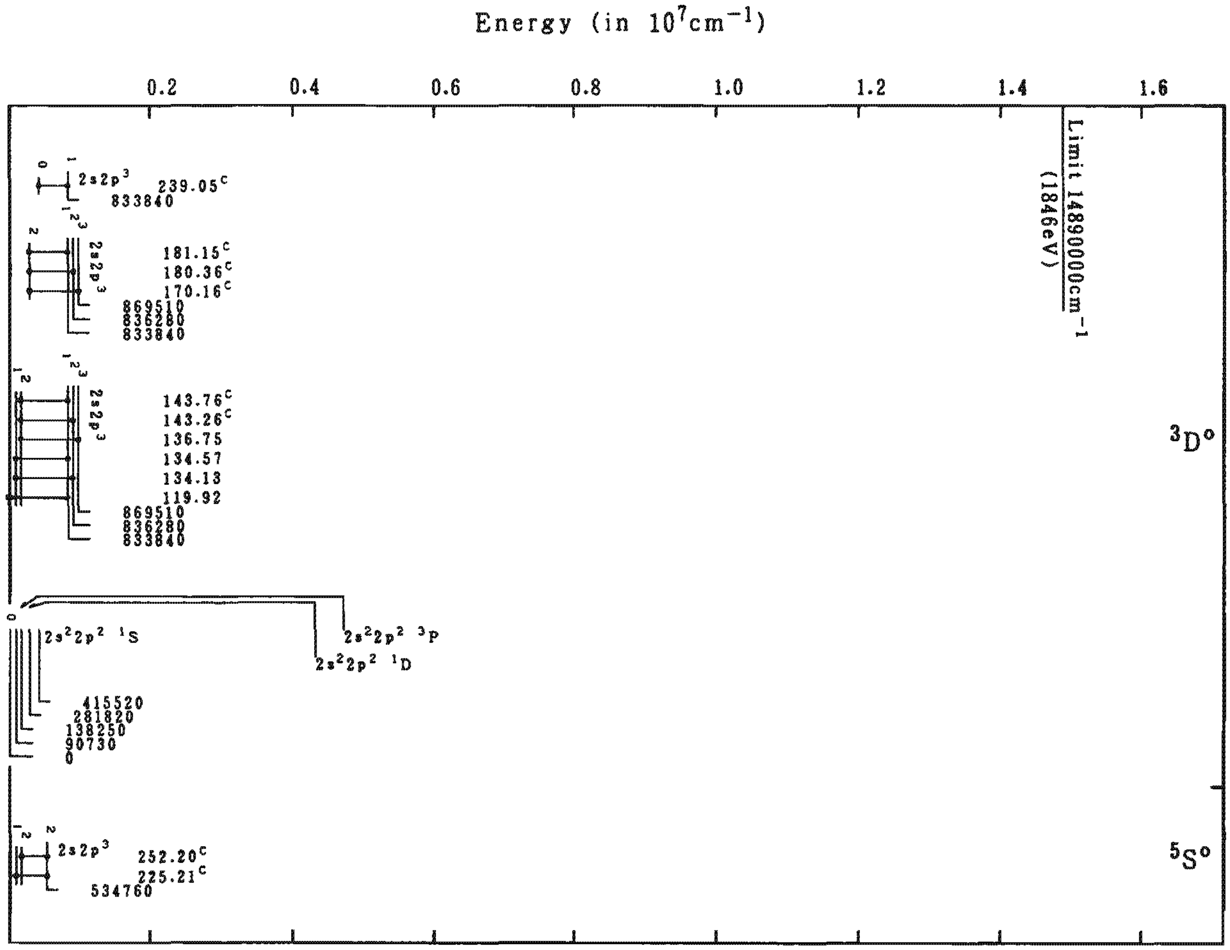

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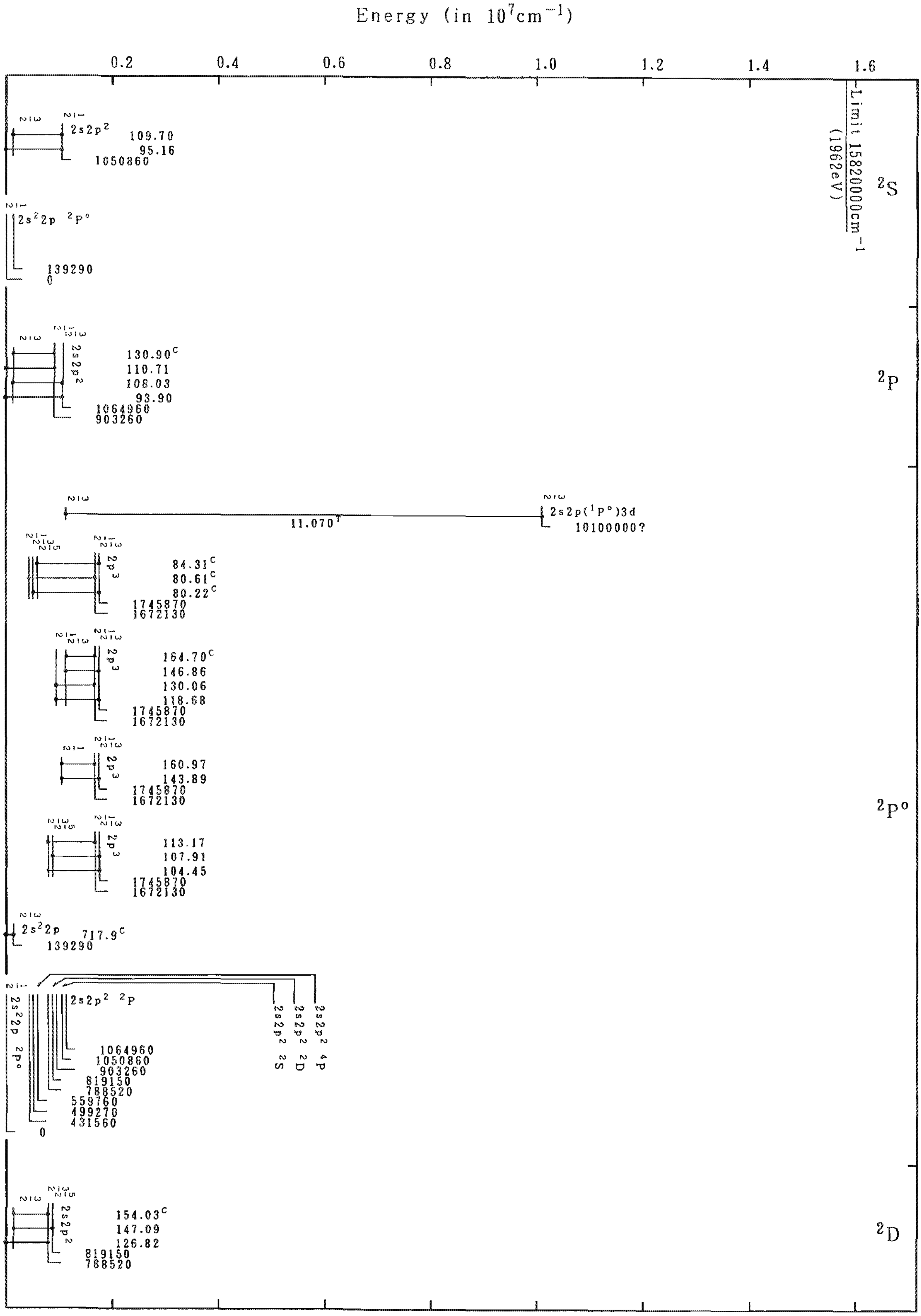

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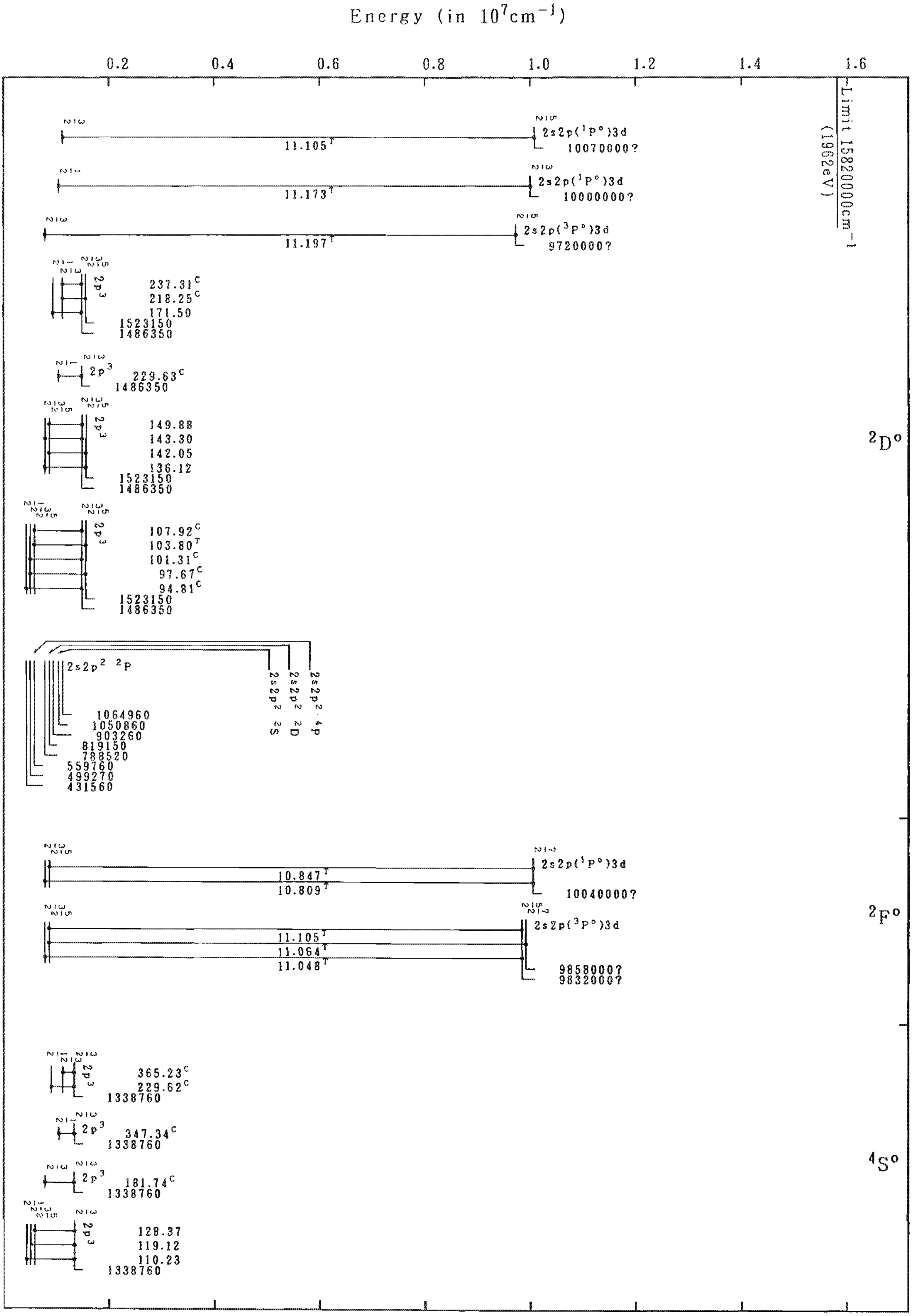

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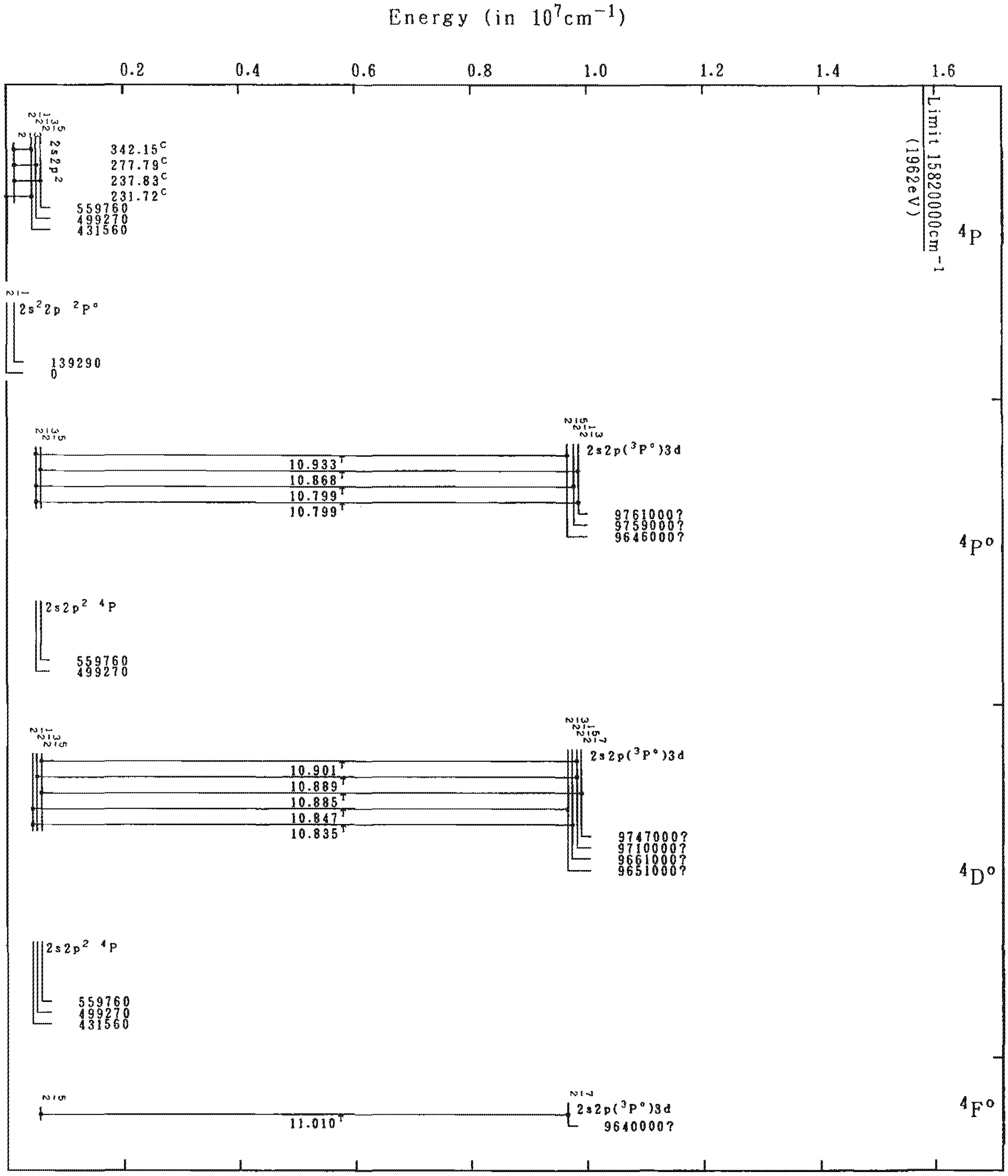

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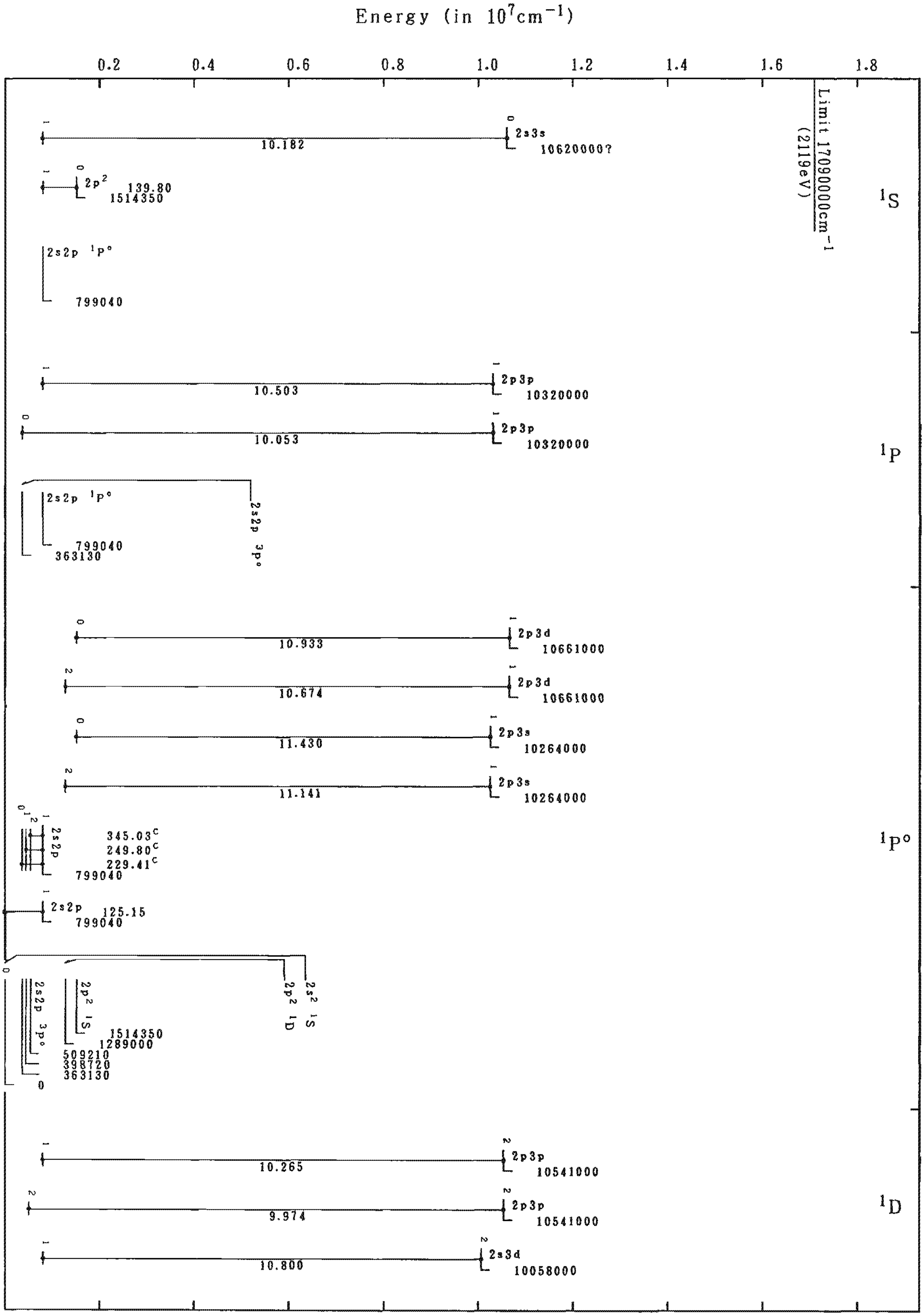

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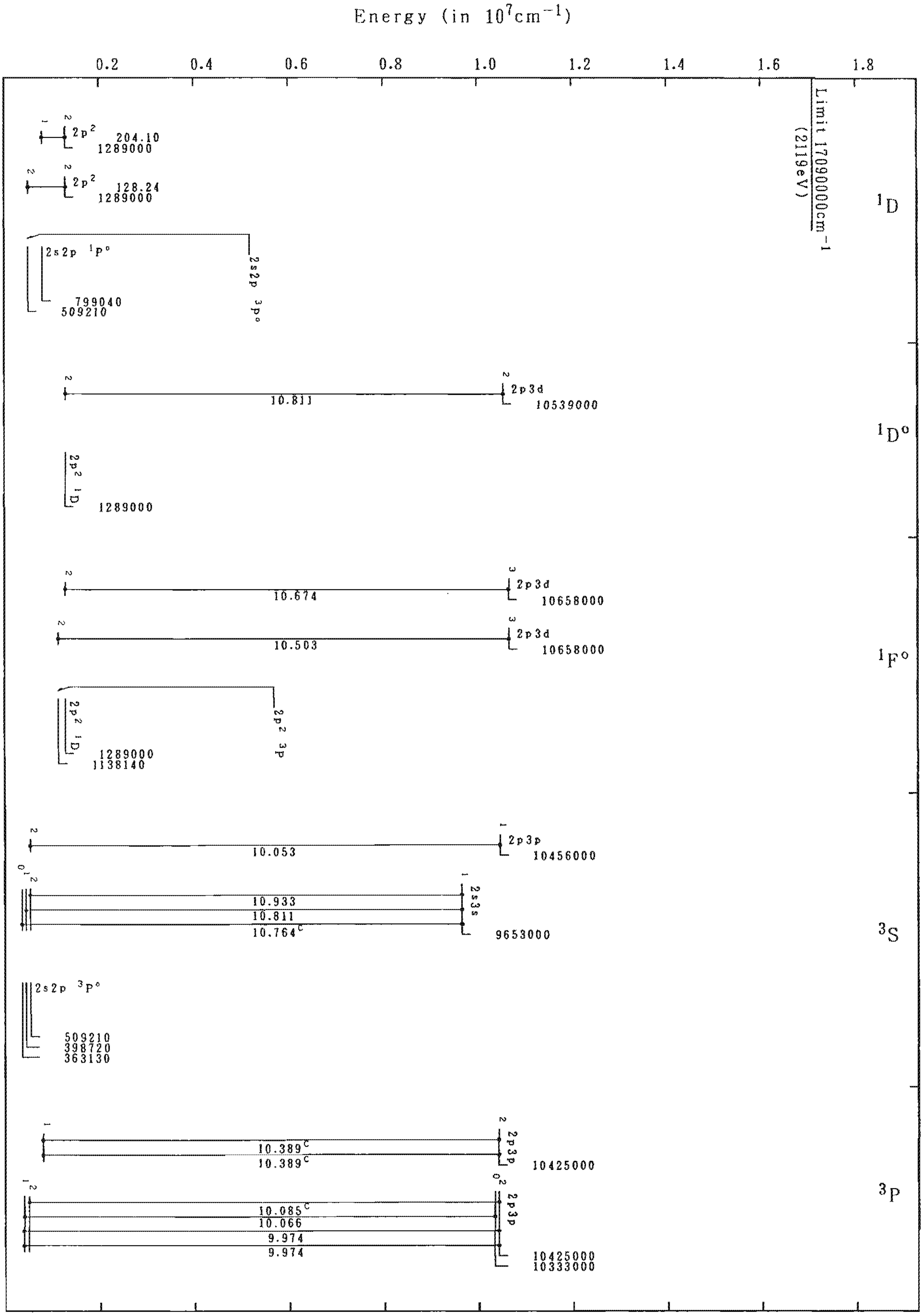

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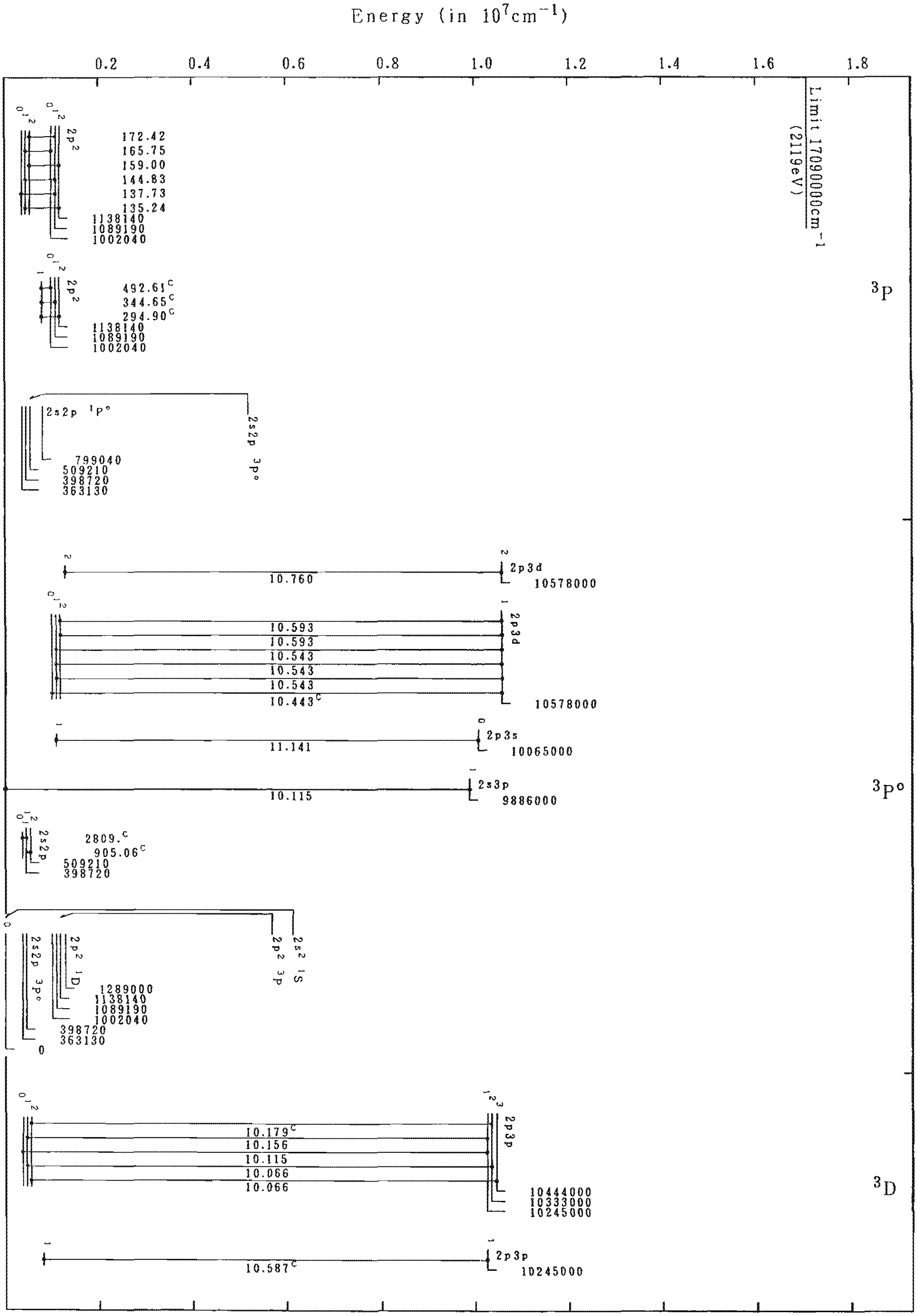

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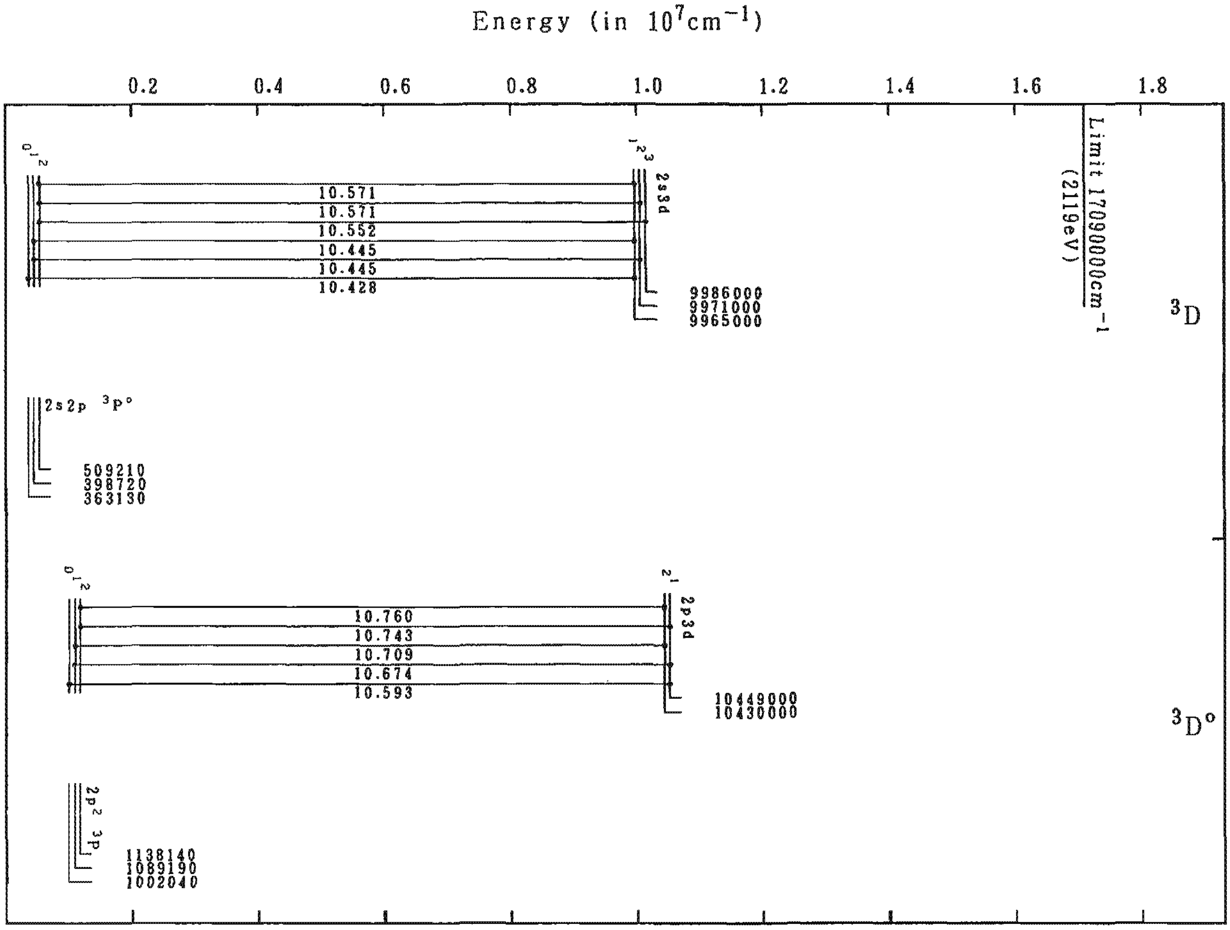

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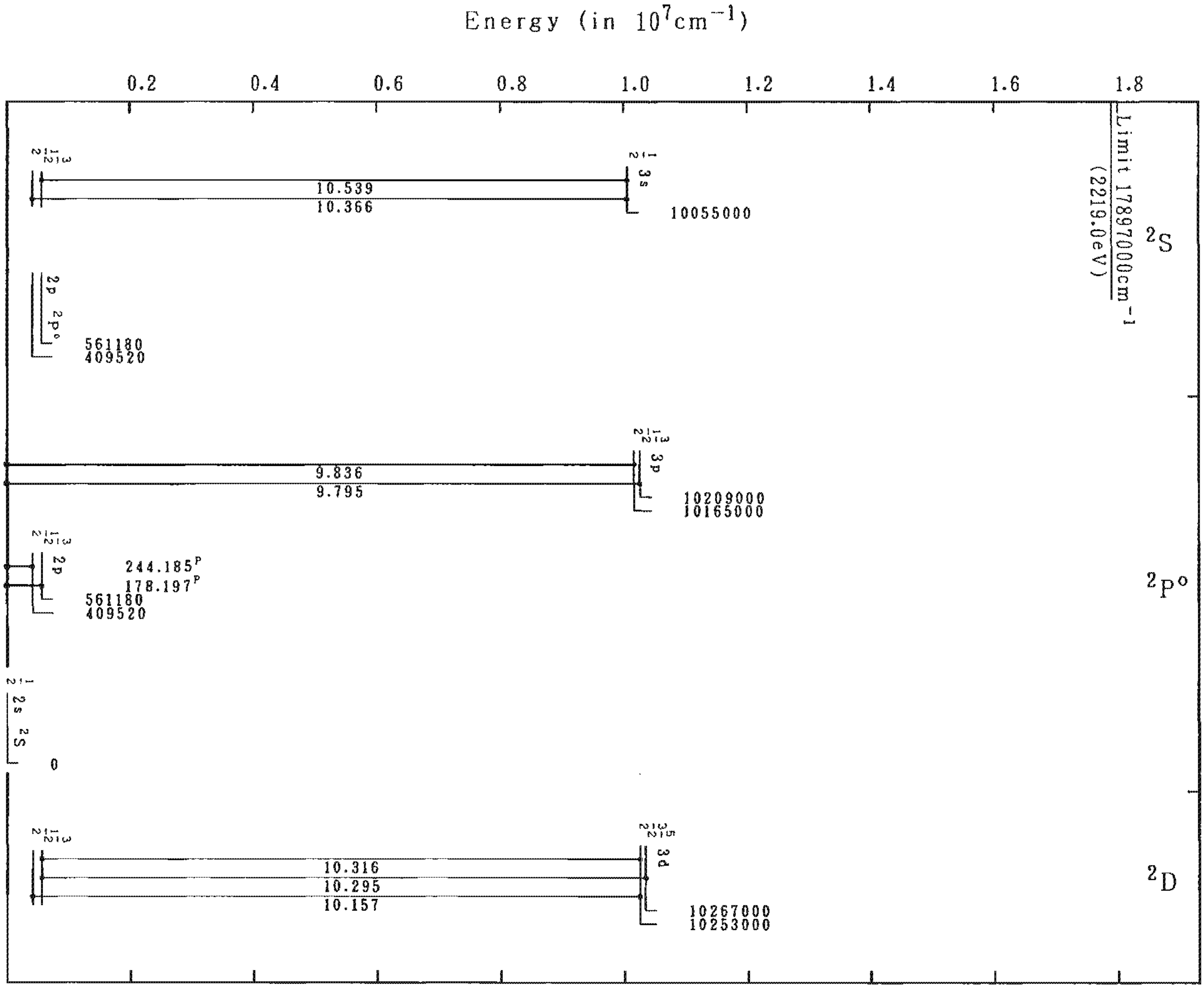
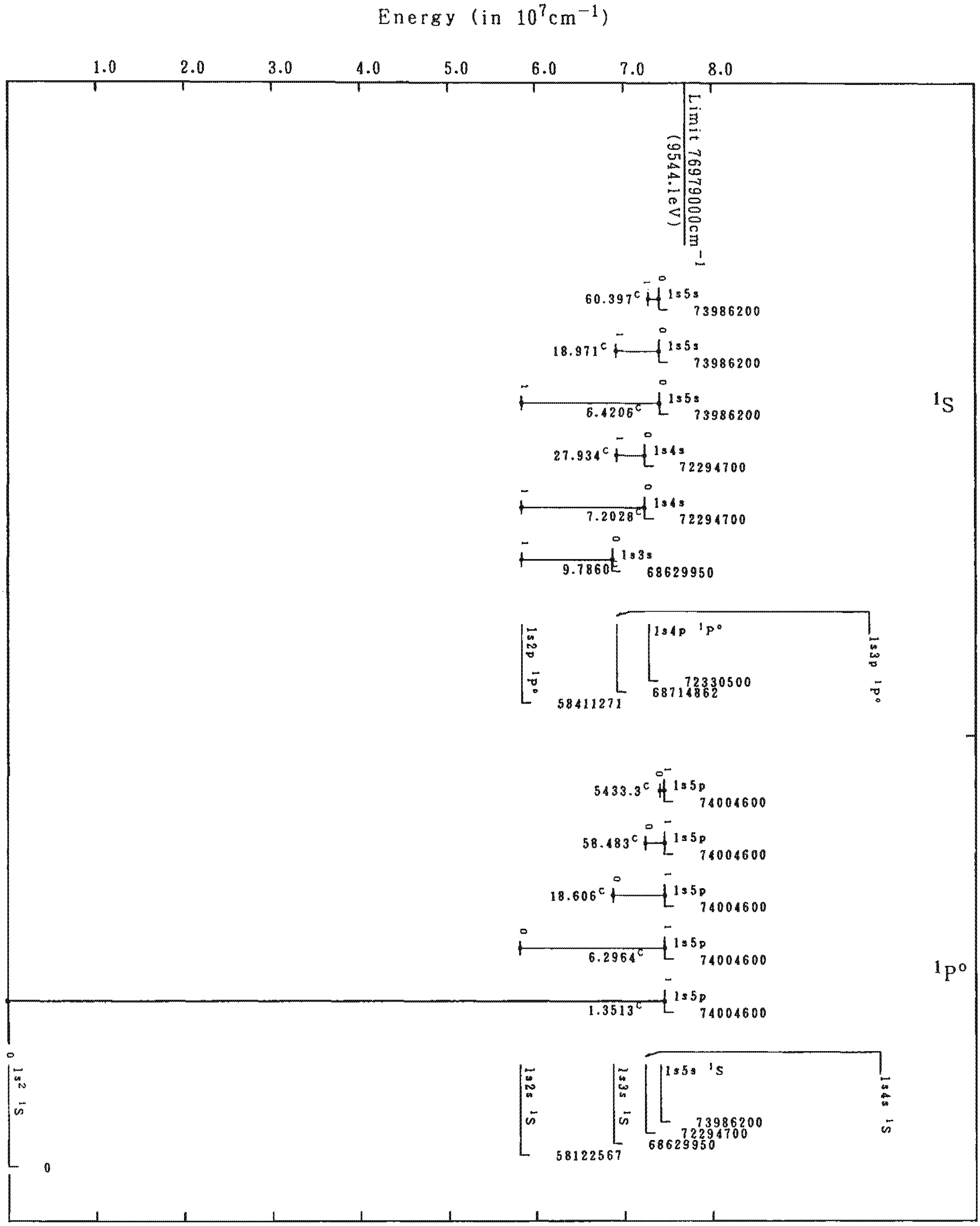


Co XXV (Li–Sequence)



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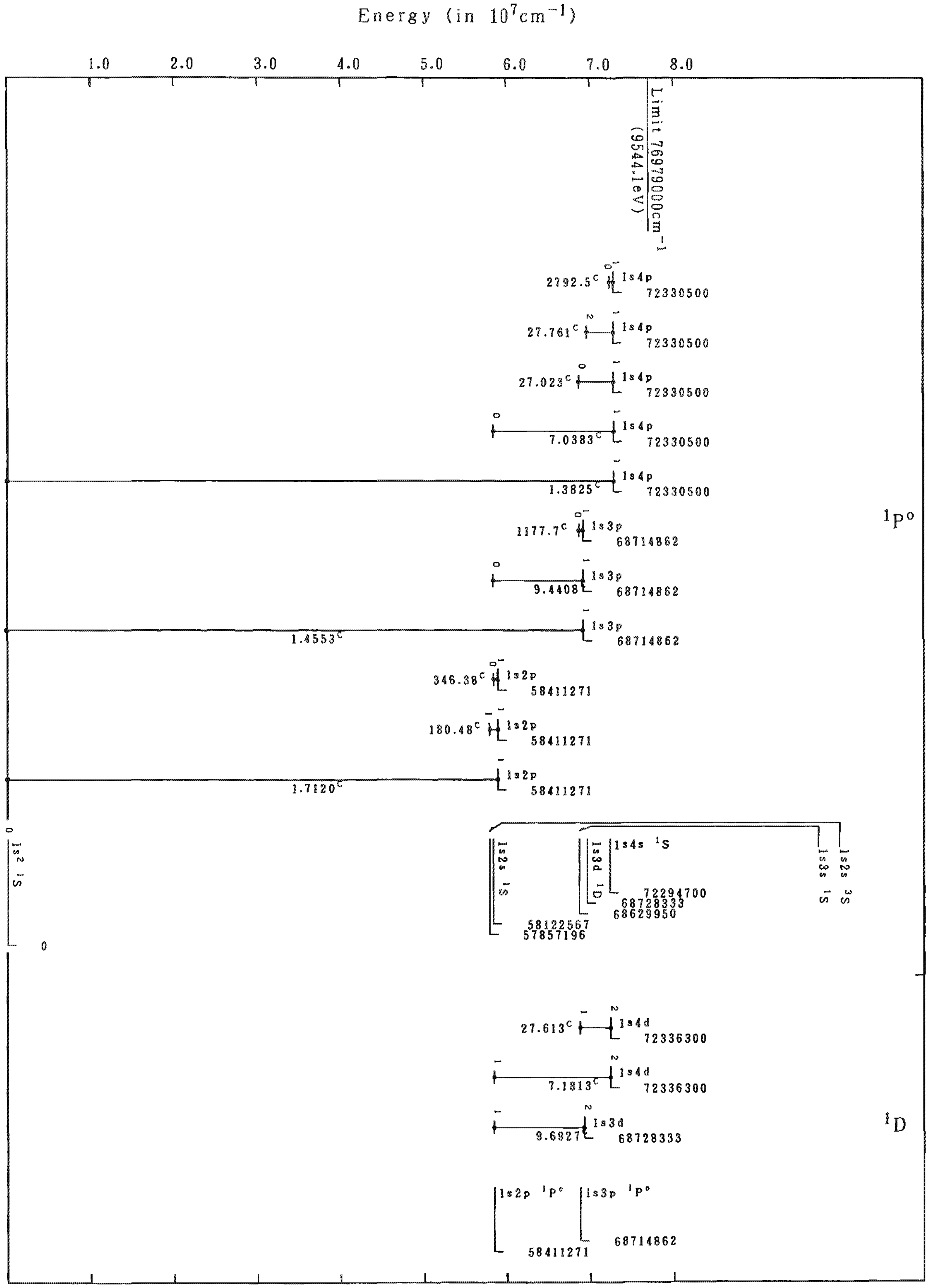

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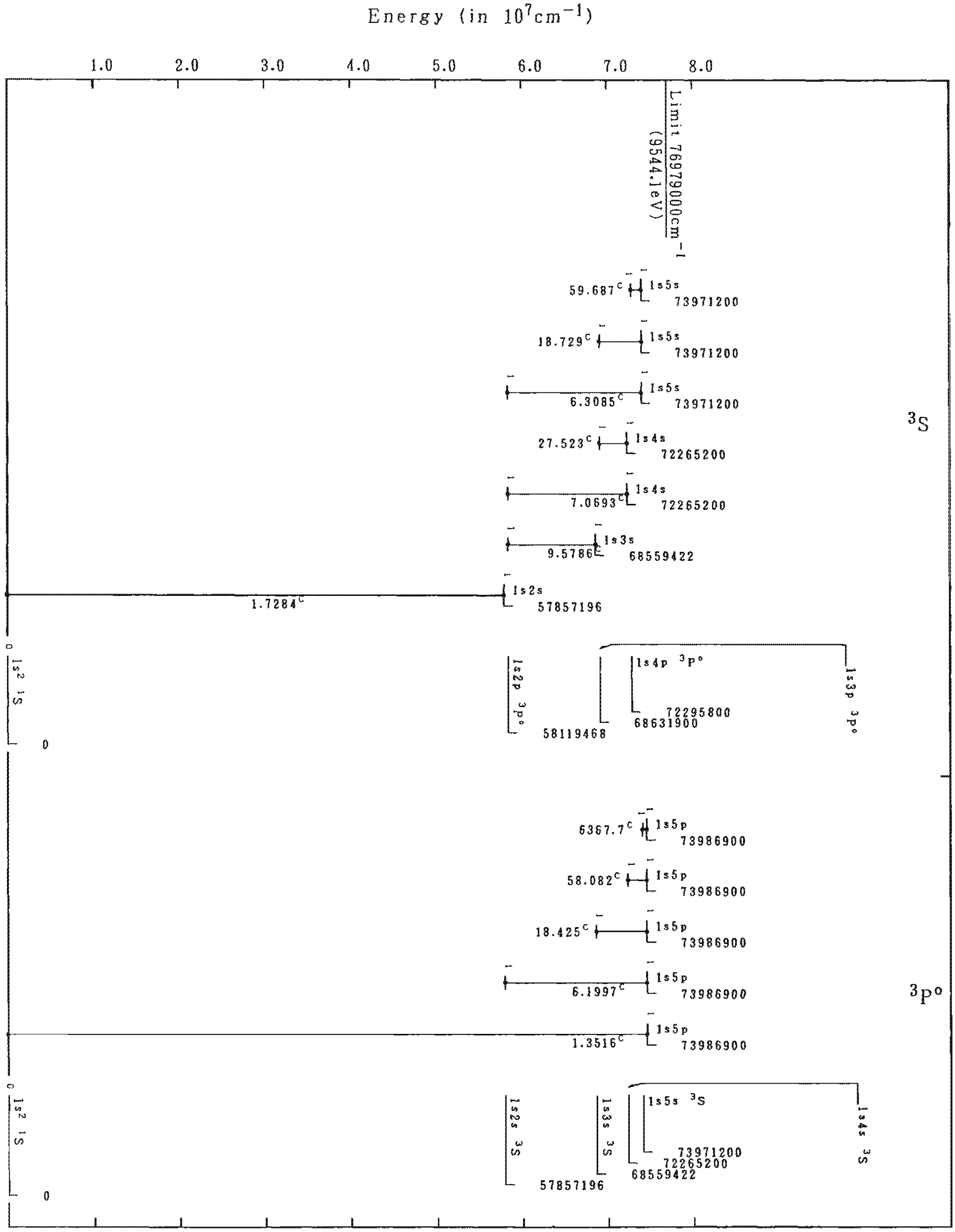

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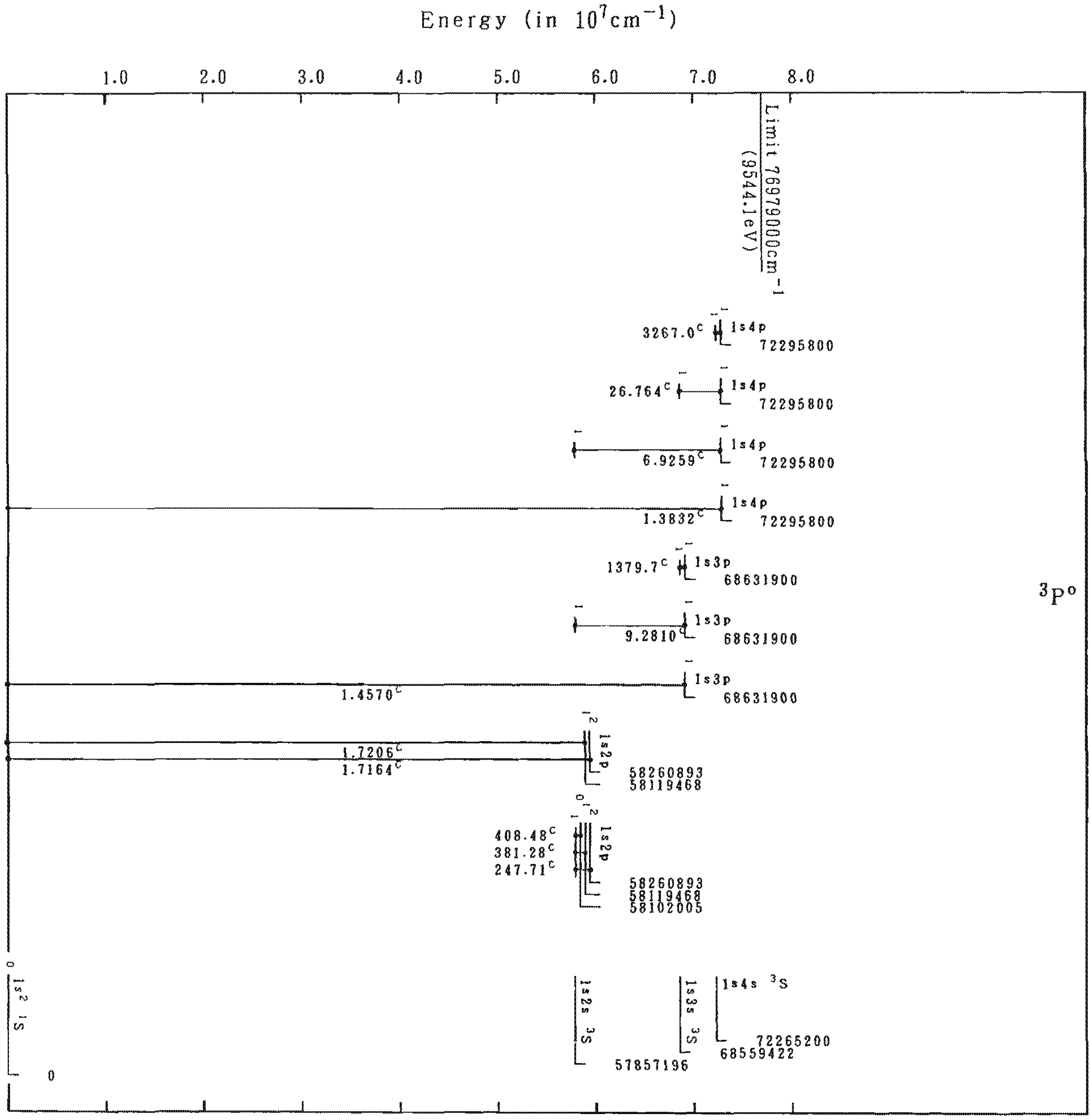

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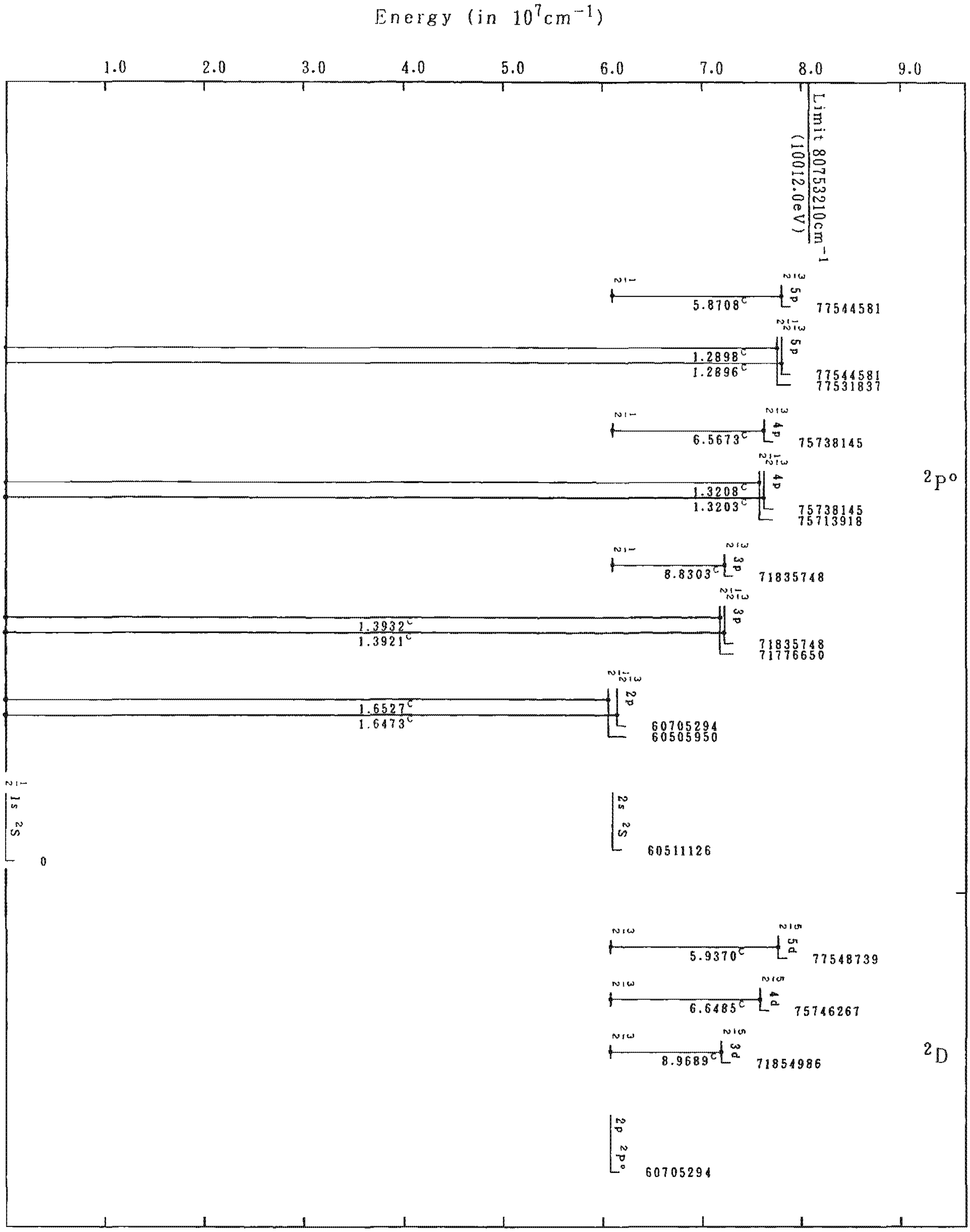

Co XXVII (H–Sequence)

7. References for Comments and Tables

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