# LINE SPECTRA OF THE ELEMENTS

## PART I. EARLY OBSERVATIONS AND SYSTEMS OF CLASSIFICATION

## BIBLIOGRAPHY I. PAPERS PUBLISHED DURING 1920–1931*

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## TABLE OF CONTENTS



## INTRODUCTION

IN THE early attempts to find relationships or formulae whereby the arrangement of lines in spectra could be systematically described, investigators were guided to a considerable extent by the assumption that the mechanism responsible for the emission of these lines was similar to that already known to exist in the production of sound. Consequently much effort was spent in trying to arrange lines into series, the frequencies of which would form a set, at least approximately, of harmonic overtones of some fundamental frequency. One sought, therefore, to find lines in a given spectrum, the

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ratio of whose wave-lengths (or of whose frequencies) would yield relatively small integral numbers. In a few cases such ratios were found but the number of such instances was too scattering and incomplete to warrant the formulation of any generalized law. In some of the simpler spectra certain descriptive facts were discovered. Pairs of lines or other groups of lines (usually triplets) having constant separations or gradually changing separations were found in the spectra of some of the elements. Systematic variations in the relative intensities of these groups were observed. It was possible to classify some of the lines according to their degree of sharpness or diffuseness and to relate these characteristics in some degree to the position of the lines in the spectrum.

These early observations stimulated the extension of wave-length measurements to a larger number of elements and to a wider range of the spectrum. From a study of such data Liveing and Dewar reported the existence of alternately sharp and diffuse doublets or triplets in the spectra of various elements. Their charts showed these groups to be less widely separated and to have decreasing intensities with decreasing wave-lengths. In fact they appeared to be converging to definite wave-length limits. This was not in accord with the idea of harmonic ratios so well known in sound. Attempts to find a formula that would describe in any adequate way the position in the spectrum of these somewhat related lines were not then successful.

Fairly accurate and complete descriptions of spectra gradually accumulated. An important advance was made when certain of these descriptions, expressed first in terms of wave-lengths, were recast by Hartley in terms of a scale of frequencies. He called attention to the fact that in terms of frequencies the intervals between the components of a group (doublets or triplets) were the same for many of the groups of any one element and further that these intervals were larger for elements of higher atomic weight. These observations led to a more or less rough classification of lines into series, although no numerical or quantitative relationship was found to connect even the groups of lines assigned to a single series. In other words the actual laws of the series were not recognized.

In spite of the helpful and what proved later to be significant observation of Hartley that certain regularities in spectra would be stated more precisely if expressed in terms of frequencies rather than wave-lengths, the first useful step toward the formulation of laws governing the location of lines in a spectrum was made when a formula was found by Balmer in 1885 that described quantitatively the position according to wave-lengths of the lines in the spectrum of hydrogen. This formula involving only certain constants and a single variable integral parameter was arrived at empirically by Balmer and in view of its simplicity was surprisingly exact. He proposed it in the form

$$\lambda(\text{in angstroms}) = h\frac{n^2}{n^2 - 4}$$

wherein $h = 3645.6$ and $n$ took successive integer values as follows for the wave-lengths as then measured of the first four lines:

| | $\lambda$(Obs). | $n$ | $\lambda$(calc.) |
|---|---|---|---|
| $H\alpha$ | 6562.10 | 3 | 6562.08 |
| $H\beta$ | 4860.74 | 4 | 4860.80 |
| $H\gamma$ | 4340.10 | 5 | 4340.00 |
| $H\delta$ | 4101.20 | 6 | 4101.30 |

More precise measurements of the wave-lengths and extension to additional lines in the ultraviolet region of the spectrum later necessitated a slight increase in the value of $h$.

One of the important characteristics of lines as then grouped and considered as belonging to a given series for each element was the smaller and smaller interval between successive lines or groups of lines (doublets or triplets) in passing from longer to shorter wave-lengths and the existence of a short wave-length limit for lines in a particular series. It is readily seen that Balmer's formula conformed to both of these characteristics for as $n$ increases from one integer to the next the value of the fraction $n^2/(n^2-4)$ decreases by smaller and smaller steps and approaches a value of unity for large values of $n$ so that the limit of the series is a wave-length represented by $h$.

Shortly after Balmer reported his formula for the hydrogen spectrum, studies of spectral series by Kayser and Runge were announced in which series formulae were proposed for elements other than hydrogen whereby the wave-length of any member of a series might be computed by a suitable choice of an integer parameter. They were successful in fitting both new and old wave-length observations into formulae of the type $\lambda = 1/(a+bn^{-1}+cn^{-2})$ or $\lambda = 1/(a+bn^{-2}+cn^{-4})$ the second of which is a slightly more general form of the Balmer equation for hydrogen.

$$\lambda = \frac{hn^2}{n^2-4} = \frac{1}{\dfrac{1}{h} - \dfrac{4}{hn^2}} = \frac{1}{a - bn^{-2}}.$$

Later these investigators, recognizing the need for more precise wave-length measurements embarked upon a long series of such measurements and in consequence accumulated a vast amount of new data that proved to be not only immediately useful but served as valuable material for future studies. In reporting the results of their extensive measurements they now proposed series formulae of the type

$$\nu = A - \frac{B}{n^2} - \frac{C}{n^3} \quad \text{or} \quad \nu = A - \frac{B}{n^2} - \frac{C}{n^4}$$

where $\nu$ represented the reciprocal of the wave-length, a number proportional to the frequency of the radiation, in conformity with the procedure initiated by Hartley somewhat earlier. $A$, $B$ and $C$ were constants characteristic of a given series for a particular element, and $n$ took on successive integer values in passing from one member of a series to the next. These three-constant formulae proved in many instances to be highly successful in defining fairly accurately the location in the spectrum of various members of a series. They even served in some instances as guides in extending a series experimentally to higher members. Kayser and Runge also determined the refractive indices of air thus making it possible to reduce wave-lengths to vacuum before computing their reciprocals, a correction that renders the reciprocal wave-lengths strictly proportional to the frequencies of the radiation and therefore independent of the medium through which the radiation is passing.

But it was the contemporary work of J. R. Rydberg of Lund that led to the discovery of a type of formula for series which has proved to be more useful and to have a more lasting significance, not only in correlating a vast number of lines radiated or absorbed by the atoms of various elements but also in interpreting the nature of the radiation and absorption processes. Rydberg's first report was made in 1889 about a year before Kayser and Runge announced their second type of formulae. Rydberg employed the purely empirical method of attack in an extensive study of existing wave-length data taken largely at first from the reports of Liveing and Dewar. By carefully and systematically sorting and cataloguing intervals between lines he was able greatly to extend the observations previously made by Hartley of the constancy of the separations between lines in a succession of groups of lines (doublets or triplets) in a spectrum, provided always the intervals were expressed in terms of reciprocal wave-lengths. The greater significance and usefulness arising from the use of reciprocal wave-lengths instead of wave-lengths themselves became increasingly apparent as Rydberg's studies progressed. He was able, as a result of his laborious sorting and grouping of intervals, to show that lines at considerable distances from each other could often properly be grouped together as doublets or triplets. Not infrequently there were other intervening lines having no definite relation to those of the group. Rydberg classified the lines emitted by the alkali metals when burned in an arc or a very hot flame into three distinct series, all members of which were called doublets. Similar series with both single and triple members were found for such elements as magnesium, aluminum, calcium and other elements having similar chemical properties. These three series together with another series to be described later are sometimes referred to as the chief series. The names given to these series were selected to represent certain descriptive characteristics of the lines in each series. The principal series, for example, included in general the strongest lines in the spectrum although the intensities of lines in this series as well as in the other series fell off rapidly as one proceeded to higher members of the series. Many of the stronger lines in this series were easily reversed under normal conditions of excitation, the reason for which will be pointed out later. The sharp series consisted in general of sharp, narrow lines often of relatively low intensity. In the diffuse series the lines were on the whole less sharp, sometimes showing a diffuse or nebulous condition on one side or the other or on both sides. For some elements the lines in this series had an intensity intermediate between that of lines in the principal and sharp series. These names of series, however, should not be taken too seriously as representing a basis of classification of all lines now listed under these headings. They constitute an inheritance from the days when they appeared to have a greater significance. We continue to use them to designate series whose lines have been classified in the main according to other criteria, which in some cases yield classifications not unlike those obtained from the earlier basis just described. Often but not always the strongest lines in a given spectrum constitute the first members (doublets, triplets) of the principal series. Quite frequently the lines in the higher members of this series are comparatively weak. There is little, sometimes, in the quality of lines (sharpness, diffuseness or intensity) to distinguish those belonging to the so-called sharp and diffuse series. Somewhat later a fourth chief series was observed in the infrared region by Bergmann for the alkali metals and by some has been called the Bergmann series even in the case of other elements. For reasons that are now regarded as having little or no significance, Hicks considered this fourth series as more fundamental than the others and accordingly called it the fundamental series. This designation, however, has persisted and thus we have the four chief series called sharp, principal, diffuse, and fundamental that now should be regarded merely as convenient names. From these names much of our recent abbreviated terminology has been derived, a fact that perhaps justifies the emphasis here placed upon them.

Rydberg laid the foundation upon which later developments have to a great extent depended. As already pointed out he discovered many instances of equal or regularly varying intervals between lines in a group and thus established series. By plotting reciprocals of wave-lengths of lines belonging to a series against consecutive integer numbers he discovered that curves similar in shape were obtained not only for the different series of any one element but even for series of different elements. Many of these curves had the approximate shape of rectangular hyperbolas which suggested that the position of lines in a series might be defined by

$$\nu = \frac{1}{\lambda} = A - \frac{B}{m + \mu}$$

where $m$ assumes consecutive integer values and $A$, $B$ and $\mu$ are constants for any one particular series. $A$ is equal to $\nu$ when $n$ is infinite, that is $A$ is the limit of the series. While this formula fitted certain series-data approximately Rydberg found that the formula

$$\nu = A - \frac{N}{(m + \mu)^2}$$

was more widely applicable. $N$ proved to be approximately the same for all series of all elements while $A$ and $\mu$ were constants characteristic of a particular series for a single element. Although Rydberg used $N$ to designate the universal spectral constant, commonly called the Rydberg constant, the prevailing practice in recent years has been, very appropriately, to represent it by $R$.

Rydberg's formula is accordingly written

$$\nu = \nu_\infty - \frac{R}{(m + \mu)^2}$$

where $\nu_\infty$, equal to $\nu$ for $m$ infinite, is the limit of the series.

The success of Rydberg's formula firmly established the use of reciprocal wave-lengths and at this point we may well digress briefly to define certain symbols that will hereafter be used frequently in this review.

Unless otherwise specified $\nu$ will be used to represent $1/\lambda_{vac}$ where $\lambda_{vac}$ represents a wave-length in cm measured on the International scale of wave-lengths and corrected when necessary to vacuum.

Thus

$$\nu = \frac{1}{\lambda_{vac} \text{ in cm}} = \frac{10^8}{\lambda \text{ in angstroms}} .$$

The unit for $\nu$ is reciprocal centimeters written cm$^{-1}$. As thus defined $\nu$ is strictly proportional to the frequency of the radiation which in this report will be represented by $\bar{\nu}$, so that

$$\bar{\nu} = c/\lambda_{vac} = c\nu$$

where $c$ is the velocity of light.

In using this convention of symbols we are following that adopted by Mohler (Qg 250) in 1924. Ruark and Urey (Q90) in their recent book have used $\tilde{\nu}$ to represent wave number and $\nu$ to represent frequency of radiation. It, however, seems desirable, in view of the long established and widespread use of $\nu$ in the publication of data and especially in the numerous tables of spectral data to represent wave number, to continue that practice and then to use $\bar{\nu}$ to represent frequency of radiation.

As just mentioned, it is customary to call $\nu$ the wave number meaning thereby the number of complete wave-lengths in a centimeter. Following these conventions $R$ will be expressed in cm$^{-1}$. It is more convenient to utilize wave numbers to designate frequencies of radiation instead of the true frequencies themselves. Furthermore, spectroscopic measurements are often capable of being made accurately to more significant figures than can be done in measuring $c$.

## The Balmer Series

Returning now to the formula proposed by Balmer for lines in hydrogen and writing it in terms of wave numbers we have

$$\lambda \text{ in angstroms} = \frac{hn^2}{n^2 - 4}$$

$$\nu = \frac{1}{\lambda \text{ cm}} = \frac{n^2 - 4}{n^2 h \times 10^{-8}} = \frac{4}{h \times 10^{-8}}\left(\frac{1}{2^2} - \frac{1}{n^2}\right).$$

In this form the Balmer formula resembles that of Rydberg, the limit being equal to

$$\frac{1}{h \times 10^{-8}} \text{ cm}^{-1}, \quad R = \frac{4}{h \times 10^{-8}} = \frac{4n^2}{n^2 - 4} \nu \text{ cm}^{-1}$$

and $\mu = 0$. Thus the Rydberg form of the Balmer formula is

$$\nu = \frac{R}{2^2} - \frac{R}{n^2}\,.$$

The value of $R$ as determined from wave-length data of hydrogen lines is about 109678 $cm^{-1}$. Attention will be called later to a more precise determination of the value of $R$ from measurements of the fine structure of hydrogen lines. As a matter of fact the value of $R$ is not quite the same for all elements being slightly larger the more massive the atom.

## Rydberg Formula

It is important to remember that Rydberg upon finding it impossible to fit the position of lines for other elements into a formula as simple as that of Balmer for hydrogen chose not to adjust the formula by the addition of more terms as was done by Kayser and Runge but rather to make the adjustment by a modification of the denominator of the second term of the equation.

The essential point to be stressed in this connection is that by so doing the wave number corresponding to any given frequency of radiation was always to be expressed as the difference of two terms, one of which was constant representing the limit of a series, and the other variable, a point of view that has been fully justified by later developments.

Not only did Rydberg discover a type of formula applicable to all series but he was able by means of the formula to establish relations between the different series for a given element. He found for example that if $\nu_P(m) = \nu_{\infty P} - R/(m+P)^2$ represented the principal series where $m = 1, 2, 3, \cdots$ and $\nu_S(m) = \nu_{\infty S} - R/(m+S)^2$ represented the sharp series where $m = 2, 3, 4, \cdots$ and $\nu_D(m) = \nu_{\infty D} - R/(m+D)^2$ represented the diffuse series where $m = 2, 3, 4, \cdots$, then $\nu_{\infty P} = R/(1+S)^2$ and $\nu_{\infty S} = \nu_{\infty D} = R/(1+P)^2$. It was also later found that the limit of the fundamental or Bergmann series $\nu_{\infty F} = R/(2+D)^2$ so that the four chief series can be written as follows.

$$\text{Principal} \quad \nu_P(m) = \frac{R}{(1+S)^2} - \frac{R}{(m+P)^2} \quad m = 1, 2, 3, \cdots.$$

$$\text{Sharp} \quad \nu_S(m) = \frac{R}{(1+P)^2} - \frac{R}{(m+S)^2} \quad m = 2, 3, 4, \cdots.$$

$$\text{Diffuse} \quad \nu_D(m) = \frac{R}{(1+P)^2} - \frac{R}{(m+D)^2} \quad m = 2, 3, 4, \cdots.$$

$$\text{Fundamental} \quad \nu_F(m) = \frac{R}{(2+D)^2} - \frac{R}{(m+F)^2} \quad m = 3, 4, 5, \cdots.$$

These formulae are often abbreviated to read

$$\begin{aligned} \nu_P(m) &= 1S - mP \\ \nu_S(m) &= 1P - mS \\ \nu_D(m) &= 1P - mD \\ \nu_F(m) &= 2D - mF \end{aligned}$$

From the above it will be seen that the limits of the sharp and diffuse series are the same. Another connection between these series is seen in the relation

$$\nu_P(1) = \nu_{\infty P} - \nu_{\infty S}.$$

Put into words this equality means that the wave number of the first line of the principal or $P$ series is equal to the difference between the limit of the $P$ series and the common limits of the $S$ and $D$ series, a relation that was announced independently in the same year by both Rydberg and Schuster and accordingly is often referred to as the Rydberg-Schuster law of limits. After the discovery of the fourth chief series by Bergmann, Runge called attention to the existence of certain common intervals between lines in the $F$ and $D$

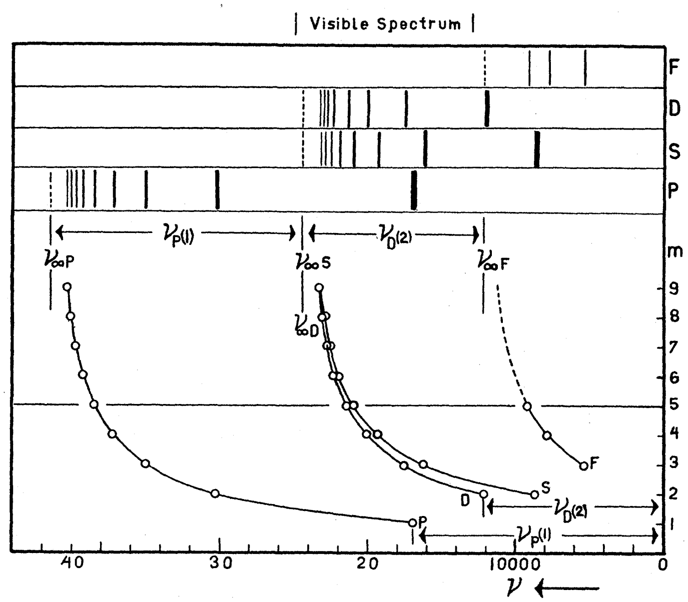


Fig. 1. Chief series of sodium.

series of caesium and predicted that the wave number of the first line of the $D$ series would be found equal to the difference between the common limits of the $S$ and $D$ series and the limit of the $F$ series. This equality which may be put in symbolic form as follows

$$\nu_D(2) = \nu_{\infty D} - \nu_{\infty F}$$

is often called Runge's law of limits, although Ritz was the first actually to establish this relationship.

The various relations between the four chief series are shown graphically for sodium in Fig. 1.

## Doublets in Series Spectra

It was early recognized that the series spectra arising from neutral atoms of the alkali metals, commonly called the arc spectra, exhibited a doublet character. At first it was thought that this doublet character consisted in a mere doubling of the lines of all series. Then as measurements became more refined and precise it was found that, while in the sharp and principal series each member of the series consisted of only a pair of lines, early members of the diffuse series were composed of two comparatively strong lines and a third weak line which was termed a satellite. It proved possible to account for all these data by giving double values to the $P$ and $D$ terms while leaving the $S$ terms single valued. In order to account for the observed data it was necessary in a few cases to give double values to the $F$ terms, although the difference between such terms was usually extremely small. Later study has shown that all $F$ terms for alkali metals should be double-valued. Except in the case of caesium, however, these terms have not been resolved. Some new evidence concerning the $F$ terms of rubidium has been reported recently by Ramb, (Rb I 65).

To represent these facts by series formula of the Rydberg type various systems of notation have been employed. Of these the two most widely used in recent years are those found in a Report on Series in Line Spectra by Fowler (Q 15) and in Seriengesetze der Linienspektren by Paschen and Götze (Q 17). In Table I these two systems of notation are contrasted.

TABLE I. *Symbolic series formulae for doublets showing two common notations.*

| Fowler | | | Paschen-Götze | | |
|---|---|---|---|---|---|
| Series | $\nu$ | $m$ | Series | $\nu$ | $m$ |
| Principal | $1\sigma - m\pi_1$<br>$1\sigma - m\pi_2$ | 1, 2, 3, · · · . | Haupt | $1s - mp_1$<br>$1s - mp_2$ | 2, 3, 4, · · · . |
| Sharp | $1\pi_1 - m\sigma$<br>$1\pi_2 - m\sigma$ | 2, 3, 4, · · · . | II Neben<br>(II Subordinate) | $2p_1 - ms$<br>$2p_2 - ms$ | 2, 3, 4, · · · . |
| Diffuse | $1\pi_1 - m\delta$<br>$1\pi_2 - m\delta'$ | 2, 3, 4, · · · . | I Neben<br>(I Subordinate) | $2p_1 - md_1$<br>$2p_2 - md_2$ | 3, 4, 5, · · · . |
| Fundamental | $2\delta - m\phi$<br>$2\delta' - m\phi$ | 3, 4, 5, · · · . | Bergmann | $3d_1 - mf_1$<br>$3d_2 - mf_2$ | 4, 5, 6, · · · . |

The minimum value of $m$ here given is so chosen in each case as to exclude negative wave-numbers. The largest $\sigma$ or $s$ term value is obtained by using $m = 1$. For further explanation see discussion under "Negative wave-numbers".

The notation for the double terms in both systems has in general been chosen so as to make the term value larger for the one with the larger subscript or prime. There is some confusion on this point for the $f$ terms, which are given by Paschen and Götze for the alkali metals only in the case of caesium. Fowler does not list double values for $\phi$ terms. In this connection the new data of Ramb (Rb I 65) and of Meissner and Masaki (Rb I 64) should be consulted.

To illustrate the use of these formulae examples will now be given of data taken from the tables of Fowler and of Paschen and Götze.

## Principal Series of Sodium

Fowler, page 99

$$1\sigma = 41449.00$$
$$1\pi_1 = 24475.65$$
$$1\pi_2 = 24492.83$$
$$\nu_1 = 41449.00 - 24475.65 = 16973.35 \text{ cm}^{-1}$$
$$\nu_2 = 41449.00 - 24492.83 = 16956.17 \text{ cm}^{-1}$$
$$\lambda_{1\text{vac}} = 1/\nu_1 = 1/16973.35 = 5891.589\text{A}$$
$$\lambda_{2\text{vac}} = 1/\nu_2 = 1/16956.17 = 5897.558\text{A}$$
$$\lambda_1 \text{ air} = 5889.963\text{A} \quad \lambda_2 \text{ air} = 5895.930\text{A}.$$

Unless otherwise specified wave-lengths in these tables are given in air, whereas the wave numbers are for vacuum conditions.

Paschen-Götze, page 56

$$1s = 41448.59$$
$$3p_1 = 11177.49$$
$$3p_2 = 11181.93$$
$$\nu_1(sp_1) = 41448.59 - 11177.49 = 30271.10 \text{ cm}^{-1}$$
$$\nu_2(sp_2) = 41448.59 - 11181.93 = 30266.66 \text{ cm}^{-1}.$$

From these tables one readily observes the rapid decrease in size of interval between the $\pi$ or $p$ terms with increase of $m$, and how nearly constant is the interval between the lines of the $\sigma$ or $s$ series, the interval being due solely to that between the fixed terms of those series which is also equal to the interval between the first pair of terms in the $\pi$ or $p$ series.

## Diffuse Series of Caesium

Fowler, page 107

$$1\pi_1 = 19672.3$$
$$1\pi_2 = 20226.3$$
$$2\delta = 16807.1$$
$$2\delta' = 16905.0$$

| | Computed | Observed |
|---|---|---|
| $\nu(\pi_2\delta') = 20226.3 - 16905.0 =$ | 3321.3 | 3321.4 |
| $\nu(\pi_1\delta) = 19672.3 - 16807.1 =$ | 2865.2 | 2865.2 |
| $\nu(\pi_1\delta') = 19672.3 - 16905.0 =$ | 2767.3 | 2767.3 |
| $\nu(\pi_2\delta) = 20226.3 - 16807.1 =$ | 3419.2 | not found. |

Lines corresponding to only three out of the four possible term differences are observed. The interval $\nu(\pi_2\delta') - \nu(\pi_1\delta')$ remains equal to about 554 cm$^{-1}$ throughout this series whereas the interval $\nu(\pi_1\delta) - \nu(\pi_1\delta')$ decreases rapidly with increasing $m$.

The way in which the various term values vary with $m$ is shown for caesium in Fig. 2. In every case there is at first a rapid decrease in all term values and then a more gradual approach to the same limiting value of zero as $m$ increases. On the same diagram the way in which the intervals $\Delta p$ and $\Delta d$ change with $m$ is shown by enlarging the interval scale by a factor of 20,

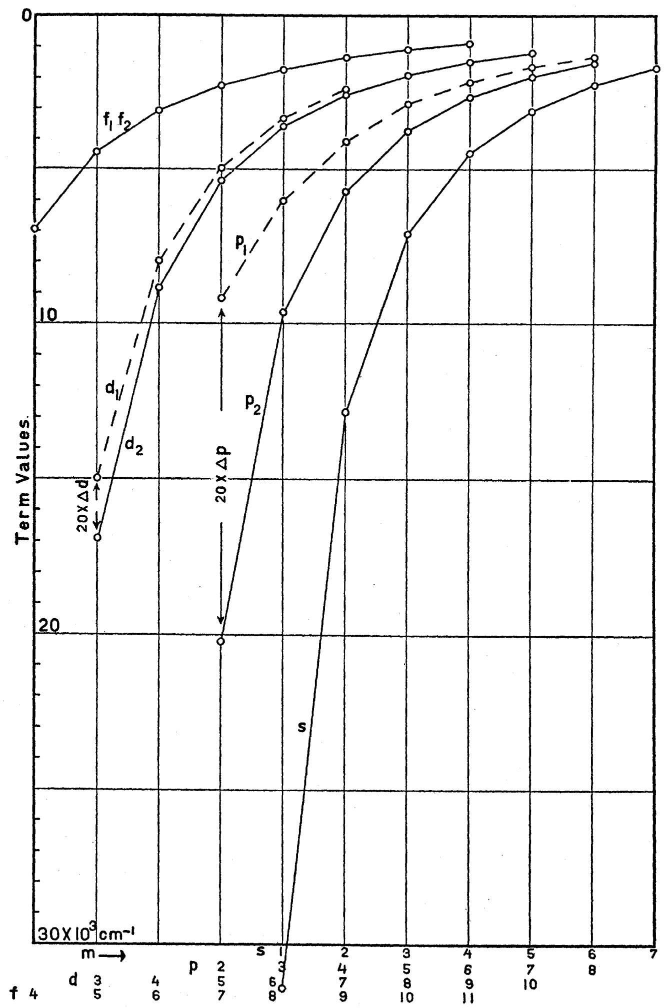


Fig. 2. Term values for caesium. Paschen-Götze notation.

so that the points for $p_1$ and $d_1$ are removed from their partners by a distance that is 20 times too large. The much smaller interval $\Delta f$ is not shown. Of course the lines in this figure have no real significance as these terms have values only for integer values of $m$. They assist the eye, however, in associating related points. Similar curves could be drawn for the other alkali elements. Except for $d$ terms the corresponding term values are for the most part larger for elements of smaller atomic number, but the intervals $\Delta p$ and $\Delta d$ increase with atomic number. These variations are illustrated in Fig. 3. An exception to this regular increase in $\Delta d$ has been reported by Ramb (Rb I 65). From Fig. 3 it is readily seen, even with the broken scale, that the first members of the principal series increase in wave-length in the order Na, Li, K, Rb, and Cs whereas in the sharp series the order is the same as the atomic number. The

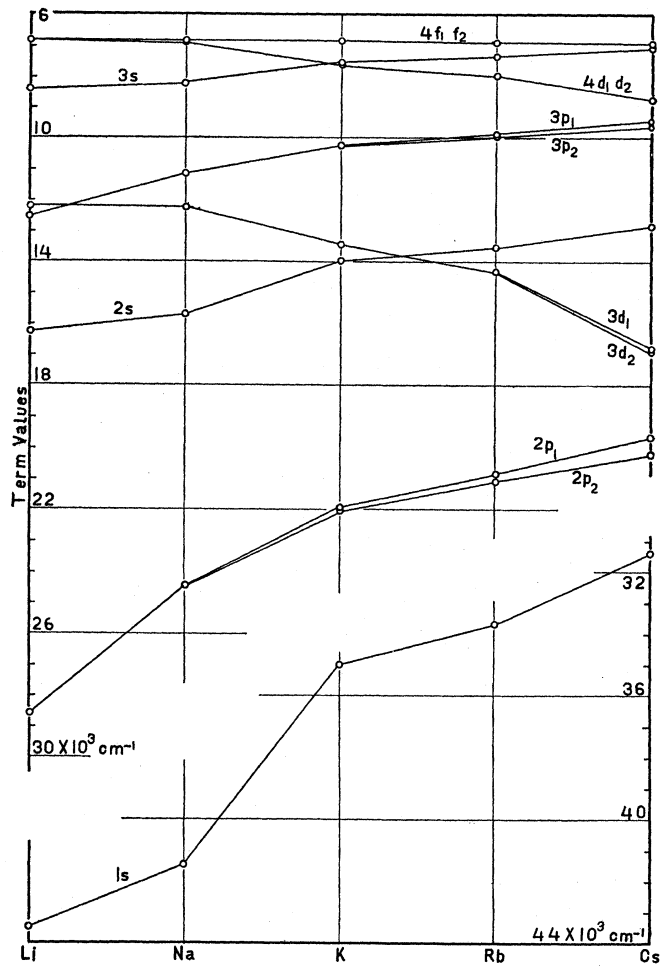


Fig. 3. Variation in term values and doublet-separations for the alkali metals.

absence of $3p$ terms (they would appear above the top of this diagram) shows that the wave-lengths of the second and higher members of the principal series are comparatively small, whereas the wave-lengths of many lines of the sharp and diffuse series are relatively much larger.

## Intensity Relations for Doublets

In all series the intensities of lines fall off rapidly with increasing values of $m$. The recorded data show considerable lack of uniformity in the relative intensities of lines in the pairs throughout a series. In the sharp and principal series the line derived from the $\pi_1$ or $p_1$ terms in somewhat more often stronger than that derived from the $\pi_2$ or $p_2$ term as predicted by recent theoretical considerations. In the diffuse series for caesium, for which element the data for this series are most complete, the line derived from the $\delta'\pi_1$ or $d_2p_1$ terms is uniformly the weakest of the three. This line was appropriately called the satellite line although lately such a designation has lost much of its significance. It is between this line and the stronger of the other two lines in these groups that the $\Delta\delta$ or $\Delta d$ interval is found, an interval that decreases through the series while between this same line and the other line of the group is found the $\Delta\pi$ or $\Delta p$ interval which interval is maintained throughout the series.

## Negative Wave Numbers

In Fowler's report (Q 15) the tables for the alkali elements contain a negative wave number as the first number of the sharp series. The negative sign of course has no physical significance and is obtained merely by using a value of $m$ that yields negative wave numbers exactly equal numerically to those of the first member of the principal series to which series they properly belong. Other instances of negative wave numbers appear in Fowler's tables. In every case, however, such wave numbers with signs reversed actually belong to some other series. In some cases no definite name has been given to the other series as for example when a $\delta$ term value exceeds a $\pi$ term value such that their difference $m'\delta - m\pi$ yields a positive wave number corresponding to a radiated line. Still higher $\pi$ terms may also combine with the given $\delta$ term and thus establish a series of radiated lines that is as truly a series as any of the four chief series which we have become accustomed to describe by name. In fact just such a series is given by Fowler on page 124 of his report where he lists a series of radiated lines as calcium singlets under the heading "combination $1\ D - m\ P$" which series was formerly known as $S\ L\ 2$.

Paschen and Götze (Q 17) have also included the negative wave numbers in their tables but without the minus sign as for example on page 57 where the two yellow lines of sodium $\lambda$5890–6A are included in the II nebenserie under a value of $m = 1$. These lines, however, belong properly to the hauptserie where they are also listed. The inclusion of $m$ values that yield negative wave numbers does facilitate the listing of the largest term of a given type in the same table with others of the same type, as in the case of $1\ s = 41445$ for sodium. Therefore, in order to include all terms of a given type in a series of term values (not a series of radiated lines) it is sometimes necessary to use smaller $m$ values than those used in formulae for radiated lines when negative wave numbers are excluded. Failure to stress this point has often left the beginning reader confused. The difference between the minimum limits to be placed upon $m$ for various series of radiated lines and for related series of term values is clearly illustrated by comparing Tables I, II and III with Table V.

## Singlet and Triplet Series

Elements appearing in the second group of the periodic table, i.e. elements with two valence electrons, such as magnesium, calcium and mercury, have been found to yield an arc spectrum consisting of singlet and triplet series. In the case of singlet series each member of the series consists of a single line whose wave number is expressible as the difference of two terms each taken from a series of single valued terms.

As in the case of doublets of the alkalis, four chief series have been recognized and catalogued with the same names for the series. Fowler and Paschen and Götze have used symbols in common to represent terms in the singlet series, namely $S$, $P$, $D$ and $F$ for the variable term in the sharp (II Neben), principal (Haupt), diffuse (I Neben), and fundamental (Bergmann) series respectively. The choice of $m$ values however is slightly different in the two reports as shown in Table II.

TABLE II. *m values in singlet series.*

| Series | Formula | $m$ values | |
|---|---|---|---|
| | | Fowler | Paschen and Götze |
| Principal (Haupt) | $1s-mP$ | 1, 2, 3, · · · | 2, 3, 4,[c] · · · |
| Sharp (II Neben) | $1P-mS$ ($2P-mS$) | 2, 3, 4, · · · | 2, 3, 4, · · · |
| Diffuse (I Neben) | $1P-mD$ ($2P-mD$) | 2, 3, 4, · · · | 3, 4, 5,[d] · · · |
| Fundamental (Bergmann) | $1D$[a]$-mF$ ($3D-mF$) | 2, 3, 4,[b] · · · | 4, 5, 6,[e] · · · |

[a] $m=2D-mF$ for Hg.
[b] $m=3, 4, 5, \cdots$ for Ca, Sr and Hg.
[c] $m=1, 2, 3, \cdots$ for Ca. $1P=25652$ is, however, called $2P$ as limit of II Nebenserie.
[d] $m=4, 5, 6, \cdots$ for Ca and Ba.
[e] $m=3, 4, 5, \cdots$ for Sr.
Minimum $m$ values have been so chosen as to exclude negative wave numbers. Smaller values of $m$ are sometimes required for the largest term of a given type. See discussion under "Negative wave numbers".

The relative values of singlet terms for Be, Mg, Zn, Cd, and Hg are shown in Fig. 4. By observing differences between appropriate terms the relative positions of lines in the principal, sharp and diffuse singlet series for these elements are readily deduced from Fig. 4.

The chief observed triplet series can all be accounted for by taking differences between terms consisting of single valued $s$ terms and triple valued $p$, $d$ and $f$ terms. Fowler and Paschen and Götze have both used the small English letters to represent triplet terms with subscripts 1, 2 and 3, increasing with the term value to differentiate the three values of $p$ terms. The same practice is continued by Paschen and Götze for $d$ and $f$ terms while Fowler uses $d$, $d'$, $d''$ and $f$, $f'$, $f''$ respectively for these terms. The differences in the assignment of $m$ values is shown in Table III.

Triplet term values have also been included in Fig. 4. The marked increase in $\Delta p$ as we proceed to elements of higher atomic number is at once evident. One also notes the relative position of the singlet and triplet terms of the same type and with the same $m$ value. In most cases the triplet term value

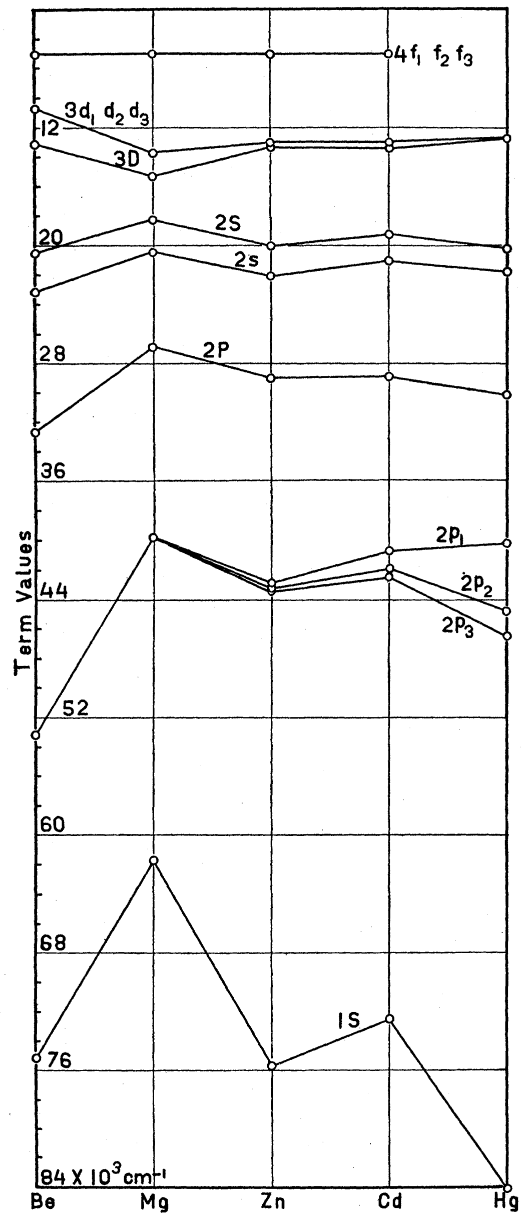


Fig. 4. Term values for Be, Mg, Zn, Cd, and Hg.

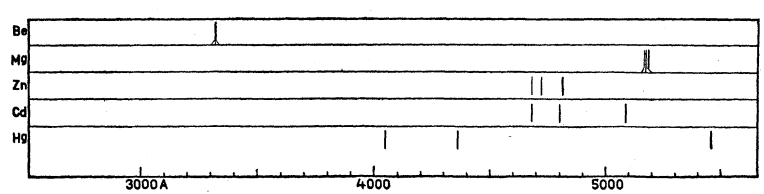


Fig. 5. Relative separation and position in spectrum of the triplet $2p_{1,2,3}-2s$ of Be, Mg, etc.

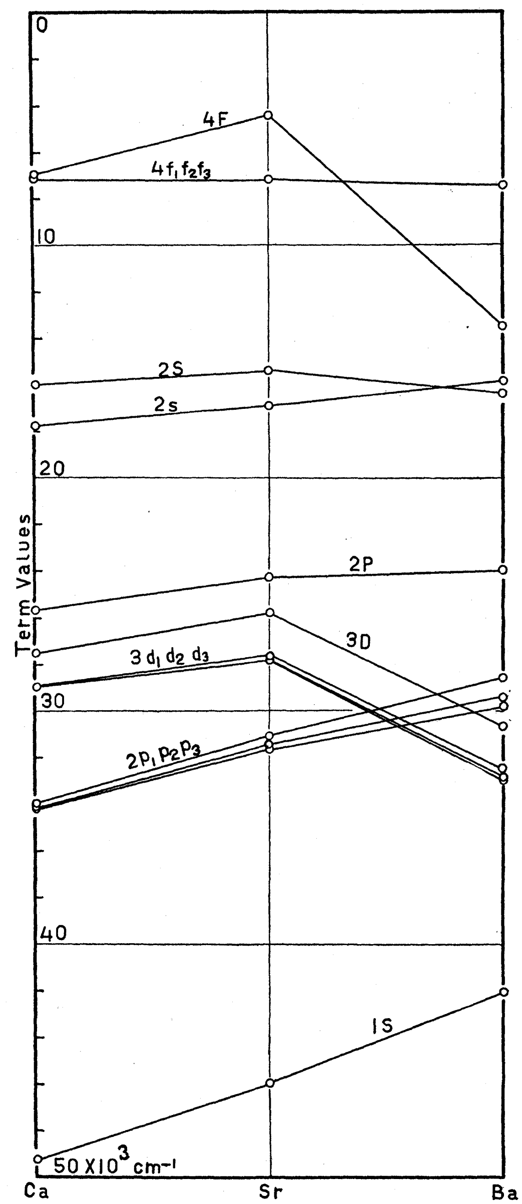


Fig. 6. Term values for Ca, Sr, and Ba.

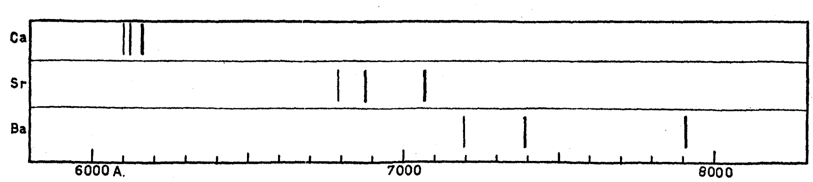


Fig. 7. Relative separation and position in spectrum of triplet $2p_{1,2,3}-2s$ of Ca, Sr, and Ba.

TABLE III. *m values in triplet series.*

| Series | Formula | $m$ values | |
|---|---|---|---|
| | | Fowler | Paschen and Götze |
| Principal (Haupt) | $1s-mp_{1,2,3}$ | 2, 3, 4, · · · . | 3, 4, 5, · · · . |
| Sharp (II Neben) | $1p_{1,2,3}-ms$<br>$(2p_{1,2,3}-ms)$ | 1, 2, 3, · · · . | 2, 3, 4, · · · . |
| Diffuse (I Neben) | $1p_{1,2,3}-md,\ d',\ d''$<br>$(2p_{1,2,3}-md_1,\ d_2,\ d_3)$ | 2, 3, 4,[a] · · · . | 3, 4, 5,[b] · · · . |
| Fundamental (Bergmann) | $2d,^{c}\ d'\ d''-mf,\ f',\ f''$<br>$(3d_1,d_2,d_3-mf_1,f_2,f_3)$ | 3, 4, 5, · · · . | 4, 5, 6, · · · . |

[a] 1, 2, 3, · · · for Ca and Sr.
[b] 4, 5, 6, · · · for Ba.
[c] 1 for Ca, Sr and Ba.
Minimum $m$ values have been so chosen as to exclude negative wave numbers.

is larger than the corresponding singlet term value. Similar relations hold for Ca, Sr, and Ba as shown in Fig. 6. In Figs. 5 and 7 are shown the relative positions in the spectrum of certain corresponding triplet lines. The rapid decrease in triplet term separation with increasing $m$ is illustrated in Fig. 8 with data from Hg.

While the diffuse triplet series of lines is represented by differences between three $p$ terms and three $d$ terms, not all of the nine possibilities are observed. At most not more than 6 lines are found, and sometimes some of these are too weak to observe. Just how accurately sets of term values can be found that will serve to relate observed wave numbers is illustrated in Table IV. In each case the observed wave-length in air is given in angstroms and

TABLE IV. *Observed combinations of triplet terms of Ba. Paschen and Götze notation.*

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| $26229_{vac}$<br>3812.6 | | | | | $4f_1$<br>7398.6 | 3993.40<br>25034.4 | | — | | — |
| | | | | | (14.2)<br>$4f_2$<br>7412.8 | (14.2)<br>3995.66<br>25020.2 | (381.0) | 3935.72<br>25401.2 | | — |
| $4d_1$<br>11211.6 | (67.4) | $4d_2$<br>11279.0 | (54.9) | $4d_3$<br>11333.9 | (14.0)<br>$4f_3$<br>7426.8 | (14.1)<br>3997.92<br>25006.1 | (381.2) | (13.9)<br>3937.88<br>25387.3 | (181.5) | 3909.92<br>25568.8 |
| 5777.7<br>17303.2 | (67.4) | 5800.30<br>17235.8<br>(878.1) | (55.1) | 5818.91<br>17180.7<br>(878.2) | $2p_1$<br>28514.8<br>(878.0) | 25515.7<br>3918.2 | (380.8) | 23255.3<br>4299.0<br>(877.9) | (181.6) | 22313.4<br>4480.6<br>(878.0) |
| — | | 5519.12<br>18113.9 | (55.0) | 5535.93<br>18058.9<br>(370.5) | $2p_2$<br>29392.8<br>(370.5) | — | | 29223.9<br>3421.1 | (181.5) | 27751.1<br>3602.6<br>(370.5) |
| — | | — | | 5425.55<br>18429.6 | $2p_3$<br>29763.3 | — | | — | | 30933.8<br>3231.9 |
| | | | | | | 32433.0<br>$3d_1$ | (381.1) | 32814.1<br>$3d_2$ | (181.5) | 32995.6<br>$3d_3$ |

below it the corresponding wave-number in vacuum. In the upper right hand corner of the table are found the combinations (differences) between *3d* and *4f* terms, first members of a Bergmann series; in the lower left hand corner, combinations between $2p$ and $4d$ terms, members of a diffuse series; and in the lower right hand corner, combinations between $3d$ and $2p$ terms, members of an unnamed series although listed by some as negative members of the above diffuse series. A single observed line serves as the lone representative of the

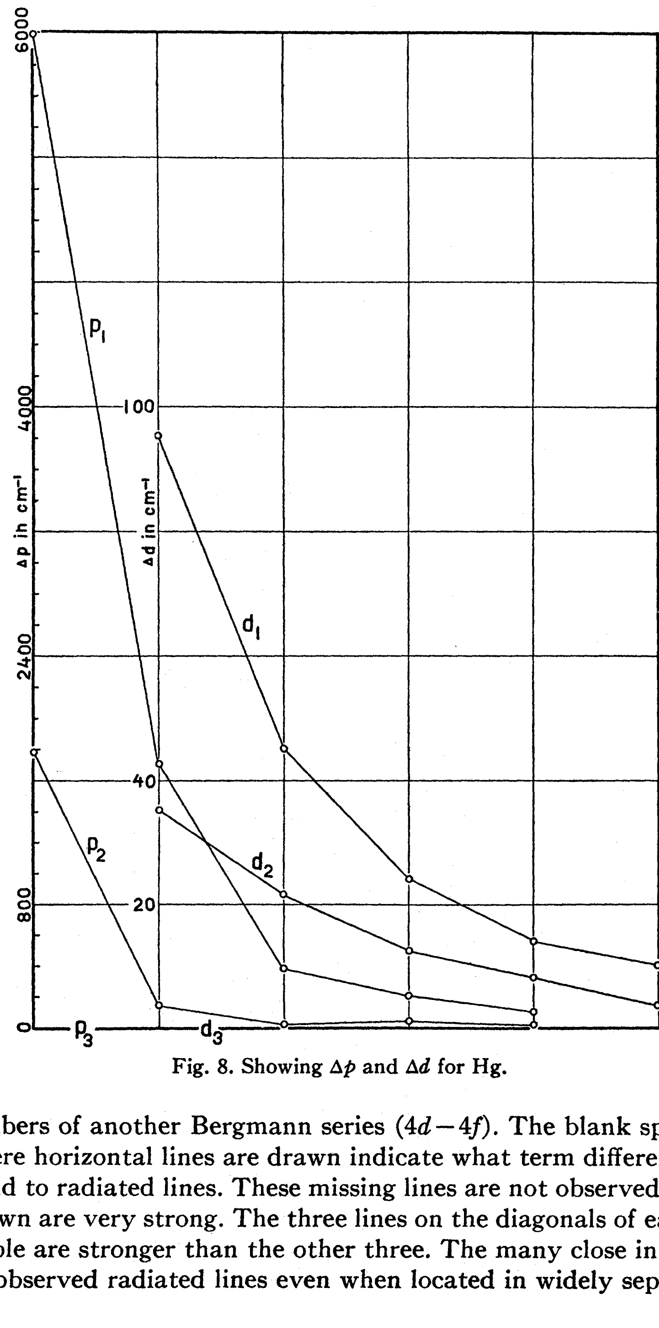


Fig. 8. Showing $\Delta p$ and $\Delta d$ for Hg.

first members of another Bergmann series $(4d-4f)$. The blank spaces in the table where horizontal lines are drawn indicate what term differences do not correspond to radiated lines. These missing lines are not observed even when those shown are very strong. The three lines on the diagonals of each quarter of the table are stronger than the other three. The many close interrelations between observed radiated lines even when located in widely separated portions of the spectrum is clearly demonstrated by the numerous almost exact common differences. These common differences and even the wave numbers themselves are independent of the absolute values of the terms for if all the terms were increased or decreased by the same amount all differences between them would remain unchanged. The absolute values of the terms are determined from series limits as will be illustrated later in this report, but the close numerical interrelations between radiated lines when once established are entirely unaffected by the accuracy of the absolute values of the terms.

## Spectra of Singly Ionized Atoms

Whenever a single electron is removed from an atom of any element the number of extranuclear electrons remaining is equal to that in a neutral atom of the next preceding element in the periodic table. It is plausible, therefore, to anticipate similar types of radiations from two such isoelectronic atoms or ions. Numerous instances of such similarities were observed prior to the publication of spectral tables by Fowler and by Paschen and Götze in 1922 and were included by them in their reports. A few illustrations taken from their data will suffice for the present to point out the nature of this similarity. It was early noted that the spectra obtained from an arc and from a spark of the same element exhibited marked differences. Some lines appearing in the arc did not appear in the spark and vice versa. Some lines appearing in both arc and spark showed a greater relative intensity in the spark while others were relatively weaker. To those lines appearing only in the spark and to those whose intensity was increased on passing to the spark the term enhanced lines was applied. It was found possible to arrange the enhanced lines of magnesium, calcium, strontium and later barium into a family of series involving doublet terms exactly similar to those of the alkali metals. The formula defining a series for the enhanced lines was different from that of the corresponding arc series of the alkalis in that the terms contained a factor of 4 in the numerator and in general a wave number was expressed by

$$\nu = \frac{4R}{(m' + \mu')^2} - \frac{4R}{(m + \mu)^2}.$$

Later these enhanced line series came to be regarded as arising from singly ionized atoms, an assumption that has been fully corroborated by recent developments in both theory and experimentation, and the extra factor of 4 is fully accounted for.

These larger term values are derived from larger wave-numbers so that the doublet spectra of singly ionized calcium, sometimes indicated by $Ca^+$, now more commonly designated as Ca II, are on the whole displaced toward the violet from the corresponding doublet series in the spectra of neutral potassium, which in accordance with the above convention may be designated as K I. Some of the term values for Ca II, Sr II, Ba II and Ra II are shown in Fig. 9. When one takes into consideration the much reduced scale of plotting used in Fig. 9 compared with that in Fig. 3, it at once becomes evident how very much larger the separations between terms of a given type become in passing from the spectra of neutral atoms such as K, Rb, and Cs to those of Ca II, Sr II and Ba II. A further comparison of these figures reveals another important difference between these spectra namely the marked shift in the relative position of the corresponding $p$ and $d$ terms.

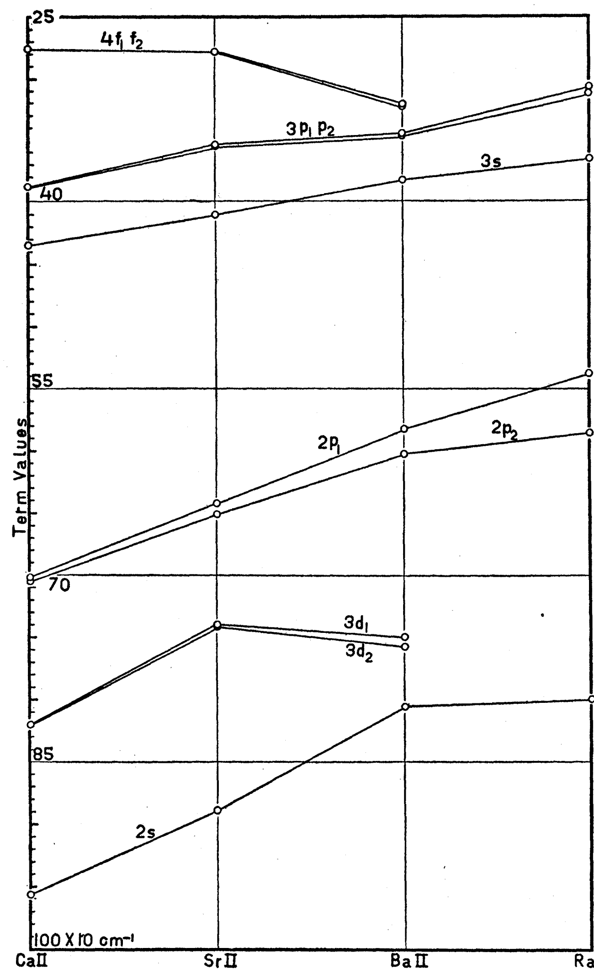


Fig. 9. Variation in term values and doublet separations for the first spark spectra of the alkaline earths.

## Series of Terms

As has already been pointed out in a previous section the value of $m$ in the variable Rydberg term of a given type that will yield a minimum positive wave number for a given series of radiated lines does not always coincide with the value of $m$ corresponding to the maximum value of that type of term for any given element. In other words, whenever there is any difference between the two cases, the variable term in the Rydberg formula for a series of radiated lines fails to assume for a given series of positive wave numbers all possible or existing values of that term.

For example in Table I the minimum value of $m$ for positive wave numbers in the sharp (or II Neben) series of alkali doublets is 2 whereas there exists a $\sigma$ or $s$ term for which $m=1$ as indicated in Table V, which term is the limit for the principal (or haupt) series of radiated lines. Failure thus to include all possible variable terms in any given series of radiated lines is even more marked in such cases as $\nu=3\sigma-m\pi$, $m=3, 4, 5, \cdots$, the first number of which series is listed as a combination by Fowler for caesium (see p. 108). In this case both the $1\pi$ and $2\pi$ terms are not included in defining the series of radiated wave-numbers. Numerous other instances of this sort can be found in the tables of Fowler and of Paschen and Götze. In Table V are listed the

TABLE V. *m values for a series of terms*

| Fowler | | | Paschen and Götze | | |
|---|---|---|---|---|---|
| Term | $m$ | Series | Term | $m$ | Series |
| $S\sigma s$ | $1, 2, 3, \cdots$. | Singlets, Doublets, Triplets | $Ss$ | $1, 2, 3, \cdots$. | Singlets, Alkali Doublets |
| $P\pi p$ | $1, 2, 3, \cdots$. | Singlets, Doublets, Triplets | $s$ | $2, 3, 4, \cdots$. | Doublets (CaII, SrII, BaII), Triplets |
| $D\delta d$ | $2, 3, 4, \cdots$. | Singlets, Doublets, Triplets (Except for Ca, Sr, Ba) | $Pp$ | $2, 3, 4, \cdots$. | Singlets,[b] Doublets, Triplets |
| $D\delta d$ | $1, 2, 3, \cdots$. | Singlets, Doublets, Triplets (For Ca, Sr, Ba) | $Dd$ | $3, 4, 5, \cdots$. | Singlets, Doublets, Triplets |
| $F\phi f$ | $3, 4, 5, \cdots$. | Singlets,[a] Doublets, Triplets | $Ff$ | $4, 5, 6, \cdots$. | Singlets,[c] Doublets, Triplets |

[a] $F$ 2, 3, 4, $\cdots$ for Ba. [b] $P$ 1, 2, 3, $\cdots$ for Ca. [c] $F$ 2, 3, 4, $\cdots$ for Sr.

values of $m$ as assigned by both of the above mentioned authors for a series of terms of the various types, in the case of elements appearing in the first two groups (columns) of the periodic table. It is upon terms as thus defined for the present that we shall place the greater emphasis as the discussion proceeds, leaving the radiated wave number to be thought of merely as the difference between two properly chosen terms. We, of course, establish the term values from observed radiations and then tabulate the terms and use them to designate the various radiations. One needs, therefore to become thoroughly familiar with the notations used for representing terms. This is true of these notations as well as of some that have come into use more recently and which will be described later, for the notations of Fowler and of Paschen and Götze are still often used by some writers. The fact that these authors do not always agree in assigning values to $m$ for a given term is more a source of annoyance to the worker in the field who must of necessity be ready to distinguish between the two systems, than of fundamental significance. Fowler's use of Greek letters to represent doublet terms is of some assistance in reducing confusion arising from different $m$ value assignments. In the case of singlet and triplet terms one often has to search among numerical values given for a clue as to the system being used by an author. Sometimes the nationality or language of the author furnishes a safe initial guide in the matter.

It is more or less immaterial how the $m$ values are assigned to the terms for as the value of $m$ in a given Rydberg term, $R/(m+\mu)^2$ for example, is given smaller and smaller or larger and larger integer values $\mu$ assumes correspondingly larger and larger or smaller and smaller values. The only important point to remember is that in a series of Rydberg terms $m+\mu$ changes by 1 in passing from one term to the next and as we propose to bring about this change merely by giving $m$ successive positive integer values it is quite immaterial what integer is selected as a minimum, provided $\mu$ is adjusted accordingly.

In general Fowler chose to make the minimum value of $m$ as small an integer as possible without letting $\mu$ become very large (never as large as 2) and at the same time maintain a fairly uniform system for similar elements. In no case do his assignments of $m$ values make the values of $\mu$ negative. Paschen and Götze, on the other hand, used for the most part somewhat larger values of $m$ for corresponding terms, thereby making it frequently necessary for $\mu$ to assume a negative value. Their system of assignment is somewhat simpler and more easily remembered. Except for certain $s$ terms the $s$, $p$, $d$, and $f$ terms (including capitals as well) almost always begin the sequence with an $m$ value of 1, 2, 3 and 4 respectively.

## Determination of Series Limits

Although the limits and term values appearing in the reports by Fowler and by Paschen and Götze have been computed in general from more exact formulae, it is desirable first to consider how the simple Rydberg formula can be utilized for this purpose. With a minimum of observed data approximate series limits can be obtained with this formula, thus making it possible to establish a provisional set of terms from which the wave numbers of as yet unobserved radiated lines can be computed approximately.

Suppose for example we were furnished with the following observed wave-lengths and were assured that there is good reason to think they constitute the first two pairs (unresolved) of lines in the principal series of lithium.

$$\lambda_P(1) = 6707.85$$

$$\lambda_P(2) = 3232.61.$$

To determine series limits and term values we would first compute the corresponding wave numbers in vacuum. If the wave-lengths happened to be given in terms of the Rowland scale, correction to the international scale (based upon the International angstrom which is represented by I. A. and is defined by agreeing to call the wave-length of a certain red Cd line measured in dry air at 15°C, 760 mm pressure and with $g=980.67$ as 6438.4696 I.A., an agreement that was reached in 1907 by the International Solar Union now a part of the International Astronomical Union) and then to vacuum would have to be made. These corrections are greatly facilitated by use of the tables appearing on pages 80 and 81 of Fowler's report. The wave numbers in vacuum for the above lines of lithium are found to be

$$\nu_\pi(1) = 14903.8$$

$$\nu_\pi(2) = 30925.9\ .$$

Then according to Rydberg's formula

$$14903.8 = A_\pi - \frac{109678.3}{(1+\pi)^2}$$

$$30925.9 = A_\pi - \frac{109678.3}{(2+\pi)^2}.$$

Fowler used $R = 109678.3$ cm$^{-1}$, a value that as we shall see later is slightly too small for lithium.

Eliminating $A_\pi$, we have

$$16022.1 = \frac{109678.3}{(1+\pi)^2} - \frac{109678.3}{(2+\pi)^2}.$$

Solving this equation by the method of successive approximations we find $\pi = 0.960483$ from which the terms $1\pi$ (symbolic notation) $= (109678.3)/(1+0.960483)^2 = 28536.1$, and $2\,\pi$ (symbolic notation) $= (109678.3)/(2+0.960483)^2 = 12514$ whence $A_\pi = 43439.9$. This value for the limit is slightly smaller than that derived by Fowler from a more complex formula which represents the series much more exactly. However, the agreement is fairly good, the percentage difference being only about 0.1 of one percent, a variation that in many branches of physics would be considered extremely small.

To determine how closely the observed radiations are represented by the Rydberg formula in this case, we may compare the observed wave numbers with those computed according to the above Rydberg formula.

$$\nu = 43439.9 - \frac{109678.3}{(m+0.960483)^2}.$$

TABLE VI. *Check on Rydberg formula.*

| $m$ | $\nu$(Compt.) | $\nu$(Obs.) | $\Delta\nu$ |
|---|---|---|---|
| 1 | 14903.8 | 14903.8 | 0.0 |
| 2 | 30925.9 | 30925.9 | 0.0 |
| 3 | 36447.5 | 36468.1 | 20.6 |
| 4 | 38982.6 | 39012.7 | 30.1 |
| 10 | 42526.9 | 42569.1 | 42.2 |

The deviations illustrated in Table VI increase gradually with $m$ and show that the simple Rydberg formula is not adequate to define the principal series with great accuracy although the values thus obtained for the limit of this series and for the wave numbers of the higher members of the series are not far wrong. If one were seeking to discover this series and felt reasonably sure of his observations for the first two members, he could utilize the Rydberg formula as above to predict the position of the third member. Thus the $\lambda_{vac}$ for the third member would according to the above computation $= 10^8/36447.5 = 2743.67$A and $\lambda_{air} = 2743.67 - 0.81 = 2742.86$A. (See p. 81 of Fowler's Report.)

A line due to lithium is found at 2741.31A, very close to the wave-length predicted by the Rydberg formula. If we now use the second and third members of the principal series in a Rydberg formula we have

$$30925.9 = A_\pi - \frac{109678.3}{(2+\pi)^2}$$

$$36468.1 = A_\pi - \frac{109678.3}{(3+\pi)^2}\cdot$$

Subtracting

$$\Delta\nu = 5542.2 = \frac{109678.3}{(2+\pi)^2} - \frac{109678.3}{(3+\pi)^2}\cdot$$

Suppose now instead of using the laborious method of successive approxima tions, we take advantage of a Rydberg Interpolation Table as given on pp. 82–84 of Fowler's Report. We search in the columns headed by $\Delta\nu$ for values nearest to 5542.2 and find 5573 and 5524 indicating that $\pi$ lies between 0.95 and 0.96 and that $(109678.3)/(2+\pi)^2$ lies between 12603 and 12518 and $(109678.3)/(3+\pi)^2$ between 7030 and 6994. Interpolating we obtain 12549.6 for $(109678.3)/(2+\pi)^2$ and 7007.4 for $(109678.3)/(3+\pi)^2$.
Whence

$$A_\pi = 30925.9 + 12549.6 = 43475.5$$

$$= 36468.1 + 7007.4 = 43475.5.$$

Further interpolation from Rydberg's table gives results shown in Table VII.

TABLE VII. *Further check on Rydberg formula.*

| $m$ | $R/(m+\pi)^2$ | $\nu$ Comp. | Obs. | $\Delta\nu$ |
|---|---|---|---|---|
| 4 | 4464.7 | 39010.8 | 39012.7 | 1.9 |
| 5 | 3091.7 | 40383.8 | 40387.1 | 3.3 |
| 6 | 2266.6 | 41208.9 | 41213.0 | 4.1 |
| 9 | 1106.7 | 42368.8 | 42372.7 | 3.9 |

From the above data we see higher members of a series can be predicted more accurately from the application of the Rydberg formula to the second and third members of a series than to the first and second.

So far we have applied the Rydberg formula only to lines in the principal series. We will now examine the corresponding results as obtained from the data of the sharp and diffuse series. Omitting negative wave numbers, as their inclusion often introduces a marked error, we have for lithium

$$\nu_\sigma(2) = 12302.0 = A_\sigma - \frac{109678.3}{(2+\sigma)^2}$$

$$\nu_\sigma(3) = 20107.3 = A_\sigma - \frac{109678.3}{(3+\sigma)^2}$$

and $\Delta\nu = 7805.3$.

Interpolating from Rydberg's table we have

$$\frac{109678.3}{(2+\sigma)^2} = 16294.4$$

and

$$\frac{109678.3}{(3+\sigma)^2} = 8487.0$$

whence

$$\begin{aligned} A_\sigma &= 12302.0 + 16294.4 = 28596.4 \\ &= 20107.3 + \ \ 8487.0 = \underline{28594.3} \\ &\qquad\qquad\qquad\quad \text{av. } 28595.3 \ . \end{aligned}$$

Similar computations from the diffuse series data are as follows:

$$\begin{aligned} \nu_\delta(2) &= 16379.4 = A_\delta - \frac{109678.3}{(2+\delta)^2} \\ \nu_\delta(3) &= 21719.0 = A_\delta - \frac{109678.3}{(3+\delta)^2} \\ \Delta\nu &= 5339.6. \end{aligned}$$

From Rydberg's table

$$\frac{109678.3}{(2+\delta)^2} = 12199.1$$

$$\frac{109678.3}{(3+\delta)^2} = 6860.1.$$

Whence

$$\begin{aligned} A_\delta &= 16379.4 + 12199.1 = 28578.5 \\ &= 21719.0 + 6860.1 = \underline{28579.1} \\ &\qquad\qquad\qquad \text{Av. } 28578.8 \ . \end{aligned}$$

The value of $1_\sigma = A_\pi$ may also be computed from these data for

$$\begin{aligned} A_\pi &= A_\sigma + \nu_\pi(1) = 28595.3 + 14903.8 = 43499.1 \\ &= A_\delta + \nu_\pi(1) = 28578.8 + 14903.8 = 43481.8. \end{aligned}$$

Repeating for the sake of comparison,

$1\sigma = A_\pi$ from principal series lines $= 43439.9$

$1\sigma$ from Fowler's Report, p. 97 (Hicks formula) $= 43486.3$.

Thus the largest term value in the lithium arc spectrum determined by the application of the simple Rydberg formula to the first two members of either the principal, sharp or diffuse series (to the first two of the variable $\pi$, $\sigma$, or $\delta$ terms of series formula but not involving negative wave numbers) is in fairly good agreement with that found by using the more precise Hicks formula, the use of which will be explained shortly. The agreement is least exact for the $\pi$ terms, is much better for the $\sigma$ terms, and is best for the $\delta$ terms. This relative degree of agreement is not completely maintained for the other alkali elements, for although the $\sigma$ terms continue to yield better agreements than the $\pi$ terms, the value of $1\sigma$ computed from the $\delta$ terms is generally much too small. These differences are not greatly unlike those described by Russell (Qg 623) for more complex spectra. Whenever the data are limited to so few terms that the limits can be determined only by the use of a Rydberg formula it is always well to determine as many limits as possible and use an average to fix the value of the highest term in the spectrum. For example in the rubidium spectrum

$$\begin{aligned} 1\sigma &= 34022.2 \text{ from } \pi \text{ terms} \\ &= 33762.4 \text{ from } \sigma \text{ terms} \\ &= 33263.8 \text{ from } \delta \text{ terms} \\ &= 33682.8 \text{ average of above} \\ &= 33689.1 \text{ from Hicks formula.} \end{aligned}$$

How accurately the Hicks formula defines the principal series of rubidium is shown on pp. 105–6 of Fowler's report.

In several instances, as in the spark spectra of zinc and cadmium where the data were meagre, Fowler has determined the limits from a Rydberg table. In such cases a system of term values has been worked out which are correct relative to each other provided only the radiated lines have been correctly identified. In other words a correct system of relative term values can be set up from observed wave numbers even though the largest term value upon which the system is based may be quite incorrect in absolute value. For reasons that will appear later it is, however, desirable to determine the absolute value of the whole system as accurately as possible. One seeks, therefore, to find the limit of a series with fairly high precision.

## More Precise Series Formulae

A great many attempts have been made to improve upon the formula of Rydberg in an endeavor to find a not too complex expression that will more accurately define the various members of a series. Some of the improvements proposed are described on pages 31–38 of Fowler's report. Among these one commonly known as the Hicks formula and the other as the Ritz formula deserve special consideration here because of their widespread use. Interesting comments upon these formulae are made on pages 32–35 of Fowler's report. Our purpose here will be briefly to point out certain salient features and to indicate how to use them.

The Hicks formula as used almost exclusively by Fowler in his report is as follows:

$$\nu = A - \frac{R}{\left(m + \mu + \dfrac{\alpha}{m}\right)^2}.$$

Ritz proposed formulae in various forms, two of which have been used extensively. They may be written as follows:

$$\nu = A - \frac{R}{\left(m + \mu + \frac{\beta}{m^2}\right)^2}$$

$$\nu = A - \frac{R}{[m + l + k(A - \nu)]^2}.$$

All three of these formulae, wherein $\mu$, $\alpha$, $\beta$, $l$ and $k$ are constants for any one series and $m$ assumes successive integer values as we pass from member to member through the series, are essentially three-constant formulae but of quite a different type from those used by Kayser and Runge as previously described. They all retain the Rydberg form of expressing the wave number as the difference between a fixed and a variable term. As Rydberg modified the Balmer formula by inserting an additive constant in the denominator of the variable term so here both Hicks and Ritz modified the Rydberg formula by a further but variable addition to the same denominator. The constants $\alpha$, $\beta$ and $k$ are very small so that even for small values of $m$ the denominator of the variable term is thus changed only to a slight extent and this change becomes less and less as $m$ is increased. But this is just the sort of correction to the formula that is needed to satisfy more closely the observed data for, as has already been pointed out with a concrete example, the deviations from a Rydberg formula become smaller and smaller as we pass to the higher members of a series. To utilize a Hicks or Ritz formula, observational data must be available involving at least three values of the variable term. As a means of determining the limit of a series or what amounts to the same thing the maximum value of a series of like terms these formulae are usually very reliable even when only the minimum required data are known. One can usually depend upon them for predicting very closely the location of additional lines in a series. When the observations include many lines of a series it is possible to adjust the constants slightly so as to give a maximum of agreement with observations throughout the series. It was in connection with the study of such adjustments that Hicks was led to think the numeration of terms (choice of $m$ values) was properly made when the agreement with observations was most complete. Even if his conclusion were accepted as being widely applicable it would be better to sacrifice a certain amount of accuracy in agreement between data and formula for the sake of a uniform system of numeration, a procedure that has been generally followed by Fowler and by Paschen and Götze. On pages 76–78 of his report Fowler has described three ways of computing the constants for a formula such as that of Hicks. He also indicates the procedure followed by Saunders and others in adjusting limits when the observations are not so closely in agreement with these formulae.

As has already been mentioned Fowler used the above Hicks formula for computing series limits and term values given in his report except in those cases where incomplete data made it possible to determine only rough approximations to the values of these quantities by means of a Rydberg formula. He says of that formula, "the Hicks formula seems to have been proved by general experience to be even more accurate than that of Ritz, and it is probably the most generally useful formula which has yet been proposed".

In building his table of limits and term values Fowler determined the constants in a Hicks formula for one of the chief series, the series selected being in general the one for which the data were the more complete or were considered the more accurate. With the limit of one series thus found the term values connected with that series were then obtained by subtracting the various observed wave numbers from that limit. After the limits of the other chief series were determined by applying the Rydberg-Schuster and Runge laws which have been illustrated in Fig. 1, the term values for these series were obtained in a similar manner. It was usually found that quite a few of the wave numbers of observed lines, not already assigned to the chief series, were fairly closely equal (often exactly equal) to the difference between two of the terms obtained for the four chief series. These lines sometimes forming more or less fragmentary series have been listed as combination lines with the terms from which they originate indicated. For example in the case of lithium the constants in the formula, $\pi_1(m) = 43486.3 - R/(m + 0.951125 + 0.007766/m)^2$, were determined evidently from the first two lines and some higher member, possibly the 40th, of the principal series. How closely the principal series of lithium is represented by this formula can be seen from the residuals given on page 98. These residuals are the differences, $(\Delta\nu)$, between the observed and computed wave numbers. Usually these residuals are well within the accuracy of the observations. The combinations $1\pi - m\pi$ are rather unusual. However, as we shall see later the combinations $2\pi - m\sigma$ and $2\pi - m\delta$ are quite to be expected on the basis of quantum ideas.

The tables by Paschen and Götze contain much the same data as these of Fowler. Their limits have been determined mainly by means of a Ritz formula. In many cases the data given are the same as those given in a report published by Dunz. Some others have been taken from a hand written dissertation compiled by Frommel in 1921. The constants of the Ritz formula are not given for any of the series and it is therefore impossible to ascertain readily how closely the formula agree with observed data. Even where Fowler and Paschen and Götze have used the same wave-length data, as in the case of the principal series of sodium, they list slightly different wave numbers, having apparently used different data for correction of wave-lengths to vacuum. Further differences are introduced in computing limits and term values by the use of different formulae and in some cases by using different values for $R$. Except for helium Fowler has used 109678.3 for $R$ throughout his tables. Paschen and Götze do not state what value they have used for $R$. Where they have used the earlier computations of Dunz it is safe to assume that the computations have been based upon a value of $R$ comparable with that used by Fowler. The fact that in the back of their book Paschen and Götze have inserted a Rydberg table (less complete than the one given by Fowler) in which a value of 109737.1 is used for $R$, suggests that this latter value has been used in their series computations in some cases. These discrepancies, however, are on the whole of minor significance and are commented upon merely to assist the student of spectroscopy in overcoming a certain lack of confidence that is likely to develop when he undertakes first to examine these data in detail.

Anyone who compares the data given in the above reports will discover in certain cases a systematic lack of agreement in wave-length values even when both have been taken from the same original source. For example, the line $\lambda$5085.88 as given by Fowler for one member of a triplet in the cadmium arc spectrum is listed as $\lambda$5086.06 by Paschen and Götze, who in this case used the Rowland system of wave-lengths whereas Fowler expressed the wave-length in International angstroms, which system he has used throughout for all wave-lengths less than 10000 angstroms. Paschen and Götze have used both the Rowland and the International systems without always indicating in connection with their wave-length tables just which system has been employed. However, at the end of their report, pp. 142–149, they include a tabulation of term values and there list in every case the system of wave-lengths used in obtaining these values.

In a few cases such as the arc spectra of calcium and barium the tables in the two reports are in almost complete agreement even to the last significant figure, both authors having incorporated without change the wave-lengths, term values and limits as determined by Saunders.

A very complete tabulation of the arc spectrum of neon has been given in the report by Paschen and Götze. An explanation of the symbols used will be given later. It should, however, be mentioned that this analysis of the neon spectrum by Paschen, made before the development of the ideas of space quantization and electron coupling, has proved remarkably in accord with these later developments and has served as a useful guide in analyzing the corresponding spectra of the other rare gases. Neon, argon, krypton and xenon have all been found to have spectral series for the neutral atom that are very closely similar in character.

## Ritz Combination Principle

The general series formula as proposed by Rydberg for the wave number $\nu = R/(m_1+\mu_1)^2 - R/(m_2+\mu_2)^2$ contained two numeration numbers, $m_1$ and $m_2$, one of which, $m_1$, appeared in the term constituting the limit of a series and accordingly remained constant for any series of radiated lines. In most of his work Rydberg assigned a value of 1 to $m_1$ but he did not fail to recognize that possibly other parallel series might exist for which the limiting term would have the same value of $\mu_1$, but with $m_1$ assuming values of 2 or 3. He, however, failed to establish any such series but the same idea was enlarged upon by Ritz in 1908 who pointed out that aside from the term differences constituting the four chief series, there existed in various spectra lines whose wave numbers were equal to the differences between other terms taken from one or more of the four chief sequences. Ritz called these lines "combination lines" or "combination series" when several such lines formed a series. The agreement between such differences and the radiated wave numbers would be independent of the correctness of the absolute values of the terms themselves for in any consistent term value system all terms may have merely relative values, as was pointed out in connection with the Rydberg-Schuster and Runge laws. Ritz was inclined to consider this combination between terms as having universal application with lines to be expected for all differences between any two terms and to regard missing lines as simply too weak to be observed. The later development of the quantum theory has shown that for certain types of radiation some of the Ritz combination lines are "forbidden" or perhaps better are extremely improbable under ordinary circumstances. The degree of probability for these "forbidden" lines varies widely for different combinations and accordingly under certain conditions of pressure, electric field, and mode of excitation some of the more probable of these improbable or "forbidden" lines are observed. Indeed the observations of the past few years have revealed a slightly wider application of the Ritz "combination principle" than was thought in the decade immediately preceding to exist. Some of the "combination series", however, are very commonly observed and might well have been included among the classification of chief series. For example, the $1D-mP$ singlet series of calcium may just as properly be regarded as a chief series as are the sharp, diffuse, principal or fundamental series.

One of the direct applications of the Ritz combination principle was the prompt discovery by Paschen in 1908 of two members of an infrared series in the hydrogen spectrum which could be represented by

$$\nu = R_H\left(\frac{1}{3^2} - \frac{1}{m^2}\right) m = 4, 5, 6, \cdots .$$

a formula that involves merely the difference between terms already known from the Balmer series of Hydrogen. Poettker (H 236) has extended this Paschen series to 8 members. Two years earlier Lyman had reported three members of a series in the extreme ultraviolet spectrum of hydrogen whose wave numbers could be expressed by

$$\nu = R_H\left(\frac{1}{1^2} - \frac{1}{m^2}\right), \quad m = 2, 3, 4, \cdots .$$

This series also is in agreement with the combination principle of Ritz. Further direct applications of this principle are found in the series of hydrogen lines observed by Brackett (H 52) and Pfund (H 135) whose wave numbers are given by Brackett

$$\nu = R_H\left(\frac{1}{4^2} - \frac{1}{m^2}\right) m = 5, 6, 7, \cdots .$$

Pfund

$$\nu = R_H\left(\frac{1}{5^2} - \frac{1}{m^2}\right) m = 6, 7, 8, \cdots .$$

These series, both of which lie well out in the infrared, were discovered sometime after the theoretical basis for the combination principle had been completely changed and elaborated by the introduction of the quantum theory. Indeed the theoretical arguments advanced by Ritz in proposing this principle were quite unsound even in terms of the older classical theory. It is an excellent example of how a fundamentally correct idea is envisioned through false reasoning, to be later explained on an entirely new basis, the theoretical development of which was encouraged and assisted to some extent by the very idea itself. Observations indicated that the "combination principle" had wide application. There were many instances in which observed wave-numbers agreed with the differences between terms already established from other data. Any valid theory must find a basis for such agreements. The energy changes demanded by the quantum theory found confirmation and support in these agreements and to a certain extent the development of this theory was quickened by them.

## The Bohr Theory of the Atom

To appreciate fully the significance of the step taken by Bohr in 1913 when he applied the quantum theory, as then developed, to explain the behavior of atoms in producing line spectra, one needs to have clearly in mind the essential features of the progress already made up to that time in interpreting experimental observations by means of deductions arising from the quantum theory of Planck. It is hardly possible to discuss such questions here in detail but it will perhaps be advantageous to recall briefly a few of the more important conclusions and suggestions that were available for Bohr to draw upon when he began this study.

The changes occurring in atomic and molecular energy in either radiation or absorption took place in discrete energy units or quanta whose energy content was in every case proportional to the frequency of the radiation involved, a relation briefly expressible in equational form as $\Delta E = h\bar{\nu}$. The harmonic oscillators which served as the source or absorber of radiation were each assumed to possess energy only in discrete amounts. These assumptions served satisfactorily to account for the observed facts of black body radiation and photoelectric phenomena. At the Solvay Congress in 1911 Planck pointed out a consequence of the above relation in the case of an harmonic oscillator, to the effect that for an oscillator possessing an energy of $nh\bar{\nu}$ the integral of $pdq$ taken over a complete oscillation is equal to $nh$ where $p$ represented the momentum of the oscillator and $q$ its corresponding position coordinate and $n$ is an integer. Expressed as an equation, this relation takes the form

$$\oint pdq = nh.$$

In applying this deduction to a rotator of constant angular momentum, $p$, it was shown that $p$ assumes values equal to $nh/2\pi$, that is, the momentum is so to speak quantized into units that are multiples of $h/2\pi$. This consequence was then considered by Planck as having fundamental significance and possibly wide application. At the same meeting Sommerfeld, who later but simultaneously with others gave greater generality to the momentum quantum conditions, pointed out the relation of this deduction to the quantity called action, that occurs in Hamilton's principle of least action. $h$, which has the dimensions of energy-time, has appropriately been termed Planck's quantum of action.

In the following year Nicholson (Monthly Notices, R.A.S. **72,** 679) attempted to utilize these ideas in analyzing certain astronomical spectra. In doing so he came dangerously close to a significant solution. He applied the proper quantum conditions for a rotator but placed the emission frequency equal to the mechanical frequency of the rotating electron. In 1912 evidence was presented by Rutherford that led the scientific world to accept almost without question the existence of atoms with positive nuclei that were rendered neutral by surrounding electrons, an acceptance that has remained unqualified for nearly 20 years and which accordingly deserves to be classified as one of the outstanding scientific discoveries of the present century. The experiments of Rutherford and his co-workers clearly demonstrated the existence of a Coulomb electric field within those confines of the atom in which the extranuclear electrons were thought to exist.

With this richly suggestive background Bohr undertook to find a way of accounting for atomic or line spectra. In his first paper on the subject published in 1913 Bohr (Phil. Mag. **26,** 1, 1913) presented what at first seemed radical but, when considered in the light of the then recent developments, plausible arguments which led to the formulation of an expression that yielded quantitative results in close agreement with the observed line radiations from hydrogen. He combined boldness with conservatism and by an ingenious choice of both classical and quantum principles took an initial step that with subsequent changes, additions, and corrections has served greatly to widen and extend our understanding of the laws and processes of emission and absorption of radiation as well as of a host of other closely related phenomena.

Starting with the experimental evidence that the hydrogen atom consisted of a single proton with which in the neutral state there is associated a single electron, Bohr sought to find a way of accounting for its various series of line radiations. To account for the failure of the electron to unite with the proton in executing an atomic suicide under their mutual Coulomb attraction he accepted the idea of utilizing this force of attraction to maintain the acceleration involved in a uniform circular motion which leads to the equation

$$\frac{Ze^2}{a^2} = \frac{mv^2}{a}$$

where $Z$ represents the atomic number (which enables us to include in our discussion, except for a minor correction to be mentioned later, not only hydrogen for which $Z = 1$, but also other atoms from which $Z - 1$ electrons have been removed by some ionizing process), $e$ the electronic charge, $a$ the distance between the electron and the nucleus, $m$ the mass of the electron, and $v$ its linear velocity.

Classical theory demanded that such an acceleration should be accompanied by radiation thus causing the electron to decrease its velocity and follow a spiral path into the nucleus, a catastrophy that is contradicted by the protracted existence of atoms and of matter in general. Furthermore radiation thus produced would result in a broad band of wave-lengths instead of the observed sharp lines. To escape this predicament Bohr abandoned *classical* physics at this point and postulated the existence of "stationary states" or perhaps better "steady or quantized states" in which the electron was pictured as moving for a time in certain circular orbits without radiating, the energy of the atom for each of these orbits (stationary states) to consist of discreet amounts as in the case of Planck's harmonic oscillators. He utilized classical physics to furnish him with an expression for the energy of these stationary or steady states. Starting with the electron at infinity as representing the zero potential energy of the atom, its potential energy $U$ with the electron in a quantized orbit of radius $a$ is $-(Ze^2)/a$ and its kinetic energy $T$ is $\frac{1}{2}mv^2$ and the total energy $E$ is given by

$$E = T + U = \tfrac{1}{2}mv^2 - \frac{Ze^2}{a}\cdot$$

From the acceleration maintained by the force acting on an electron in a Coulomb electric field it is readily seen that

$$E = \frac{Ze^2}{2a} - \frac{Ze^2}{a} = -\frac{Ze^2}{2a} = -\frac{U}{2} = -T.$$

Writing $p = mav$ wherein $p$ represents the angular momentum of the electron about the nucleus, we have upon eliminating $a$ and $v$ from the above equations

$$E = -\frac{me^4Z^2}{2p^2}\cdot$$

The next step in Bohr's analysis was to select the stationary states or orbits which he did by following Planck's procedure in quantizing the momentum of the rotator wherein

$$\oint pdq = \oint pd\phi = nh$$

from which $p = nh/2\pi$, thus giving for the energy of the $n$th orbit

$$E_n = -\frac{2\pi^2me^4Z^2}{n^2h^2},\ n = 1, 2, 3, \cdots.$$

The final step was to apply Planck's radiation equation and place the change in energy when an electron "jumped" from one stationary state to another, that is from one quantized orbit to another, equal to $h\bar{\nu}$.

$$E_n - E_{n'} = \Delta E = h\bar{\nu} = \frac{2\pi^2me^4Z^2}{h^2}\left(\frac{1}{n'^2} - \frac{1}{n^2}\right)$$

whence

$$\nu = \frac{1}{\lambda} = \frac{\bar{\nu}}{c} = \frac{2\pi^2 me^4 Z^2}{h^3 c}\left(\frac{1}{n'^2} - \frac{1}{n^2}\right).$$

For hydrogen, $Z=1$, the factor $2\pi^2 me^4 Z^2/h^3 c$, upon using the then accepted values for $m$, $e$, $h$, and $c$, yielded a value 109740 $\text{cm}^{-1}$, a quantity extremely close to the value of the Rydberg constant, $R$, as determined from experimental data of the hydrogen spectra. Thus with $n'=2$ and $n=3, 4, 5, \cdots$ Bohr arrived at an equation that agreed both qualitatively and quantitatively with the observed wave-numbers of the lines in the Balmer series of hydrogen and with suitable choices for the values of $n$ and $n'$ was capable of

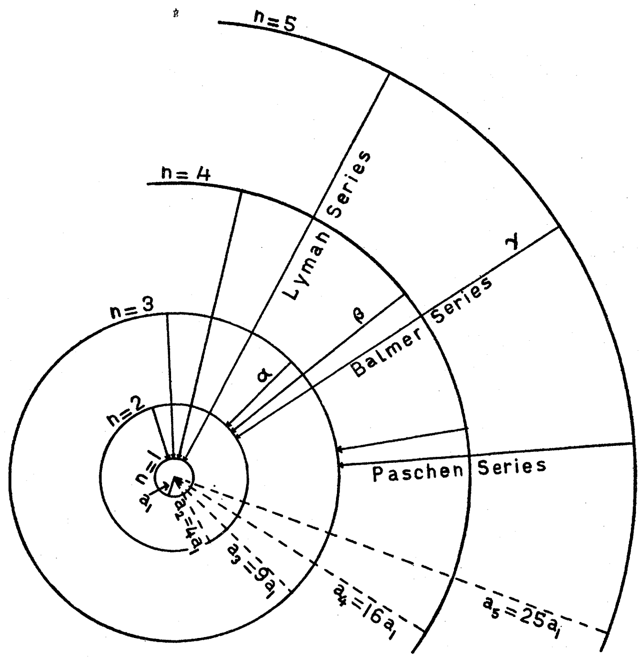


Fig. 10. Hydrogen series in terms of Bohr orbits.

accounting for both the Paschen and the Lyman series which had already been experimentally established for hydrogen. The series later observed by Brackett and Pfund, references to which have already been made, also fit accurately into the Bohr picture. According to the Bohr picture then we looked upon the Balmer series of lines as arising when electrons, in some atom in the third quantum orbit, in other atoms in the fourth quantum orbit, in still other atoms in the fifth quantum orbit and so on, jumped to the second quantum orbit. In an electrical discharge from which the various hydrogen series were observed, energy was in some way added to the atoms, removing the electrons from their normal quantum orbit number one and placing them in the higher quantum orbits from which they returned quite promptly either directly by a single jump to the first quantum orbit, thus giving rise to the

Lyman series, or by successive jumps to lower quantum orbits in which case radiations belonging to first one series and then another were obtained. This idea is shown graphically in Fig. 10 where the various orbits are drawn as concentric circles surrounding the nucleus of one proton at the center, each having a radius proportional to the square of $n$, the quantum number for that orbit, as demanded by the formula

$$a_n = \frac{n^2h^2}{4\pi^2Ze^2m} = \frac{n^2}{Z}a_1$$

where $a_1$ is the radius of the first quantum orbit of an atom of hydrogen. This expression for $a_n$ is readily obtained by eliminating $v$ from the equations for acceleration and quantized momentum, namely,

$$\frac{Ze^2}{a^2} = \frac{mv^2}{a} \text{ and } \frac{nh}{2\pi} = mav.$$

The velocity of an electron in a quantized orbit is inversely proportional to the quantum number as may readily be shown by eliminating $a$ from these same equations. Thus for $n=\infty$ these quantized relations lead to an electron at *rest* at a very great distance, comparatively speaking, from the nucleus of the atom to which it belongs.

## Unquantized Orbits—Continuous Spectrum

It seems desirable to introduce here a brief discussion of other but unquantized conditions, the possibility of which has come to be recognized since the early work of Bohr. The orbits so far considered and to which Bohr applied the appropriate quantum conditions have a periodic nature. There are other possible orbits that an electron might follow in the neighborhood of an atomic nucleus which would not be periodic. Such orbits are either hyperbolas or parabolas similar to the paths taken by certain comets in passing around our Sun to which they never return unless suitably disturbed by other celestial bodies. It can easily be shown that such orbits involve a total energy for the nucleus and the electron that is always greater than zero even though we here, as in the case of quantized orbits, arbitrarily choose to set the potential energy equal to zero when the electron is removed to an infinite distance. Thus the kinetic energy of an electron in an unquantized orbit is not zero at any time and we can place the total kinetic energy of the system, electron and nucleus, equal to $\frac{1}{2}mv^2 - Ze^2/r$, where $v$ represents the orbital velocity of the electron when it is at a distance $r$ from the nucleus. Provided the approaching velocity of the electron relative to the nucleus is not too large transitions can take place from an unquantized orbit to a quantized orbit with an emission of radiation equal to the difference between the energy in the two orbits, which energy, however, is quantized and we have

$$\Delta E = h\bar{\nu} = \tfrac{1}{2}mv^2 - Ze^2/r + 2\pi^2me^4Z^2/n^2h^2.$$

The frequency of this radiation, $\bar{\nu}$, is larger than that resulting from any transition between quantized states, and since $v$ and $r$ may vary continuously through all values we have an emission or absorption that is continuous in frequency ranging upward from that of the limit of a series. Several records of a continuous spectrum lying beyond the limit of the Balmer series are cited by Finkelnburg(Qg833) (see especially his references 76, 111, 303, 304, 306, 307). In the energy level diagram for hydrogen, Fig. 11, the relation of this energy continuum to the quantized levels is clearly evident.

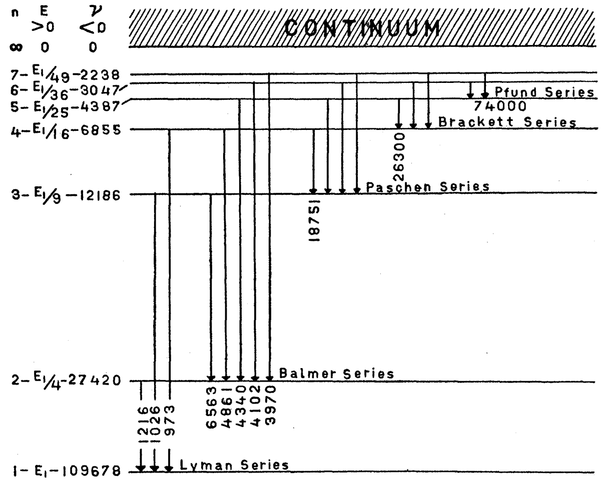


Fig. 11. Energy levels of hydrogen atom.

## The Spectrum of Ionized Helium

The formula derived by Bohr for the spectral lines of hydrogen was highly satisfactory in that it was possible to observe all of the series predicted by it. On the other hand the formula denied the existence of other series for hydrogen. Nevertheless, two other observed series had been ascribed to hydrogen, one originally measured by Fowler (Monthly notices, R.A.S., **73**, 1912)was defined by the formula

$$\nu = R\left(\frac{1}{1.5} - \frac{1}{n^2}\right) n = 2, 3, 4, \cdots .$$

Another had been discovered by Pickering in the spectra of nebular clusters which was described by the formula:

$$\nu = R\left(\frac{1}{2^2} - \frac{1}{(n + .5)^2}\right) n = 2, 3, 4, \cdots .$$

In his first paper already mentioned Bohr pointed out that both of these series would be rationally accounted for by his formula,

$$\nu = \frac{2\pi^2 me^4 Z^2}{h^3 c}\left(\frac{1}{n'^2} - \frac{1}{n^2}\right),$$

if $Z$ were given a value of 2. Since this formula was derived for a single electron moving in orbits around a positive nucleus, it seemed plausible to identify these later series as arising from ionized helium. Indeed the above formulae for these series are equivalent respectively to

$$\nu = 4R\left(\frac{1}{3^2} - \frac{1}{n^2}\right) n = 4, 5, 6, \cdots .$$

and

$$\nu = 4R\left(\frac{1}{4^2} - \frac{1}{n^2}\right) n = 5, 6, 7, \cdots .$$

except that the lines as first observed corresponded only to the even values of $n$ in the former case and to the odd values of $n$ in the latter case. Later measurements by Fowler and by Paschen resulted in the finding of all lines demanded by the modified formulae in the spectrum of pure helium. The lines missing from the first observations for the second of these series (Pickering) fall very closely though not exactly in the same position as the lines of the Balmer series of hydrogen and thus served to prevent their discovery in the earlier measurements.

The relative intensities of the lines in both parts of both these series also indicated that in each case the lines constituted a single series. Thus the theory of Bohr aided greatly in hastening the proper identification of these series as due to ionized helium. A few years afterwards Lyman discovered lines of helium in the Schumann region that later were definitely shown to correspond to the formula,

$$\nu = 4R\left(\frac{1}{2^2} - \frac{1}{n^2}\right) n = 3, 4, 5, \cdots ,$$

the first line of which lies at about 1640A. This series corresponds to the Balmer series for hydrogen.

Lyman (He II 13) was also the first to observe the first members of the ionized helium series, $\nu = 4R(1/1^2 - 1/n^2)\ n = 2, 3, 4, \cdots$ . This series has been extended to five members by Compton and Boyce, (He II 27) and to nine members by Kruger. (He II 28). The first line in this series lies at about 303A.

## Introduction to Bibliography

In the foregoing report an effort has been made to present the material in a form that may be readily followed by those who have comparatively little acquaintance with the field. Care has been taken to explain the meaning of all technical terms and symbolic representations as they are introduced and to select for discussion those topics that experience has shown are likely to be most helpful in introducing the subject to those who wish to gain a general understanding of the more important aspects of the developments in this field either for general utility or in preparation for more detailed specialization. Those who are already fairly familiar with the subject will probably find in this part of the report very little that is worthy of their perusal.

When the writer undertook to outline and plan his review of this field he soon came to feel the need for a reliable and comprehensive list of references to original sources of information, partly as an aid in extending his own information and partly for use in referring the reader to more complete and detailed discussions of topics, than can be properly incorporated in the report. Accordingly a bibliography of papers dealing with spectroscopic studies has been prepared.

For various reasons but chiefly because the reports by Fowler and by Paschen and Götze, both published in 1922, and the compilations, published from time to time by Kayser (Q 2) in his Handbuch der Spectroscopie, contain most of the important earlier data on line spectra, with references to the original sources, it seemed unnecessary to compile at this time a list of papers published prior to 1920. Thus in the following bibliography references to only those papers on spectroscopic topics published between January 1, 1920 and December 31, 1931 are included. The references for 1931 are of course quite incomplete.

A careful systematic search through abstract journals, references given in various books and in many original papers, has been made. Advantage has also been taken of numerous other bibliographic lists. A report by K. K. Darrow published as paper 47 in Volume VIII of the Bulletin of the National Research Council (1924) contains much useful information in regard to the then existing bibliographies in the fields of Physics and their contents.

Various plans of arranging the references were considered and the one finally adopted was chosen because it appeared to be most capable of conserving the time of the user. At first an attempt was made to include a complete reference only once to those papers that contain spectral data upon more than one element and then to utilize cross-references under additional elements. After using the partially completed bibliography in this form for several months in the writer's laboratory it became evident that any system of cross-references was undesirable in view of its unavoidable complexity and consequent annoyance and waste of time in running down the references for any particular element. Therefore, even at the risk of making the bibliography rather long from the standpoint of printing, all cross-references were abandoned and an effort has been made to list every paper containing data on more than one element under each element or subdivision of element involved. Doubtless in some cases, especially where new data concerning some element have been given minor consideration, the multiple listing is not complete.

The bibliography has been divided into three parts. The first part contains those references to papers in which new data on some one or more elements are reported or discussed. The majority of the references are included in this part. They are arranged according to elements and in the order of their atomic number. Under each element the references are subdivided according to the stage of ionization from which the spectra arise. Under each stage of ionization they are subdivided again according to the year of publication and within each year they are arranged alphabetically according to the names of the authors. The references under each stage of ionization of any element have been numbered consecutively. The determining criterion in the selection of references to be included was the presentation of new data or the discussion of data involving new relationships. At the top of each page the element or elements appearing on that page are designated by full name and atomic number. The beginning of the references for a particular stage of ionization for each element is indicated by the usual chemical symbol and ionization numeral (Roman).

Following the bibliography of the elements certain "General References" have been included, the compilation of which was incidental to that of the first part. In this list are found references to articles of general interest on the theory of line spectra and other special and closely related topics. Although many articles of a theoretical nature have been included here, the purpose has been to limit such entries to those touching primarily upon spectroscopic problems. References to articles that are mainly concerned with the mathematical machinery of quantum mechanics have not been included.

In the third group of references appended at the end will be found a selected list of compilations of spectroscopic data together with books and treatises on the interpretation of line spectra. The letter, Q, used as a symbol heading for this list as well as Qg for the "general references" was adopted after observing that Q is the only letter of the English alphabet that is not used as the first or only letter in the symbol of some element. In order to conserve space no references to data or classifications included under this third group, such as to Fowler's report or that of Paschen and Götze, have been listed in the bibliography of the separate elements.

One important guide in designing the order of arrangement of references was a desire to facilitate the continuity of numbering in the publishing from time to time of such supplementary lists as will keep the bibliography reasonably up to date.

In the interests of economy in printing, the periodicals have been indicated by very much abbreviated but in general fairly easily interpreted notations. In most cases the first letters of the principal words forming the title of the periodical have been chosen as abbreviations. No more than four letters have been used in any case. For similar reasons and to allow more space for the addition of a short descriptive phrase or sentence, the initials of authors, and the last page of each paper have been omitted and the punctuation reduced to a minimum consistent with clearness. The letter A following a reference has been used to indicate an "abstract" in the case of journals that publish both abstracts and extended papers such as is done in the *Physical Review*. The short descriptive phrases after the references are often not the same as the title of the paper but whenever feasible the more significant words in a title have been used.

A key to the list of periodicals is included, arranged in the alphabetical order of their abbreviations. Only the main portion of lengthy titles has been given. Since some of the periodicals are not widely known, it may often be desirable to have more detailed information regarding them. A useful source of such information is the Union list of Serials in Libraries of the United States and Canada, published in 1927 by the H. W. Wilson Company of New York to which has been added a supplement covering the years 1925–31. This list is very complete and gives full title, the usual library abbreviation, list of libraries which receive the periodical, together with the number of volumes, incomplete volumes, etc. in the possession of any library. A similar but less complete list of periodicals was published by the American Chemical Society in the November 20, 1931 issue of its Chemical Abstracts.

The writer wishes to take this opportunity to express to Mr. W. Paul Gilbert his sincere appreciation and to acknowledge his deep obligation for the thorough and pains taking performance of the many tasks of drudgery connected with the compilation of this bibliography.

While considerable time and effort has been spent in trying to eliminate errors and to avoid the omission of important papers, it is realized that complete freedom from mistakes would be hoped for in vain. For any errors of omission or commission the writer, of course, assumes full responsibility. He, however, wishes to request that any discovered correction or desirable addition be brought to his attention for use in the preparation of future supplementary lists.

It is hoped that even well informed spectroscopists who are actively engaged in doing or directing research in this field will find this bibliography of some assistance in their work.

## Key To The Periodicals

AAL Atti della reale accademia nazionale dei Lincei (Rome).
AFQ Anales de la sociedad española de física y química (Madrid).
AIP Annales de l'institute Henri Poincare (Paris).
AJ Astrophysical Journal.
AKMG Arkiv för Kemi, Mineralogi och Geologi (Uppsala).
ANSE Archives néerlandaises des sciences exactes et naturelles. Series III A.
AO Skrifter utgitt av det Norske Videnskaps-Akademi i Oslo. I. Matematisk-Natervidenskapelig Klasse.
AP Annalen der Physik.
ASCA Anales de la sociedad cientifica Argentina.
AsP Annales de Physique.
ASPN Archives des sciences physiques et naturelles (Geneva).
BADS British Association for the Advancement of Science, Report.
BAIE Bulletin de l'association des Ingenieurs electriciens sortis de l'institute electrotechnique Montefiore (Liege).
BB Bulletin de la section scientifique de l'académie roumaine (Bucharest).
BCMS Bulletin of the Calcutta Mathematical Society.
BFSC Buletinul Facultatea de stiinti, Universitatea din Cernăuti. Cernăuti, Roumania.
BIAS Bulletin international de l'académie polonaise des sciences et des lettres (Cracovie). Série A.
BNC Bulletin of the National Research Council.
BSFP Bulletin de la sociéte francaise de physique. (Supplement to Journal de physique et le radium.)
BSJ Bureau of Standards Journal of Research.
BSP Scientific Papers of the Bureau of Standards.
BTJ Bell System Technical Journal.

| | |
|---|---|
| CASI | Conférence d'actualities scientifique et industrielle (Paris). |
| ChR | Chemical Reviews. |
| CI | Chemie et industrie. |
| CJR | Canadian Journal of Research. |
| CN | Chemical News and Journal of Industrial Science. |
| CR | Compte Rendus. |
| CRK | See BIAS. |
| CRSP | See BIAS. |
| E | Engineering. |
| EEN | Ergebnisse der Exacten Naturwissenschaften (Julius Springer, Berlin). |
| FT | Fysisk Tidsskrift. |
| HPA | Helvetica Physica Acta. |
| IACS | Indian Association for the Cultivation of Science, Proceedings. |
| IEC | Industrial and Engineering Chemistry. |
| IJP | Indian Journal of Physics. |
| IPCR | Institute of Physical and Chemical Research, Scientific Papers of (Tokyo). |
| JACS | Journal of the American Chemical Society. |
| JCS | Journal of the Chemical Society (London). |
| JFI | Journal of the Franklin Institute. |
| JIC | Journal of the Indian Chemical Society (Calcutta). |
| JJP | Japanese Journal of Physics. |
| JMC | Journal of the Science Association, Maharajah's College, Vizianagaram. |
| JMU | Half-yearly Journal of the Mysore University, The. Bangalore City, S. India. |
| JOSA | Journal of the Optical Society of America. |
| JPR | Journal de physique et le radium. |
| JRE | Jahrbuch der Radioaktivität und Elektronik. |
| JRPC | Journal of the Russian Physical-Chemical Society. |
| KB | Bulletin of the Kodaikanal Observatory (India). |
| L | Lotos. Naturwissenschaftliche Zeitschrift. |
| MB | Sitzungsberichte der mathematisch-naturwissenschaftlichen Abteilung der bayerischen Akademie der Wissenschaften zu München. |
| MIT | Journal of Mathematics and Physics. Massachusetts Institute of Technology. |
| MK | Kongelige Danske Videnskabernes Selskab, Det. Mathematiskfysiske Meddelelser. |
| MKCS | Memoirs of the College of Science. Kyoto Imperial University. |
| MPAS | Memorie della pontificia accademia della scienze dei Nuovi Lincei (Rome). |
| N | Nature (London). |
| NC | Nuovo Cimento, Il. |
| Nw | Naturwissenschaften, Die. |
| P | Physica (Nederlandsh Tijdschrift voor Natuurkunde). |
| PA | Popular Astronomy. |
| PAO | Publications of the Allegheny Observatory. University of Pittsburgh. |
| PAPS | Proceedings of the American Philosophical Society. |
| PCPS | Proceedings of the Cambridge Philosophical Society. |
| PIAT | Proceedings of the Imperial Academy (Tokyo). |
| PKAA | Proceedings of the Royal Academy of Sciences of Amsterdam. |
| PLPS | Proceedings of the Leeds Philosophical and Literary Society. Scientific Section. |
| PM | Philosophical Magazine and Journal of Science, The. London, Edinburg and Dublin. |
| PMSJ | Proceedings of the Physico-Mathematical Society of Japan. |
| PNAS | Proceedings of the National Academy of Sciences of the United States of America. |
| PPS | Proceedings of the Physical Society. (London). |
| PR | Physical Review. |
| PRI | Proceedings of the Royal Institution of Great Britain. |
| PRIA | Proceedings of the Royal Irish Academy. Section A. |
| PRS | Proceedings of the Royal Society (London). Series A. |
| PRSE | Proceedings of the Royal Society of Edinburgh. |

PTRS Philosophical Transaction of the Royal Society (London). Series A.
PZ Physikalische Zeitschrift.
RAS Monthly Notices of the Royal Astronomical Society (London).
RASC Journal of the Royal Astronomical Society of Canada.
RGE Revue générale de l'électricité. (Paris).
RIGB See PRI.
RMP Reviews of Modern Physics (Formerly Physical Review Supplement).
S Science (N. S.)
SAWB Sitzungsberichte der preussischen Akademie der Wissenschaften (Berlin), Physikalische-mathematische Klasse.
SAWW Sitzungsberichte der Akademie der Wissenschaften (Wien), Mathematische-naturwissenschaftliche Klasse, Abt. IIa.
SRTU Science Reports of the Tohoku Imperial University, The. (Tokyo). First Series.
TBDR Science Reports of the Tokyo Bunrika Daigaku.
TFS Transactions of the Faraday Society (London).
TRSC Transactions of the Royal Society of Canada. Section III.
U Universum. Formerly Reclam's Universum (Leipzig).
UNLP Contribucion al estudio de las ciencias fisicas y matematicas. Serie matematico-fisica. (La Plata).
VDPG Verhandlungen der Deutschen Physicalische Gesellschaft.
VOIL Verhandlungen der Optikal Institut Leningrad.
VPGW Verhandlungen der Physikalische-medizinische Gesellschaft zu Würzburg.
WA Anzeiger der Akademie der Wissenschaften in Wien. Mathematisch-naturwissenschaftliche Klasse.
WNT Wissenschaften Natuurkundig Tijdschrift. Organ van het Vlaamsch Natuur-en Geneeskundig Congres (Ghent).
WVS Wissenschaftliche Veröffentlichungen aus dem Siemens-Konzern.
ZA Zeitschrift fur Astrophysik.
ZAC Zeitschrift fur anorganische und allgemeine Chemie.
ZE Zeitschrift fur Electrochemie und angewandte physicalische Chemie.
ZI Zeitschrift fur Instrumentenkunde.
ZP Zeitschrift fur Physik.
ZPC Zeitschrift fur physikalische Chemie.
ZtP Zeitschrift fur technische Physik.
ZwP Zeitschrift fur wissenschaftliche Photographie, Photophysik und Photochemie.

## Hydrogen 1

**H**

1. Bell: PM **40,** 489 (1920). Rydberg constant.
2. Bohr: ZP **2,** 423 (1920). Series spectrum theory.
3. David: PRS **98,** 183 (1920). Radiation on explosion of H and air.
4. Dempster: PR **15,** 138 (1920) (A). Duration of light emission.
5. Found: PR **16,** 41 (1920). Ionization potential.
6. Franck: ZP **1,** 2 (1920). Intensity distribution and the Bohr theory.
7. Gehrcke and Lau: PZ **21,** 634 (1920). Fine structure of Balmer series.
8. de Gramont: CR **171,** 1106 (1920). Ultimate lines.
9. Hicks: PTRS **220,** 335 (1920). Critical study of spectral series.
10. Horton and Davies: PRS **97,** 23 (1920). Electron collisions in H.
11. Kramers: ZP **3,** 199 (1920). Quantum theory of Stark effect.
12. Merrill: AJ **51,** 236 (1920). Air lines in spark spectra.
13. Merton: PRS **97,** 307 (1920). Fine structure of Balmer series.
14. Merton: PRS **98,** 255 (1920). Effect of concentration on the spectra of luminous gases; broadening and enhancement of lines.
15. Millikan: AJ **52,** 47 (1920). Extension of the ultraviolet spectrum.

## Hydrogen 1

16. Mohler and Foote: BSP 400, Vol. **16,** 669 (1920); JOSA **4,** 49 (1920); PR **15,** 555 (1920) (A). Ionization and resonance potentials.
17. Seeliger and Murdel: ZP **1,** 355 (1920). Excitation by electron impact.
18. Silberstein: PRS **98,** 1 (1920). Aspherical nucleus theory applied to the Balmer series.
19. Sommerfeld: PZ **21,** 619 (1920). Correspondence of H fine structure with gross structure of non-hydrogenic spectra.
20. Stark: JRE **17,** 161 (1920). Criticism of Bohr's theory of light emission.
21. Stead and Gossling: PM **40,** 413 (1920). Relative ionization potentials of gases as observed in thermionic valves.
22. Weth: AP **62,** 589 (1920). Excitation by slow canal and cathode rays.
23. Witt: PZ **21,** 374 (1920). Absorption measurements in the far infrared.
24. Wood: PRS **97,** 455 (1920). Extension of the Balmer series.
25. Yoshida: MKCS **4,** 187 (1920). Regularity in the Stark effect.
26. Birge: PR **17,** 589 (1921). Balmer series and the quantum theory.
27. Compton and Olmstead: PR **17,** 45 (1921). Note on radiating and ionizing potentials.
28. Franck: PZ **22,** 388, 409, 441, 446 and 466 (1921). Excitation by electron impact.
29. Gehrcke and Lau: AP **65,** 564 (1921). Intensity distribution in the Balmer series.
30. Gehrcke and Lau: PZ **22,** 556 (1921); ZI **41,** 99 (1921). Fine structure of Balmer series.
31. de Gramont: CN **122,** 58 (1921). Ultimate lines.
32. Kimura and Fukuda: MKCS **5,** No. 2, 165 (1921). Intensities in the Balmer series.
33. Kruger: AP **64,** 288 (1921). Ionization potential.
34. Ladenburg: ZP **4,** 451 (1921). Quantum mechanical interpretation of the number of dis persions electrons.
35. McLennan and Lowe: PRS **100,** 217 (1921). Fine structure of Balmer series.
36. McLennan and Petrie: TRSC **15,** 15 (1921). Extreme ultraviolet spectrum.
37. Mie: AP **66,** 237 (1921). Duration of light emission.
38. Polvani: NC **22,** 323 (1921). Spark in an atmosphere of H. Stark-Lo Surdo effect.
39. Ribaud: JPR **2,** 107 (1921). Dampening of radiation. Broadening of lines.
40. Rubinowicz: ZP **5,** 331 (1921). Intensity dissymmetry in the Stark effect.
41. Saha: PM **41,** 267 (1921). Temperature radiation of gases.
42. Saunders: JOSA **5,** 1 (1921). Review of series.
43. Seeliger: PZ **22,** 610 (1921). Excitation by electron impacts.
44. Seeliger and Schramm: ZP **7,** 93 (1921). Excitation by electron impact.
45. Smekal: VDPG **2,** 20 (1921). Stark's criticism of the Bohr theory.
46. Sommerfeld: AP **65,** 36 (1921). Second order Stark effect.
47. Sommerfeld: JRE **17,** 417 (1921). Criticism of Bohr's theory of radiation.
48. Wien: AP **66,** 229 (1921). Duration of light emission.
49. Wood: PM **42,** 729 (1921). Extension of Balmer series.
50. Becker: ZP **9,** 332 (1922). Stark effect.
51. Boucher: PR **19,** 189 (1922). Ionization and resonance potentials.
52. Brackett: AJ **56,** 154 (1922); N **109,** 209 (1922); PR **20,** 111 (1922) (A). Extension of infrared spectrum. A new series.
53. Compton: PAPS **61,** 212 (1922). Critical potentials.
54. Duffendack: PR **20,** 100 (A) and 665 (1922); S **55,** 210 (1922). Low voltage arc.
55. Geddes: PRSE **43,** 37 (1922/23). Fine structure of $H\alpha$ and $H\beta$.
56. Gehrcke and Lau: AP **67,** 388 (1922). Fine structure of Balmer series.
57. Greinacher: PZ **23,** 65 (1922). Radiation of ions in the spark in air.
58. Hopfield: N **110,** 732, (1922); PR **20,** 573 (1922). Extension of ultraviolet spectrum.
60. Hulburt: AJ **55,** 399 (1922); PR **20,** 112 (1922) (A). Broadening of Balmer lines with pressure.
61. Kimura and Fukuda: JJP **1,** 22 (1922) (A). Intensities of the Balmer lines.
62. Lau: Universum **1,** 143 (1922). The fine structure constant.
63. Meggers and Burns: BSP No. 441, Vol. **18,** 185 (1922). Notes on standard wave-lengths.

## Hydrogen 1


64. Merton and Barratt: PTRS **222,** 369 (1922). Measurements and classifications. Study of excitation conditions.
65. Mohler, Foote and Kurth: PR **19,** 414 (1922) (A). Critical potentials.
66. Mosharrafa: PM **43,** 943 (1922); PM **44,** 371 (1922). Stark effect for strong fields.
67. Nicholson: PRI **22,** 522 (1922). Energy distribution in spectra.
68. Oldenburg: AP **67,** 69 (1922). Fine structure of the Balmer series.
69. Oldenburg: AP **67,** 253 (1922). Fine structure and Zeeman effect of $H\alpha$.
70. Olmstead: PR **20,** 613 (1922). Interpretation of critical potentials.
71. Robertson: TRSC **16,** 151 (1922). Spectrum of electrodeless discharge.
72. Sen: PZ **23,** 397 (1922). Doppler effect and fine structure.
73. Sommerfeld and Heisenberg: ZP **10,** 393 (1922). Note on relativistic x-ray doublets and line sharpness.
74. von Traubenberg: Nw **10,** 791 (1922). Space quantization in a magnetic field.
75. Wilson: AJ **56,** 34 (1922). Quantum theory of doublets.
76. Wood: PM **44,** 538 (1922). Atomic H and the Balmer series.
77. Beatty: PM **45,** 1080 (1923). Energy distribution in the Balmer series.
78. Boguslawski: PM **45,** 145 (1923). Problem of two moving charges.
79. Bohr: AP **71,** 228 (1923). Line spectra and atomic structure. Theory of hydrogen spectrum.
80. Bohr: PPS **35,** 275 (1923). Effect of electric and magnetic fields on spectral lines.
81. Bothe: Nw **11,** 45 (1923). Fine structure of Balmer lines.
82. Carelli: NC **25,** 213 (1923). Stark effect.
83. Dempster: AJ **57,** 193 (1923). Duration of light emission. Stark effect.
84. Försterling and Hansen: ZP **18,** 26 (1923). Zeeman effect of $H\alpha$ and $H\beta$.
85. Foster: PR **21,** 710 (1923) (A). The fine analysis of the Stark effect in Balmer's series by Lo Surdo's method.
86. Geddes: PRSE **44,** 14 (1923/24). Fine structure in the Balmer series.
87. Gehrcke: ZtP **4,** 194 (1923). Hydrogen spectra and atomic theory.
88. Halpern: ZP **18,** 287 (1923). Theory of combined Stark and Zeeman effects.
89. Halpern: ZP **18,** 352 (1923). Quantum theory of the normal Zeeman effect.
90. Hicks: PM **45,** 480 (1923). Radiation and ionization potentials.
91. Hopfield and Leifson: AJ **58,** 59 (1923). Standards in extreme ultraviolet.
92. Horton and Davies: PM **46,** 872 (1923). Critical electron energies.
93. Hughes and Lowe: PR **21,** 202 (A) and 292 (1923). Intensities.
94. Hulburt: PR **22,** 24 (1923). Intensity distribution in the broadened Balmer lines.
95. Kar: PM **45,** 610 (1923). Theory of generalized quanta and the Balmer lines.
96. von Keussler: ZP **14,** 19 (1923). Critical potentials.
97. Kimura and Nakamura: JJP **2,** 53 (1923). Self-reversal of $H\alpha$ and $H\beta$.
98. Lasareff: PM **45,** 430 (1923). Number of radiating atoms of various dimensions within gaseous hydrogen, from point of view of Bohr's atom model.
99. Mackay: PM **46,** 828 (1923). Ionization potentials.
100. McLennan: N **112,** 166 (1923). Fine structure of the Balmer series.
101. Moore: AJ **58,** 86 (1923). Excitation stages in open arc light spectra.
102. Mosharrafa: PM **46,** 514 (1923). Second approximation to the quantum theory of the theory of the simple Zeeman effect.
103. Newman: PM **45,** 293 (1923). Visibility of individual spectra.
104. Nicholson: PM **45,** 801 (1923). Quantum theory and isotopes. Orbits passing through nucleus.
105. Olmstead and Compton: PR **22,** 559 (1923). Radiation potentials.
106. Olson and Glockler: PNAS **9,** 122 (1923). Critical potentials.
107. Plaskett: N **112,** 392 (1923). Origin of the nebular lines.
108. Ruark: AJ **58,** 46 (1923). Wave-lengths of Balmer lines. Calculation of Rydberg constants. Corrections to theory.
109. Smyth: N **111,** 810 (1923). Ionizing potentials.
110. Sommerfeld: JOSA **7,** 509 (1923). Quantum conditions for hydrogen atoms.

## HYDROGEN 1


111. Turner: AJ **58,** 176 (1923). Relation between the spectra and the sizes of atoms.
112. Whiddington: PM **46,** 605 (1923). Extension of the Balmer series.
113. Wien: AP **70,** 1 (1923). Radiation from canal rays. Duration of light emission.
114. Wood: PRS **102,** 1 (1923). Incandescence of substances in atomic H.
115. Falkenhagen: ZP **28,** 1 (1924). Paschen-Back effect.
116. Foster: PR **23,** 667 (1924). Stark effect at high fields.
117. Gehrcke and Lau: AP **74,** 574 (1924). Intensity distribution of components of H$\alpha$.
118. Grotrian: Nw **12,** 515 (1924). Excitation potentials.
119. Ham: PR **23,** 107 (1924) (A). Notes on fine structure theory.
120. Hanot: CR **178,** 1071 (1924). Line width in H spark.
121. Hansen: VDPG **5,** 56 (1924). Fine structure of the Balmer lines.
122. Holtsmark: PZ **25,** 73 (1924). Broadening of lines.
123. Hoyt: PM **47,** 826 (1924). Transition probabilities for Balmer series.
124. Hulburt: PR **23,** 107 (A) and 593 (1924). Extension of Balmer absorption series.
125. Johnson and Cameron: PRS **106,** 195 (1924). Effect of A on H spectrum.
126. Klein: ZP **22,** 109 (1924). Effect of crossed electric and magnetic fields on H spectrum.
127. Krefft: AP **75,** 513 (1924). Doppler effect in H canal rays.
128. Krefft: PZ **25,** 352 (1924). Doppler effect in arc and spark lines.
129. Lang: PTRS **224,** 371 (1924). Ultraviolet spectrum.
130. Lau: PZ **25,** 60 (1924). Fine structure.
131. Lenz: ZP **24,** 197 (1924). Orbital motion and quantum states of perturbed Kepler motions.
132. Millikan and Bowen: PR **23,** 1 (1924). Wave-lengths.
133. Mosharrafa: PRS **105,** 641 (1924). Half integral quantum numbers in theory of Stark effect.
134. Payne: PNAS **10,** 322, (1924). Ionization potential.
135. Pfund: JOSA **9,** 193 (1924). Extension of infrared spectrum.
136. Richardson and Tanaka: PRS **106,** 640 (1924). Striking and breaking potentials.
137. Seeliger and Wendt: PZ **25,** 160 (1924). Excitation by electron impact. Intensity ratios for H$\beta$ and H$\alpha$.
138. Shrum: PRS **105,** 259 (1924). Doublet separation of the Balmer lines.
139. Smyth: PR **23,** 297 (1924); (A) PRS **105,** 116 (1924). Ionization by electron impact.
140. von Traubenberg: PZ **25,** 606 (1924). Asymmetry in the intensity distribution of light from canal rays.
141. von Traubenberg: PZ **25,** 607 (1924). Behavior of radiation from canal rays on passage from an electrical field into field-free space.
142. Urey: AJ **59,** 1 (1924). Distribution of electrons in hydrogen orbits.
143. Urey: MK **6,** No. 2 (1924); ZP **29,** 86 (1924). Theory of effect of electric fields on Zeeman effect.
144. Wien: AP **73,** 483 (1924). Duration of light emission.
145. Wilson: PNAS **10,** 346 (1924). Coulomb's law and the hydrogen spectrum.
146. Witt: ZP **28,** 249 (1924). Infrared absorption measurements.
147. Blackett and Franck: ZP **34,** 389 (1925). Excitation by electron impact.
148. van Cittert: AP **77,** 372 (1925). Fine structure measurements.
149. Foster: AJ **62,** 229 (1925). Stark effect for H$\beta$.
150. Gehrcke: AP **78,** 461 (1925); PZ **26,** 675 (1925). Fine structure.
151. Goudsmit and Uhlenbeck: P **5,** 266 (1925). Fine structure.
152. Ham: PR **25,** 762 (1925). Relation of spectral lines to mass variations within the atom.
153. Hanot: CR **180,** 54 (1925). Width of the Balmer lines in oscillating discharge.
154. Hansen: AP **78,** 558 (1925); PZ **26,** 678 (1925). Fine structure.
155. Janicki: AP **76,** 561 (1925). Fine structure of the Balmer series.
156. Janicki and Lau: ZP **35,** 1 (1926). Fine structure of the Balmer lines.
157. Johnson: PPS **37,** 249 (1925). Experimental control of electrically broadened spectral lines.

## Hydrogen 1

158. Jolowicz: PM **50**, 1089 (1925). Absorption of Balmer lines in H.
159. Kiuti: JJP **4**, 13 (1925). Stark effect.
160. Kwei: PR **26**, 537 (1925). Characteristics of low voltage arcs.
161. Lau: AP **77**, 183 (1925). Excitation maxima of spectrum lines in layers of the positive hydrogen column.
162. McLennan and Ireton: TRSC **19**, 77 (1925). Structure of the Balmer series.
163. Nicholson: RAS 85, 449 and 659 (1925). An H spectrum of constant frequency.
164. Reichenbacker: ZP **32**, 505 and 907 (1925). Circular orbits in H atom with nucleus in motion.
165. Russell: AJ **61**, 223 (1925). Ultimate and penultimate lines.
166. Slater: PNAS **11**, 732 (1925). Interpretation of series spectrum.
167. Wien: AP **76**, 109 (1925). Radiation from canal rays. Duration of light emission.
168. Abetti: AAL **3**, 594 (1926). Structure of H$\alpha$ in solar chromosphere.
169. Beams: PR **27**, 244 (1926); (A) PR **28**, 475 (1926). Time interval between appearance of certain lines.
170. Bloch: ZP **35**, 894 (1926). Duration of emission from canal rays.
171. Bucherer: ZP **37**, 395 (1926). Relativistic fine structure.
172. Carst and Ladenburg: ZP **48**, 192 (1928). Anomalous dispersion. True intensity ratios of H$\alpha$ and H$\beta$.
173. van Cittert: AP **79**, 94 (1926). Fine structure measurements.
174. Dirac: PRS **110**, 561 (1926). Quantum mechanics and a preliminary investigation of the hydrogen atom.
175. Eckart: PR **28**, 927 (1926). H spectrum in the new quantum theory.
176. Engset: AP **81**, 572 (1926); AP **80**, 823 (1926). Orbits and radiation of H electrons.
177. Epstein: PNAS **12**, 629 (1926). Matrix for H atom and intensities of series lines.
178. Epstein: PR **28**, 695 (1926). Stark effect and Schroedinger's theory.
179. Epstein: S **64**, 621 (1926). Second order Stark effect.
180. Foster: AJ **63**, 191 (1926). Observations on second order Stark effect.
181. Foster and Chalk: PR **27**, 512 (1926) (A). Relative intensities of Stark effect components.
182. Foster and Chalk: N **118**, 592 (1926). Relative intensities of Stark components.
183. Foster, Hackey and Rowles: PR **27**, 512 (1926) (A). Stark patterns.
184. Hanot: CR **182**, 1329 (1926). Widening of Balmer lines by absorption.
185. Heisenberg and Jordan: ZP **37**, 263 (1926). Application of quantum mechanics to anomalous Zeeman effect.
186. Hertel: PR **27**, 804 (1926) (A). Stark effect.
187. Houston: AJ **64**, 81 (1926). Fine structures and wave-lengths of the Balmer lines.
188. Hulburt: JFI **201**, 777 (1926). H lines in the stars and in the laboratory.
189. Keys and Horne: PR **27**, 709 (1926). Spectrographic examination of the striated discharge.
190. Langer: PNAS **12**, 639 and 644 (1926). The dispersion of atomic H.
191. Leifson: AJ **63**, 73 (1926). Absorption spectrum in Schumann region.
192. Lockrow: AJ **63**, 205 (1926). Critical potentials.
193. Lowe: TRSC **20**, 217 (1926). Variation of intensities of Balmer lines with pressure.
194. Lyman: N **118**, 156 (1926). Reversal in the ultraviolet series.
195. McPetrie: PM **1**, 1082 (1926). Time of excitation of H atoms.
196. Mohler: PNAS **12**, 494 (1926). Photo-ionization experiment with H.
197. Nagaoka and Futagami: PIAT **2**, 153 (1926). Occurrence of harmonics in spectral lines.
198. Nakamura: MKCS **9**, 303 (1926). Doppler effect in the Balmer lines.
199. Palacious: AP **79**, 55 (1926). Theory of emission. Rutherford-Bohr model. Duration of light emission.
200. Pauli: ZP **36**, 336 (1926). H spectrum from standpoint of new quantum mechanics.
201. Pfund: JOSA **12**, 467 (1926). Intensities and reflecting powers in the Lyman region.
202. Schlesinger: ZP **39**, 215 (1926). Variation of intensity distribution with pressure.
203. Schroedinger: AP **79**, 361 and 489 (1926); AP **80**, 437 (1926); AP **81**, 109 (1926). Quantization as a characteristic value problem. Application to H Atom.

## Hydrogen 1

204. Schütz: ZP **38,** 853 (1926). Orientation of atoms.
205. Slack: PR **28,** 1 (1926). Duration of emission.
206. Sommerfeld and Unsöld: ZP **36,** 259 (1926). Interpretation of series spectrum. The intensities of fine structure components; intensity anomalies and Paschen-Back effect for H$\alpha$.
207. Sommerfeld and Unsöld: ZP **38,** 237 (1926). Intensity of fine structure components. Metastability of the 2 $s$ term.
208. Swindler: PR **28,** 1136 (1926). Effect of potential and frequency on spectra.
209. Uhlenbeck and Goudsmit: N **117,** 264 (1926). Spinning electron and fine structure.
210. Wentzel: ZP **37,** 80 (1926). Multiply periodic systems in quantum mechanics.
211. Wentzel: ZP **38,** 518 (1926). Quantum mechanics of Stark effect. Derivation of the Balmer formula.
212. Waller: ZP **38,** 635 (1926). Quantum theory of second order Stark effect.
213. Wood: PM **2,** 876 (1926). Self reversal of red line.
214. Atkinson: PRS **116,** 81 (1927). Duration of light emission.
215. Bechert: AP **83,** 905 (1927). Boundary problems in wave mechanics.
216. Birkhoff: PNAS **13,** 165 (1927). H atom and the Balmer formula.
217. Crew and Hulburt: PR **29,** 843 (1927). Relative intensities of H$\alpha$, H$\beta$ and Hy.
218. Darwin: PRS **116,** 227 (1927). Wave equations.
219. Elsasser: ZP **45,** 522 (1927). Quantum theory of collision processes.
220. Engset: AP **82,** 143, 184 and 1017 (1927); AP **83,** 903 (1927); AP **84,** 880 (1927). Orbits and radiation of H electrons.
221. Epstein: PNAS **13,** 94 (1927). Relativity effect in H according to Schroedinger's theory.
222. Hanot: AsP **8,** 555 (1927). Width of Balmer lines under varied conditions of excitation.
223. Hanot: CR **184,** 281 (1927). Broadening of Balmer lines by intermolecular electric field.
224. Hansen: AP **84,** 688 (1927). Fine structure of the Balmer lines.
225. Harrison. N **119**, 393 (1927). Intensity distribution in fine structure of Balmer lines.
226. Herzberg: AP **84,** 553 and 565 (1927). Electrodeless ring discharge. Intensity measurements.
227. Houston: PR **30,** 608 (1927). Determination of $e/m$. The Rydberg constant.
228. Kent, Taylor and Pearson: PR 30, 266 (1927). Fine structure of the Balmer lines.
220. Kerschbaum; AP **84,** 930 (1927). Duration of light emission. Stark effect.
230. Ladenburg: PM **3,** 512 (1927). Absorption and selective dispersion of the Balmer lines.
231. Lau: ZtP **8,** 537 (1927). Fine structure of H$\alpha$.
232. Lindsay: PNAS **13,** 413 (1927). Pendulum orbits in atomic models.
233. Mohler: PR **29,** 354(A) and 419 (1927). Excitation of spectra by atomic H.
234. Pauling: PRS **114,** 181 (1927). Wave mechanics of the H atom.
235. Phipps and Taylor: PR **29,** 309 (1927). Magnetic moment.
236. Poettker: N **119,** 123 (1927); PR **30,** 418 (1927). Infrared spectrum.
237. Richter: PNAS **13,** 476 (1927). H atom with spinning electron in wave mechanics.
238. Rusk: PR **29,** 213(A) and 354(A) (1927). Resonance glow. Critical potentials.
239. Slack: AP **82,** 576 (1927). Intensity asymmetry in Stark effect and Schroedinger's wave mechanics.
240. Steubing: AP **83,** 822 (1927). Doppler effect in H canal rays.
241. Sugiura: JPR **8,** 113 (1927). Number of dispersing electrons for H lines.
242. von Traubenberg and Levy: ZP **44,** 549 (1927). Influence of weak magnetic fields on polarization of light from canal rays.
243. Tschudi: JFI **204,** 219 (1927). Intensity distribution in the H discharge.
244. Wien: AP **83,** 1 (1927). Duration of light emission.
245. Wierl: AP **82,** 563 (1927). Intensity asymmetry in the Stark effect.
246. Wrede: ZP **41,** 569 (1927). Magnetic moment of H atom.
247. Bramley: JFI **206,** 605 (1928). Schroedinger dynamics of the H atom.
248. Carst and Ladenberg: ZP **48,** 192 (1928). Anomalous dispersion. Intensity ratios of H$\alpha$ and H$\beta$.

## Hydrogen 1


249. Doetsch: ZP **49,** 705 (1928). Elimination of the Doppler effect in fine structures and determination of the components.
250. Doi: PMSJ **10,** 223 (1928). Third order Stark effect on Balmer lines.
251. Foster and Chalk: N **121,** 830 (1928). Relative intensities of Stark components of H$\alpha$.
252. Gordon: ZP **48,** 11 (1928). Energy levels of H atom according to Dirac theory of electron.
253. Hanot: CR **186,** 1716 (1928). Lines in the electric arc.
254. Hanot: JPR **9,** 156 (1928). Width of Balmer lines.
255. Harrison: PPS **40,** 300 (1928). Variations in the fine structure of H $\alpha$.
256. Hiedemann: ZP **50,** 609 (1928). Appearance of the Balmer lines on addition of argon.
257. Ishida: N **122,** 277 (1928). Stark effect at high fields.
258. Ishida and Hiyama: IPCR **8,** 1 (1928). Stark effect of Balmer series.
259. Kleiber: AP **87,** 461 (1928). Theory of light emission. Classical assumptions and Bohr's theory. Atomic collisions. The Balmer formula.
260. Kupper: AP **86,** 511 (1928). Intensities in wave mechanics. Comparison with experiment.
261. McDonald: TRSC **22,** 417 (1928). Elementary wave mechanical treatment of H atom with moving nucleus.
262. Mark and Wierl: Nw **16,** 725 (1928). Intensities of Stark effect components.
263. Oppenheimer: PR **32,** 361 (1928). Quantum theory of electron impacts.
264. Ornstein, Zernike and Snoek, Jr.: ZP **47,** 627 (1928). Doublet components of H$\alpha$ in absorption.
265. Robertson and Dewey: PR **31,** 973 (1928). Stark effect and series limits. Energy of conditionally aperiodic orbits.
266. Rojansky and Van Vleck: PR **32,** 327 (1928) (A). Non-metastability of the 2 $S$ level in atomic H.
257. Ruark: JOSA **16,** 40 (1928). Simple derivation of the H-energy levels in wave mechanics.
268. Ruark: PR **31,** 533 (1928). Zeeman and Stark effects in wave mechanics.
269. Rubinowicz: PZ **29,** 817 (1928). Multipole radiation. Theory of forbidden lines.
270. Schlapp: PRS **119,** 313 (1928). Stark effect of fine structure.
271. Slack: PR **31,** 527 (1928). Computation of intensities of series lines by wave mechanics.
272. Snoek and Ornstein: ZP **50,** 600 (1928). Fine structure of H$\alpha$ and H$\beta$ in absorption. Comparison with Schroedinger's theory.
273. Stark: AP **87,** 909 (1928). Duration of light emission.
274. von Traubenberg: PZ **29,** 895 (1928). Stark effect at high fields.
275. Bethe: ZP **57,** 815 (1929). Calculation of electron affinity.
276. Brasefield: PR **34,** 431 (1929). Line density as a function of velocity of exciting electrons.
277. Foster & Chalk: PRS **123,** 108 (1929). Relative intensities of Stark components.
278. Guth: ZP **58,** 368 (1929). Theory of second order Zeeman effect.
279. Goldstein: JPR **10,** 439 (1929). Intensity distribution in fine structure by the Dirac relativistic theory.
280. Gordon: AP **2,** 1031 (1929). Matrices for the H atom.
281. Gordon and Minkowski: Nw **17,** 368 (1929). Intensity of Stark effect components of the Balmer series.
282. Kiuti: ZP **57,** 658 (1929). Second order Stark effect of the Balmer lines.
283. Levy: L **77,** 20 (1929). Influence of magnetic field on polarization of light from H canal rays.
284. Levy and von Traubenberg: ZP **56,** 435 (1929). Influence of weak magnetic fields upon the intensity of the Balmer series in canal rays.
285. Mark and Wierl: ZP **53,** 526 (1929); ZP **55,** 156 (1929); ZP **57,** 494 (1929). Intensities of Stark components.
286. Rojansky: PR **33,** 1 (1929). Quantum mechanics of Stark effect.
287. Sen: ZP **56,** 673 (1929). Quantum mechanical calculation of splitting of H lines in crossed electric and magnetic fields.
288. Snoek: ANSE **12,** 164 (1929); ZP **52,** 654 (1929). Absorption measurements on the Balmer series.

## HYDROGEN 1

289. Stark: AP **1**, 323 (1929). Duration of light emission.
290. Stark: AP **1**, 1009 (1929). Intensity ratios in the Stark effect.
291. Stark: N **124**, 125 and 946 (1929). Asymmetry in the Stark effect.
292. Takamine and Suga: IPCR No. **202**, 193 (1929). Absorption of H$\alpha$.
293. von Traubenberg: PZ **30**, 751 (1929). Investigations on canal rays.
294. von Traubenberg and Gebauer: ZP **54**, 307 (1929); ZP **56**, 254 (1929). Second order Stark effect for the Balmer series.
295. Blaton: ZP **61**, 263 (1930); CRSP **5**, 17 (1930). Intensity of multipole lines in the Balmer series.
296. Chaudhurl: ZP **65**, 824 (1930). Relativity separation of lines in crossed electric and magnetic fields.
297. Foster: JFI **209**, 585 (1930). Stark effect.
298. Gebauer and von Traubenberg: ZP **62**, 289 (1930). Third order Stark effect for H$\beta$ and H$\alpha$.
299. Gronwall: PR **36**, 1671 (1930). A diophantine equation connected with the H spectrum.
300. Gupta: ZP **66**, 246 (1930). Influence of a nonhomogeneous electric field on fine structure.
301. van Keussler: AP **7**, 225 (1930). Absorption of H$\alpha$ fine structure.
302. Lanczos: ZP **65**, 431 (1930). Wave mechanical theory of term displacement in high electric fields.
303. Ornstein and Burger: ZP **62**, 636 (1930). Intensity ratios of Balmer and Paschen lines.
304. Ornstein and Lindeman: ZP **63**, 8 (1930). Intensities of the Balmer lines as a function of the excitation conditions.
305. Penny: PM **9**, 661 (1930). Hydrogen lines as standards.
306. Slack: PR **35**, 1170 (1930). H atom in the Stark effect. Wave function characteristics showing electronic charge distribution.
307. Stark: AP **4**, 607, 665, 685 (1930). Intensity dissymmetry in the Stark effect.
308. Steubing: Nw **18**, 1098 (1930). Effect of crossed electric and magnetic fields on the Balmer lines.
309. Steubing: PZ **31**, 350 (1930). Stark effect. Method of Lo-Surdo.
310. Temple: PRS **127**, 349 (1930). Operational wave equation and the energy levels of the H atom.
311. von Traubenberg and Gebauer: Nw **18**, 132 (1930). Stark effect at high fields.
312. von Traubenberg, Gebauer and Lewin: Nw **18**, 417 (1930). Stark effect at high fields.
313. Zahradnicek: ZP **59**, 723 (1930). Bohr's theory of the hydrogen series.
314. Doi: TBDR **1**, 7–12. p. 97 (1931). Relative intensities of Balmer and Paschen lines.
315. Finkelnburg: ZP **70**, 375 (1931). Emission spectrum of compressed hydrogen.
316. Gebauer and von Traubenberg: ZP **71**, 291 (1931). Dependence of intensity and line breadth of Stark effect components of H$\gamma$ on the field strength.
317. Hirsch and Schön: ZP **70**, 409 (1931). Axiality of light emission of canal rays.
318. Lanczos: ZP **68**, 204 (1931). Falling off of intensity in high electric fields. Wave mechanical theory.
319. McRae: PR **37**, 1688 (1931) (A); PRS **132**, 257 (1931). Asymmetry in Stark components of H$\alpha$.
320. Matuyama: JOSA **21**, 792 (1931). Spectrum appearing in early stages of the spark. Stark effect of inter-ionic field.
321. Nagaoka and Futagami: PIAT **7**, 54 (1931). Spectra from condensed discharge.
322. Nagashima: TBDR **1**, 7–12. p. 133 (1931). Reversal of the Balmer lines.
323. Ornstein, Eymers and Wouda: PKAA **34**, 505(1931). Boltzmann distribution in the H arc.
324. Ornstein, Kruithof and Dekkers: PKAA **34**, 610 (1931). Excitation by electron impact and high velocity protons.
325. Ornstein and Lindeman: ZP **67**, 1 (1931). Intensities of the Balmer lines. Theoretical.
326. Rao and Badami: N **128**, 585 (1931). Resonance spectrum. Intensity anomalies.
327. Saha and Banerji: ZP **68**, 704 (1931). Distribution of intensity in fine structure components according to Dirac's electron theory.

## Hydrogen 1; Helium 2

328. Sjögren: Nw **19,** 640 (1931). Stark effect in the Balmer series.
329. Stahl: ZP **72,** 478 (1931). Influence of pressure and foreign gases upon the intensity variations of the Balmer lines in weak magnetic fields.
330. Steubing: AP **10,** 296 (1931). Field distribution and sources of error in the Stark effect according to the method of Lo-Surdo.
331. Steubing: PZ **32,** 290 (1931). Effect of crossed electric and magnetic fields on the Balmer lines.
332. Straub: AP **10,** 670 (1931). Doppler effect in canal rays.
333. Vencov: AsP **15,** 131 (1931). Discharges and spectra due to electronic impacts.

## Helium 2

**He I**

1. Bell: PM **40,** 489 (1920). Rydberg constant.
2. Compton: PM **40,** 553 (1920). Excitation by electron impact.
3. Compton and Lilly: AJ **52,** 1 (1920). Excitation by electron impact. Critical potentials.
4. Compton, Lilly and Olmstead: PR **15,** 545 (1920); (A) PR **16,** 282 (1920). Low voltage arc.
5. Found: PR **16,** 41 (1920). Ionization potential.
6. Franck and Knipping: ZP **1,** 320 (1920). Ionization and resonance potentials.
7. Franck and Reiche: ZP **1,** 154 (1920). Discussion of He and par-He.
8. de Gramont: CR **171,** 1106 (1920). Ultimate lines.
9. Horton and Bailey: PM **40,** 440 (1920). Effect of impurities on measurement of ionization velocities.
10. Horton and Davies: PM **39,** 592 (1920). Critical electron velocities.
11. Lande: PZ **21,** 114 (1920). Perturbation theory of He atom.
12. McLennan: PRS **98,** 114 (1920). Wave-lengths.
13. Millikan: AJ **52,** 47 (1920). Extension of the ultraviolet spectrum.
14. Saha: PM **40,** 809 (1920). Elements in the sun.
15. Stead and Gossling: PM **40,** 413 (1920). Ionization potential.
16. Waran: PCPS **20,** 45 (1920). Effect of magnetic field on intensity of He lines.
17. Yoshida: MKCS **4,** 187 (1920). Regularity in the Stark effect.
18. Fricke and Lyman: PM **41,** 814 (1921). Extreme ultraviolet spectrum. New lines.
19. de Gramont: CN **122,** 58 (1921). Ultimate lines.
20. Horton and Davies: PM **42,** 746 (1921). Excitation by electron impact.
21. Kemble: PM **42,** 123 (1921). Normal state of He.
22. Landé: ZP **7,** 398 (1921). Anomalous Zeeman effect.
23. McLennan and Petrie: TRSC **15,** 15 (1921). Extreme ultraviolet spectrum.
24. Meggers: JOSA **5,** 308 (1921). Standard wave-lengths.
25. Meggers: PR **18,** 160 (1921) (A). Standard wave-lengths.
26. Millikan: PR **18,** 456 (1921). Discussion of suggested models for He.
27. Plaskett: N **108,** 209 (1921). Pickering series in O type stars.
28. Seeliger: PZ **22,** 610 (1921). Excitation by electron impact.
29. Seeliger and Mierdel: ZP **5,** 182 (1921). Excitation by electron impact.
30. Seeliger and Schramm: ZP **7,** 93 (1921). Excitation by electron impact.
31. Compton: PM **43,** 531 (1922). Ionization by cumulative action.
32. Compton: PR **20,** 283 (1922). Theory of ionization by culminative action and of the low voltage arc.
33. Davies: PRS **100,** 599 (1922). Critical potentials.
34. Foster: PR **20,** 214 (1922). Relative intensities of Stark effect components.
35. Franck: ZP **11,** 155 (1922). Excitation and ionization potentials.
36. Hicks: N **110,** 309 (1922). Theoretical derivation of He I lines.
37. Hopfield: PR **20,** 573 (1922). Extension of ultra-violet spectrum.
38. Horton and Davies: PM **43,** 1020 (1922); PM **44,** 1140 (1922). Ionization by cumulative effects.

## Helium 2

39. Kannenstine: AJ **55**, 345 (1922). Formation and life of metastable helium.
40. Lyman: N **110**, 278 (1922); S **56**, 167 (1922). Extreme ultraviolet spectrum.
41. Nicholson: PRI **22**, 522 (1922). Energy distribution in spectrum.
42. Raman: N **110**, 700 (1922). Theoretical derivation of lines.
43. Silberstein: AJ **56**, 119 (1922); N **110**, 247 (1922); PR **19**, 399 (A) (1922). Quantum theoretical derivation of He I lines. Aspherical nucleus theory.
44. Taylor: AJ **56**, 16 (1922); PR **19**, 255 (1922). Line width as a function of pressure in the source.
45. Van Vleck: PM **44**, 842 (1922). Normal He atom and the quantum theory.
46. Van Vleck: PR **19**, 419 (A) (1922). Ionization potential of Kemble's He model.
47. Bär, von Laue and Meyer: ZP **20**, 83 (1923). Low voltage arc.
48. Born and Heisenberg: ZP **16**, 229 (1923). Electron paths of He. Calculation of terms.
49. Carelli: NC **25**, 213 (1923). Stark effect.
50. Compton: PM **45**, 750 (1923). Resonance radiation and excited atoms. Interpretation of metastable states.
51. Curry: PR **21**, 203 (1923). (A) Relative intensities as a function of current.
52. Davies: PM **45**, 786 (1923). Critical potentials. Ultraviolet spectrum.
53. Dejardin: JPR **4**, 121 (1923). Excitation by impact of slow electrons.
54. Dufford and Thompson: PR **21**, 212 (1923). (A). Low pressure spectrum.
55. Hertz: Nw **11**, 778 (1923). Excitation by electron impact.
56. Hicks: N **111**, 146 (1923). Theoretical derivation of He I lines.
57. Hicks: PM **45**, 480 (1923). Ionization potential.
58. Hopfield and Leifson: AJ **58**, 59 (1923). Standards in extreme ultraviolet.
59. Hughes and Lowe: PR **21**, 202 (A) and 714 (A) (1923); PRS **104**, 480 (1923); TRSC **17**, 197 (1923). (A) Intensities.
60. Hulburt: PR **22**, 24 (1923). Intensities of broadened Balmer lines.
61. Kramers: ZP **13**, 312 (1923). Model of the He atom. Calculation of term values.
62. Lyman: PR **21**, 202 (1923). (A) Extreme ultraviolet spectrum.
63. Mackay: PM **46**, 828 (1923). Ionization potential.
64. Newboult: PM **45**, 1085 (1923). Langmuir's He model.
65. Nicholson: PM **45**, 801 (1923). Quantum theory and isotopes. Orbits passing through nucleus.
66. Offerhaus: ANSE **7**, 60 (1923); P **3**, 309 (1923). Wave-lengths.
67. Plaskett: N **112**, 392 (1923). Origin of nebular lines.
68. Raman and Ganesan: AJ **57**, 243 (1923). Silberstein's formula for He I lines.
69. Silberstein: AJ **57**, 248 and 257 (1923). Crossed orbit model of helium, its ionization potential, and the Lyman series.
70. Silberstein: N **111**, 46 (1923); PR **21**, 388 (1923). Quantum theory of He lines.
71. Sommerfeld: JOSA **7**, 509 (1923). Quantum theory of He spectrum.
72. Tschulanowsky: ZP **16**, 300 (1923). Effect of electric field on series spectrum.
73. van Vleck: PR **21**, 372 (1923). (A) Quantum theory of He I.
74. Bazzoni and Lay: PR **23**, 327 (1924). Intensity relations.
75. Bazzoni and Lay: PR **23**, 769 (1924). (A) The 23 volt arc in He.
76. Birge: JOSA **8**, 233 (1924). Series of divalent elements.
77. Brunetti: AAL **33**, 413 (1924). Fine structure of $\lambda$5876.
78. Dejardin: AsP **2**, 241 (1924). Excitation by electron impact.
79. Dempster: AJ **59**, 142 (1924). Determining factors in the life of metastable He.
80. Eckart and Compton: PR **24**, 97 (1924). Low voltage arc.
81. Foster: PR **23**, 293 (1924). (A) New combination series.
82. Foster: PR **23**, 667 (1924). Stark effect.
83. Hertz: Nw **12**, 1211 (1924). Excitation and ionization potentials.
84. Hertz: ZP **22**, 18 (1924). Excitation by electron impact.
85. Holtsmark: PZ **25**, 73 (1924). Broadening of spectral lines.
86. Johnson and Cameron: PRS **106**, 195 (1924). Effect of argon on certain spectra.

## Helium 2


87. Jones and Boyce: PRS **106**, 773 (1924). Constants of the Rydberg-Ritz equation.
88. Kannenstine: AJ **59**, 133 (1924). Life of metastable helium.
89. Krefft: PZ **25**, 352 (1924). Doppler effect in arc and spark lines.
90. Kronig: S **58**, 537 (1924). A model of the He atom.
91. Lyman: AJ **60**, 1 (1924); S **59**, 422 (1924). Extreme ultraviolet spectrum.
92. Mackay: PR **24**, 319 (1924). Ionization potential.
93. Mierdel: PZ **25**, 240 (1924). Spectrum of electrodeless discharge.
94. Millikan and Bowen: PR **23**, 1 (1924). Ultraviolet wave-lengths.
95. Ornstein and Burger: ZP **26**, 57 (1924). Fine structure of λ5876.
96. Payne: PNAS **10**, 322 (1924). Synopsis of ionization potentials.
97. Raman and Ganesan: AJ **59**, 61 (1924). On Silberstein's He model.
98. Ruark, Foote and Mohler: JOSA **8**, 17 (1924). Inner quantum numbers for He I.
99. Turner: PM **48**, 384 and 1010 (1924). Quantum defect and atomic number.
100. Udden and Jacobsen: PR **23**, 322 (1924). Excitation by electron impact.
101. Wien: AP **73**, 483 (1924). Duration of light emission.
102. von Wisniewski: PZ **25**, 135 (1924). Calculation of term corrections.
103. Dymond: PRS **107**, 291 (1925). Precise measurement of critical potentials.
104. Eckart: S **61**, 517 (1925). Life of metastable He.
105. Eckart and Compton: PR **25**, 139 (1925). Abnormal low voltage arc.
106. Foster: N **116**, 135 (1925). Observed Stark effect patterns.
107. Gehrcke: PZ **26**, 675 (1925). New results of fine structure research.
108. Goudsmit and Uhlenbeck: P **5**, 266 (1925). Fine structure.
109. Hertz: PKAA **28**, 767 (1925). Excitation by electron impact.
110. Hertz and Kloppers: ZP **31**, 463 (1925). Excitation and ionization potentials.
111. Hertz and de Visser: P **5**, 41 (1925); or ZP **31**, 470 (1925). Excitation by electron impact.
112. Hertzfeld and Wolf: AP **76**, 71 and 567 (1925). A test of the classical dispersion formula. The number of dispersion electrons.
113. Kuhn: ZP **33**, 408 (1925). Total strength of the absorption lines proceeding from one state.
114. Russell: AJ **61**, 223 (1925). Ultimate and penultimate lines.
115. Slater: PNAS **11**, 732 (1925). Interpretation of the He spectrum.
116. Tartakowsky: ZP **34**, 216 (1925). Diamagnetism and anomalous Zeeman effect.
117. von Wisniewski: PZ **26**, 255 (1925). Calculation of *s*-terms.
118. Beams and Rhodes: PR **28**, 1147 (1926). Time intervals between the appearance of certain lines.
119. Burger: ZP **38**, 437 (1926). Intensity relations of the apparent doublets of He.
120. Crudeli: AAL **3**, 666 (1926). On a model of the He atom.
121. Dewey: PR **28**, 1108 (1926). Intensities in the Stark effect.
122. Dorgelo: P **6**, 150 (1926). Intercombination line in He I proved to be a line in the neon spectrum.
123. Dorgelo and Abbink: ZP **37**, 667 (1926). Extreme ultraviolet spectrum.
124. Foster: AJ **63**, 191 (1926). Second order Stark effect.
125. Glockler: PR **27**, 423 (1926). Resonance potentials.
126. Heinrich: AP **80**, 349 (1926). Spectrophotometer measurements.
127. Heisenberg: ZP **38**, 411 (1926). Problem of several bodies and resonance in quantum mechanics.
128. Heisenberg: ZP **39**, 499 (1926). Quantum mechanical interpretation of the spectra of two-electron atoms.
129. Hertz and Abbink: Nw **14**, 648 (1926). Resonance lines of the noble gases.
130. Hicks: AsP **6**, 294 (1926). Structure of rare gas spectra.
131. McCurdy: PM **2**, 529 (1926); PNAS **12**, 231 (1926). Absorption and resonance radiation. Structure of λ3889.
132. MacNair and McCurdy: N **117**, 159 (1926). Structure of the $D_3$ line.
133. Merton: PM **2**, 975 (1926). Reversals in vacuum tube spectra.

## Helium 2


134. Swindler: PR **28**, 1136 (1926). Effect of potential and frequency on spectra.
135. Takamine: IPCR No. **69**, 55 (1926). Spectroscopic study of the discharge in He.
136. Takamine and Werner: Nw **14**, 47 (1926). Stark effect intensities.
137. Trkal: ZP **36**, 194 (1926). Dynamics of the He atom.
138. Unsöld: ZP **36**, 92 (1926). Polarizability. Calculation of quantum defect.
139. Waller: ZP **38**, 635 (1926). Rydberg correction for certain terms.
140. Dewey: PR **30**, 770 (1927). Intensities in the Stark effect.
141. Dorgelo and Washington: PKAA **30**, 33 (1927). Duration of metastable states.
142. Foster: PR **29**, 916 (1927) (A); PRS **117**, 137 (1927). Quantum mechanics of the Stark effect.
143. Foster: PRS **114**, 47 (1927). Stark patterns.
144. Hansen: N **119**, 237 (1927). Fine structure.
145. Houston: PNAS **13**, 91 (1927). Fine structure.
146. Houston: PR **30**, 608 (1927). Determination of Rydberg constant.
147. Kellner: Nw **15**, 561 (1927); ZP **44**, 91 (1927). Calculation of ionization potential by wave mechanics.
148. Ornstein and Burger: ZP **40**, 403 (1927). Intensities.
149. Ornstein and Bouwman: ZP **43**, 839 (1927). Intensities.
150. Paschen: SAWB **29**, 207 (1927). Excitation through the metastable condition of rare gas atoms.
151. Pauling: PR **29**, 285 (1927). Ionization potential.
152. Slater: PNAS **13**, 423 (1927). Calculation of energy levels by wave mechanics.
153. Stark: PZ **28**, 421 (1927). Axiality of light emission and atomic structure.
154. Sugiura: ZP **44**, 190 (1927). Numerical calculation of mean values between ortho- and para-terms by quantum mechanics.
155. Trumpy: ZP **42**, 327 (1927). Intensities.
156. Unsöld: AP **82**, 355 (1927). Calculation of *s*-terms. Stark effect.
157. Burger and van Cittert: ZP **51**, 638 (1928); Broadening of lines by auto-absorption.
158. Compton and Boyce: JFI **205**, 497 (1928). Extreme ultraviolet spectrum excited by electron impact.
159. Cornog: PR **32**, 746 (1928). Energy relations.
160. Gaunt: PCPS **24**, 328 (1928). Theory of Hartree's atomic fields.
161. Glaser and Böhm: VPGW, Page 39 (1928). Zeeman effect.
162. Hartree: PCPS **24**, 111 (1928). Distribution of charge calculated from wave equation for a central field. Ionization potential.
163. Hodges and Michels: PR **32**, 913 (1928). Intensity measurements.
164. Hylleras: ZP **48**, 469 (1928). Energy of the ground state.
165. Ishida: N **122**, 277 (1928). Stark effect at high fields.
166. Ishida and Kamijima: IPCR No. **160**, 117 (1928). Stark effect.
167. McLennan, Ruedy and Allin: TRSC **22**, 273 (1928). Absorption spectrum.
168. Oppenheimer: PR **32**, 361 (1928). Quantum theory of electron impacts.
169. Ornstein, Burger and Kapuscinski: ZP **51**, 34 (1928). Origin of the spectrum excited by electron impact. Intensity studies.
170. Slater: PR **32**, 349 (1928). An approximate wave function for He I.
171. Stark: AP **86**, 530 (1928). Intensity ratios in ortho- and para-series.
172. Stark: AP **87**, 927 (1928). Optical investigation of the atomic structure of He.
173. Takamine and Suga: PM **5**, 141 (1928). Reversal of lines.
174. Wei: AJ **68**, 246 (1928). Fine structure of the $D_3$ line.
175. Bethe: ZP **55**, 431 (1929). Comparison of the distribution of electrons in the ground state as calculated by different methods.
176. Buchanan: TRSC **23**, 227 (1929). Second genus orbits.
177. Burger: ANSE **12**, 147 (1929); ZP **54**, 643 (1929). Intensity measurements.
178. Burger and van Cittert: ZP **52**, 300 (1929). Broadening by auto-absorption.
179. Elenbaas: PKAA **32**, 1334 (1929). Line intensity as a function of pressure and electron velocity.

## Helium 2

180. Foster: PRS **122,** 599 (1929). He spectrum in combined electric and magnetic fields.
181. Fujioka: IPCR No. **181,** 99 (1929). Stark effect of $2P-6D$ line by quantum mechanics.
182. Gaunt: PRS **122,** 513 (1929); PTRS **228,** 151 (1929). Quantum theory of He triplets.
183. Glockler: PR **33,** 175 (1929). Efficiency of electron impact leading to resonance.
184. Hanle: PZ **30,** 169 (1929); ZP **56,** 94 (1929). Excitation functions.
185. Hansen: VDPG **10,** 5 (1929). Fine structure.
186. Hirsch and Döpel: AP **1,** 963 (1929). Duration of emission.
187. Hylleras: FT **27,** 117 (1929); Nw **17,** 982 (1929); PZ **30,** 249 (1929); ZP **54,** 347 (1929). Calculation of energy of ground state by quantum mechanics.
188. Michels: PR **33,** 267 (1929). (A). Intensity measurements.
189. Ornstein: JFI **208,** 589 (1929). Spectral energy distribution.
190. Paschen: SAWB **30,** 662 (1929). Lyman's He spectrum.
191. Peteri and Elenbaas: ZP **54,** 92 (1929). Line intensity as a function of pressure and electron velocity.
192. Stark: N **124,** 946 (1929). Asymmetry in the Stark effect.
193. Takamine and Suga: IPCR No. **198,** 131 (1929). New infrared spectra of He.
194. Anderson: CJR **2,** 13 (1930). Duration of metastable states.
195. Beeck: AP **6,** 1001 (1930). Ionization by alkali ions.
196. Breit: PR **36,** 383 (1930). Spin interaction of two electrons and fine structure.
197. Deslandres: CR **190,** 1250 (1930). Properties of abnormal series.
198. Eckart: PR **36,** 149 (1930). Calculation of energy levels.
199. Eckart: PR **36,** 878 (1930). Calculation of screening constants. Ionizing potentials.
200. Elenbaas: ZP **59,** 289 (1930). Line intensity as a function of pressure and electron velocity.
201. Foster: JFI **209,** 585 (1930). Stark effect.
202. Foster: N **126,** 845 (1930). Stark effect. Intersection of levels with equal $m$ values.
203. Hopfield: AJ **72,** 133 (1930). Extension of ultraviolet series.
204. Hylleras: ZP **65,** 209 (1930). Calculation of ionization energy by wave mechanics.
205. Hylleras: ZP **66,** 453 (1930). Para-ortho separation and the average value of the $S$ terms for higher quantum numbers.
206. Hylleras and Undheim: ZP **65,** 759 (1930). Numerical calculation of the two $S$ terms of ortho- and para-helium.
207. Ishida: IPCR **14,** 49 (1930). Notes on effect of electric field on He spectrum.
208. Ishida and Tamura: IPCR **13,** No. 241, 115 (1930). A combination series. Stark effect.
209. Kruger: PR **36,** 855 (1930). New lines and classifications.
210. Langstroth: PRS **129,** 70 (1930). Relative intensities of Stark components.
211. Michels: PR **36,** 1362 (1930). Optical excitation functions.
212. Mulder and Razek: PR **35,** 1423 (A) and 1442 (A) (1930). Voltage-intensity variations.
213. Penny: PM **9,** 661 (1930). Helium lines as standards.
214. Stark: AP **4,** 607, 665 685 (1930). Intensity asymmetry in the Stark effect.
215. Takamine and Suga: IPCR **13,** 1 (1930). Near infrared spectrum.
216. Tomiyama: IPCR **9,** 461 (1930). He spectrum and relativistic quantum mechanics.
217. Wierl: Nw **18,** 86 (1930). Stark effect and polarization.
218. Zener: PR **36,** 51 (1930). Analytic atomic wave functions.
219. van Atta: PR **38,** 876 (1931). Excitation probabilities for electrons in helium.
220. Cowan, Brown and Emeléus: N **127,** 593 (1931). Spectrum of glow discharge. Intensity distribution.
221. Foster: PR **37,** 1687 (1931); (A) PRS **131,** 133 (1931). Effect of combined electric and magnetic fields on He spectrum.
222 Gibbs and Kruger: PR **37,** 1559 (1931). Structure of He λ3888.
223. Hardy: PR **38,** 2162 (1931). Resolution of infrared lines.
224. Hirsch and Schön: ZP **70,** 409 (1931). Axiality of light emission of canal rays.
225. Hylleras: ZP **69,** 361 (1931). Origin of the corona lines.
226. Levy: ZP **72,** 578 (1931). Anomalous dispersion. Transition probabilities.
227. Majorana: NC **8,** 78 (1931). Classification of certain lines.

## HELIUM 2

228. Massey and Mohr: N **127**, 234 (1931). Excitation probabilities of singlet and triplet states.
229. Nagoaka and Futagami: PIAT **7**, 54, (1931). Spectra from condensed discharge.
230. Razek: PR **37**, 1252 (1931). Voltage-intensity variations.
231. Roberts and Whiddington: PM **12**, 962 (1931). Energy of excitation by electron impact.
232. Smith: PR **38**, 1961 (1931). Evaluation of the matrix components for helium.
233. Sutton and Mouzon: PR **37**, 379 (1931). Ionization by alkali ions.
234. Townsend and Jones: PM **11**, 679 (1931); PM **12**, 815 (1931). Excitation of visible spectrum. Critical potentials.
235. Vinti: PR **37**, 448 (1931). Energies and wave functions of the state $1s2s\ ^1S_0$.
236. Weizel: PR **38**, 642 (1931). Broadening of resonance line.
237. Whiddington and Roberts: N **128**, 966 (1931). Electron exchange phenomena. Transition probabilities.
238. Whiddington and Roberts: PLPS **2**, 201 (1931). Determination of excitation energy by electron impact.
239. Womer: PR **38**, 454 (1931). Ionization by electron impact.

### He II

1. Kramers: ZP **3**, 199 (1920). Quantum theory of Stark effect.
2. Lyman: N **104**, 565 (1920). Series.
3. Hansen and Jacobsen: MK **3**, No. 11 (1921). Zeeman effect of λ4686.
4. McLennan and Petrie: TRSC **15**, 15 (1921). Extreme ultraviolet spectrum.
5. Davies: PRS **100**, 599 (1922). Critical potentials.
6. Rogestwensky: JRPC **50**, 1 (1922). Series of He II and Mg II compared.
7. Wilson: AJ **56**, 34 (1922). Quantum theory of doublets.
8. Halpern: ZP **18**, 287 (1923). Theory of combined Stark and Zeeman effects.
9. Hansen and Jacobson: MK **3**, No. 11 (1923). Zeeman effect of fine structure components.
10. Hicks: PM **45**, 480 (1923). Radiation and ionization potentials.
11. Ham: PR **23**, 107 (1924). (A) Notes on fine structure theory.
12. Lau: PZ **25**, 60 (1924). Fine structure. Intensity ratios of Balmer components.
13. Lyman: AJ **60**, 1 (1924). Ultraviolet spectrum. Radiation and ionization potentials.
14. Urey: ZP **29**, 86 (1924). Theory of perturbing effect of electric fields on the Zeeman effect.
15. Foster: AJ **62**, 229 (1925). Stark effect of λ4686.
16. Gehrcke: PZ **26**, 675 (1925). Fine structure of λ4686.
17. Goudsmit and Uhlenbeck: P **5**, 266 (1925). Fine structure.
18. Russell: AJ **61**, 223 (1925). Ultimate and penultimate lines.
19. Slater: PNAS **11**, 732 (1925). Interpretation of the He spectrum.
20. Kunze: AP **79**, 610 (1926). Fine structure of λ4686.
21. Leo: AP **81**, 757 (1926). Fine structure of the Fowler series.
22. Sommerfeld and Unsöld: ZP **38**, 237 (1926). Intensities of fine structure components.
23. Uhlenbeck and Goudsmit: N **117**, 264 (1926). Rotating electron and fine structure.
24. Kellner: ZP **44**, 110 (1927). Calculation of fundamental term by wave mechanics.
25. Ornstein and Bouwman: ZP **43**, 839 (1927). Intensities.
26. Paschen: AP **82**, 689 (1927). Relativistic fine structure.
27. Compton and Boyce: JFI **205**, 497 (1928). Extreme ultraviolet spectra excited by electron impacts.
28. Kruger: PR **36**, 855 (1930). New lines and classifications.
29. Penny: PM **9**, 661 (1930). He lines as standards.
30. Foster: PR **37**, 1687 (1931). (A) Effect of combined electric and magnetic fields on the He spectrum.
31. Maxwell: PR **38**, 1664 (1931). Average life of ionized atoms.
32. Saha and Banerji: ZP **68**, 704 (1931). Distribution of intensity in fine structure components according to Dirac's electron theory.

## LITHIUM 3

**Li I**

1. Gouy: AsP **13,** 188 (1920). Intensity measurements.
2. de Gramont: CR **171,** 1106 (1920). Ultimate lines.
3. de Gramont: CN **122,** 58 (1921). Ultimate lines.
4. Millikan: PNAS **7,** 289 (1921). Extension of the ultraviolet spectrum.
5. Ramsauer and Wolf: AP **66,** 373 (1921). Duration of emission in quenched arc.
6. Seeliger and Thaer: AP **65,** 423 (1921). Displacement law. Study of excitation energies.
7. Becker: ZP **9,** 332 (1922). Stark effect.
8. McLennan and Ainslie: PRS **101,** 342 (1922). Fine structure of λ6708.
9. Merton: N **110,** 632 (1922). Fine structure of λ6708.
10. Robertson: PR **19,** 470 (1922). Spectrum of electrodeless discharge.
11. Bartels: ZP **20,** 398 (1923). Intensity distribution, term sequence, and excitation functions.
12. Nagaoka and Sugiura: JJP **2,** 167 (1923). Spectroscopic evidence of isotopy.
13. Newman: PM **45,** 181 and 293 (1923). Visibility of spectra.
14. Turner: AJ **58,** 176 (1923). Relation between spectra and sizes of alkali atoms.
15. van Urk: ZP **13,** 268 (1923). Normal orbits of the series electrons.
16. Ainslie: TRSC **18,** 137 (1924). Fine structure of λ6708.
17. Bowen and Millikan: PR **24,** 209 (1924). Extension of the doublet laws.
18. Hartree: PCPS **22,** 409 (1924). Identification of lines. Term values.
19. Hartree: PRS **106,** 552 (1924). Term excess. Quantum defect. Spectra of lithium-like atoms.
20. Kimura and Nakamura: JJP **3,** 29 (1924). Cathode spectra of metals.
21. Landé: ZP **25,** 46 (1924). Doublet and triplet intervals. Doublet laws.
22. Lindsay: MIT **3,** 191 (1924). Electron orbits of the alkalies.
23. Millikan and Bowen: PR **23,** 1 (1924). Wave-lengths.
24. Morand: CR **178,** 1897 (1924). Extension of series.
25. Nagoaka and Sugiura: N **113,** 532 (1924). Spectroscopic evidence of isotopes.
26. Narayan and Gunnayya: PRS **106,** 51 (1924). Absorption spectrum.
27. Sugiura: JJP **3,** 155 (1924). Calculation of doublet frequency differences.
28. Turner: PM **48,** 384 (1924). Quantum defect.
29. von Wisniewski: CR **179,** 1316 (1924). A formula for doublet separation.
30. von Wisniewski: PZ **25,** 330 (1924). The "*p*" and "*d*" terms of lithium.
31. Back: PZ **26,** 833 (1925). Zeeman effect.
32. Green: JOSA **11,** 213 (1925). Fine structure of λ6708.
33. Holtsmark and Trumpy: ZP **31,** 803 (1925). Line broadening.
34. Mohler: BSP No. **505,** 167 (1925). Critical potentials.
35. Royds: PRS **107,** 360 (1925). Apparent tripling of certain lines.
36. Runge: AP **76,** 266 (1925). Paschen-Back effect.
37. Russell: AJ **61,** 223 (1925). Ultimate and penultimate lines.
38. Schrödinger: AP **77,** 43 (1925). Hydrogen-like spectra and polarizability of the atom core.
39. Sugiura: IPCR **3,** 1 (1925). Calculation of doublet frequency differences.
40. Tartakowsky: ZP **34,** 216 (1925). Diamagnetism and anomalous Zeeman effect.
41. Thomas: ZP **34,** 586 (1925). Formula for second order Stark effect.
42. Bogros: CR **183,** 124 (1926). Resonance of lithium vapour.
43. Hori: IPCR No. **53,** 59 (1926). Explosion spectrum.
44. Kudar: PZ **27,** 107 (1926). Correspondence principle and doublet spectra. Relativistic and screening doublets.
45. Poirot: JPR **7,** 217 (1926). Stark effect of anode rays.
46. Sowerby and Barratt: PRS **110,** 190 (1926). Absorption spectrum.
47. Takamine and Werner: Nw **14,** 47 (1926). Intensities in the Stark effect.
48. Thomas: ZP **35,** 556 (1926). Formula for second order Stark effect.
49. Unsöld: ZP **36,** 92 (1926). Polarizability. Calculation of quantum defect.
50. Waller: ZP **38,** 635 (1926). Rydberg correction.

## LITHIUM 3

51. Schüler and Wurm; Nw **15,** 971 (1927). Fine structure of λ6708.
52. Trumpy; ZP **44,** 575 (1927). Transition probabilities.
53. Unsöld: AP **82,** 355, (1927). Calculation of *s*-terms. Stark effect.
54. Ishida: N **122,** 227 (2928). Stark effect at high fields.
55. Ishida and Fukushima: IPCR No. **161,** 141 (1928). Stark effect.
56. Kupper: AP **86,** 511 (1928). Comparison of experimental and theoretical intensities.
57. Locher: JOSA **17,** 91 (1928). Time intervals between the appearance of spectral lines.
58. Trumpy: ZP **50,** 228 (1928). Transition probabilities.
59. Gibbs and White: PR **33,** 157 (1929). Doublets of stripped atoms.
60. Hargreaves: PCPS **25,** 75 (1929). Calculation of dispersion electrons by wave equation
61. Jackson: ZP **53,** 458 (1929). Magnetic moment.
62. Prokofjew: ZP **57,** 387 (1929). Intensities of forbidden lines.
63. Schüler and Brück: ZP **58,** 735 (1929). Hyperfine structure and nuclear moment.
64. Snyder: PR **33,** 354 (1929). Stark effect for diffuse lines.
65. Stern: ZP **54,** 158 (1929). Magnetic moment.
66. Taylor: ZP **52,** 846 (1929). Magnetic moment.
67. Trumpy: ZP **54,** 372 (1929); ZP **57,** 787 (1929). Transition probabilities.
68. Bogros: CR **190,** 1185 (1930). Fine structure of λ6708.
69. Deslandres: CR **190,** 1250 (1930); CR **191,** 7 (1930). Abnormal series.
70. Deslandres: CR **191,** 169 (1930). Ultimate rays.
71. Eckart: PR **36,** 149 (1930). Calculation of energy levels.
72. Eckart: PR **36,** 878 (1930). Calculation of screening constants. Ionizing potentials.
73. France: PRS **129,** 354 (1930). Absorption spectrum.
74. Goudsmit and Young: N **125,** 461 (1930). Nuclear moment.
75. Granath: PR **36,** 1018 (1930). Nuclear moment.
76. Guillemin and Zener: ZP **61,** 199 (1930). Simple eigenfunction for the ground state.
77. Harvey and Jenkins: PR **35,** 789 (1930). Nuclear spin.
78. Hughes and Eckart: PR **36,** 694 (1930). Effect of nuclear motion on spectra.
79. Schüler: ZP **59,** 149 (1930). Excitation of spectra for the investigation of hyperfine structure.
80. Stevenson: PRS **128,** 591 (1930). Intensity of quadrupole radiation.
81. Trumpy: ZP **61,** 54 (1930). Calculation of number of dispersion electrons.
82. White: PR **35,** 441 (1930). Nuclear spin and hyperfine structure.
83. Zener: PR **36,** 51 (1930). Analytic atomic wave functious.
84. Filippov: ZP **69,** 526 (1931). Anomalous dispersion. Transition probabilities.
85. Hughes: PR **38,** 857 (1931). Hyperfine structure.
86. Kronig and Frisch: PZ **32,** 457 (1931). Nuclear moments. Bibliography.
87. Schüler: Nw **19,** 772 (1931). Abundance ratio of isotopes.
88. Whitelaw and Stevenson: N **127,** 817 (1931). Intensity of forbidden transitions.
89. van Wijk: Nw **19,** 894 (1931). Abundance ratio of isotopes. Hyperfine structure.

**Li II**

1. Angerer: ZP **18,** 113 (1923). Wave-lengths.
2. Mohler: S **58,** 468 (1923). A spark line of lithium.
3. Lang: PTRS **224,** 371 (1924). Wave-lengths.
4. Morand: CR **178;** 1528 and 1701 (1924). Wave-lengths.
5. Schüler: Nw **12,** 579 (1924). Series.
6. von Wisniewski: PZ **25,** 135 (1924). Calculation of term corrections.
7. Mohler: BSP No. **505,** 167 (1925). Critical potentials.
8. Schüler: AP **76,** 292 (1925). Fine structure.
9. Sugiura: JPR **6,** 323 (1925). Series.
10. Tartakowsky: ZP **34,** 216 (1925). Diamagnetism and anomalous Zeeman effect.
11. Werner: N **115,** 191 (1925); N **116,** 574 (1925). Series.
12. Heisenberg: ZP **39,** 499 (1926). Quantum mechanical interpretation of two-electron spectra.

## LITHIUM 3; BERYLLIUM 4

13. Schüler: ZP **37,** 568 (1926). Series. Fine structure.
14. Unsöld: ZP **36,** 92 (1926). Polarizability. Calculation of quantum defect.
15. Waller: ZP **38,** 635 (1926). Rydberg correction.
16. Werner: N **118,** 154 (1926). Series.
17. Kellner: ZP **44,** 110 (1927). Calculation of lowest term by wave mechanics.
18. Pauling: PR **29,** 285 (1927). Ionization potential.
19. Schüler: ZP **42,** 487 (1927). Series. Fine structure.
20. Sugiura: ZP **44,** 190 (1927). Calculation of mean values between ortho- and para-terms by quantum mechanics.
21. Unsöld: AP **82,** 355 (1927). Calculation of *s*-terms.
22. Hylleras: Nw **17,** 982 (1929). Calculation of ionization potential.
23. Schüler and Brück: ZP **58,** 735 (1929). Hyperfine structure.
24. Breit: PR **35,** 1447 (1930). Nuclear spin and x-ray terms.
25. Breit: PR **36,** 383 (1930). Spin interaction of two electrons, and fine structure.
26. Breit and Doermann: PR **36,** 1262 and 1732 (1930). Hyperfine structure of *S* and *P* terms.
27. Eckart: PR **36,** 149 (1930). Calculation of energy levels.
28. Eckart: PR **36,** 878 (1930). Calculation of screening constants. Ionizing potentials.
29. Eckstein and Freeman: ZP **64,** 547 (1930). Explosion spectrum. Forbidden transitions.
30. Ericson and Edlen: ZP **59,** 656 (1930). Series.
31. Goudsmit and Young: N **125,** 461 (1930). Hyperfine structure.
32. Granath: PR **36,** 1018 (1930). Angular momentum of the $Li_7$ nucleus.
33. Güttinger: ZP **64,** 749 (1930). Hyperfine structure theory. Comparison with experiment
34. Hargreaves: PRS **127,** 141 (1930). Nuclear spin.
35. Hughes and Eckart: PR **36,** 694 (1930). Effect of nuclear motion on spectra.
36. Hylleras: ZP **65,** 209 (1930). Calculation of ionization energy.
37. Schüler: ZP **59,** 149 (1930). Excitation of spectra for investigation of hyperfine structure.
38. Schüler: ZP **66,** 431 (1930). Nuclear moments of $Li_6$ and $Li_7$.
39. White: PR **35,** 441 (1930). Nuclear spin and hyperfine structure.
40. Goudsmit and Inglis: PR **37,** 328 (1931). Hyperfine structure.
41. Güttinger and Pauli: ZP **67,** 743 (1931). Hyperfine structure.
42. Kronig and Frisch: PZ **32,** 457 (1931). Nuclear moment. Bibliography.
43. Vinti: PR **37,** 448 (1931). Energies and wave functions of ground state.

**Li III**

1. Angerer: ZP **18,** 113 (1923). Wave-lengths. Excitation.
2. Morand: CR **178,** 1701 (1924). Wave-lengths.
3. Werner: N **115,** 191 (1925). Excitation. Wave-lengths.
4. Ericson and Edlen: N **125,** 233 (1930); ZP **59,** 656 (1930). Series.
5. Gale and Hoag: PR **37,** 1703 (1931). New lines in extreme ultraviolet.

## BERYLLIUM 4

**Be I**

1. de Gramont: CR **171,** 1106 (1920). Ultimate lines.
2. de Gramont: CN **122,** 58 (1921). Ultimate lines.
3. Millikan: PNAS **7,** 289 (1921). Extension of the ultraviolet spectrum.
4. Glaser: AP **68,** 73 (1922). Wave-lengths.
5. de Gramont: CR **175,** 1025 (1922). "Raies ultimes".
6. Back: AP **70,** 333 (1923). Zeeman effect.
7. Birge: JOSA **8,** 233 (1924). Series of divalent elements.
8. Landé: ZP **27,** 149 (1924). Primed and displaced terms.
9. Millikan and Bowen: PR **23,** 1 (1924). Wave-lengths.
10. Bowen and Millikan: PR **26,** 150 (1925). *PP′* groups.
11. Kapitza and Skinner: PRS **109,** 224 (1925). Zeeman effect in strong fields.

## Beryllium 4; Boron 5

12. Russell: AJ **61,** 223 (1925). Ultimate and penultimate lines.
13. Bowen and Millikan: PR **28,** 256 (1926). Series.
14. McDonald, Sutton and McLay: TRSC **20,** 313 (1926). Wave-lengths.
15. McLennan and Liggett: TRSC **20,** 377 (1926). Wave-lengths.
16. Paton and Sanders: PR **27,** 106 (1926). (A) New lines.
17. Smith and Westman: TRSC **20,** 323 (1926). Infrared wave-lengths.
18. Allin and Ireton: TRSC **21,** 127 (1927). Wave-lengths from underwater spark.
19. Unsöld: AP **82,** 355 (1927). Calculation of singlet-triplet separation.
20. Bose and Mukherjee: PM **7,** 197 (1929). Wave-lengths.
21. Paton and Nusbaum: PR **33,** 1093 (1929). (A) Series.
22. Paton and Rassweiler: PR **33,** 16 (1929). Furnace spectrum.
23. Selwyn: PPS **41,** 392 (1929). Additions to series analysis.
24. Deslandres: CR **191,** 169 (1930). Ultimate rays.
25. Green: PR **36,** 157 (1930). Incomplete Paschen-Back effect.
26. Nagaoka and Futagami: PIAT **6,** 12 (1930). Reversals.
27. Paschen: SAWB **32,** 1 (1930). Extension of series.
28. Zener: PR **36,** 51 (1930). Analytic atomic wave functions.
29. Paschen and Kruger: AP **8,** 1005 (1931). Extension of series.

**Be II**

1. Bowen and Millikan: N **114,** 380 (1921). Series.
2. Bowen and Millikan: PR **24,** 209 (1924). Extension of the doublet laws.
3. Hartree: PCPS **22,** 409 (1924). Identification of lines. Term values.
4. Hartree: PRS **106,** 552 (1924). Term excess. Quantum defect.
5. Landé: ZP **25,** 46 (1924). Absolute intervals of optical doublets. Doublet laws.
6. Millikan and Bowen: N **114,** 380 (1924). Series.
7. Russell: AJ **61,** 223 (1925). Ultimate and penultimate lines.
8. Schrödinger: AP **77,** 43 (1925). Hydrogen-like spectra and polarizability of the atom core.
9. Bowen and Millikan: PR **28,** 256 (1926). Series.
10. Unsöld: ZP **36,** 92 (1926). Polarizability. Calculation of quantum defect.
11. Unsöld: AP **82,** 355 (1927). Calculation of term values.
12. Gibbs and White: PR **33,** 157 (1929). Doublets of stripped atoms.
13. Eckart: PR **36,** 149 (1930). Calculation of energy levels.
14. Eckart: PR **36,** 878 (1930). Calculation of screening constants. Ionizing potentials
15. Guillemin and Zener: ZP **61,** 199 (1930). A simple eigenfunction for the ground state.
16. Paschen: SAWB **32,** 1 (1930). Extension of series.
17. Paschen and Kruger: AP **8,** 1005 (1931). Extension of series.

**Be III**

1. Kellner: ZP **44,** 110 (1927). Calculation of lowest term by wave mechanics.
2. Pauling: PR **29,** 285 (1927). Ionization potential.
3. Hylleras: Nw **17,** 982 (1929). Calculation of ionization potential.
4. Eckart: PR **36,** 149 (1930). Calculation of energy levels.
5. Eckart: PR **36,** 878 (1930). Calculation of screening constants. Ionizing potentials.
6. Ericson and Edlen: ZP **59,** 656 (1930). Series.
7. Edlen: N **127,** 405 (1931). New lines.
8. Vinti: PR **37,** 448 (1931). Energies and wave functions of the ground state.

**Be IV**

1. Ericson and Edlen: N **125,** 233 (1930); ZP **59,** 656 (1930). Series.
2. Edlen: N **127,** 405 (1931). New lines.

## Boron 5

**B I**

1. de Gramont: CR **171,** 1106 (1920). Ultimate lines.
2. de Gramont: CN **122,** 58 (1921). Ultimate lines.

## BORON 5; CARBON 6


3. Millikan: PNAS **7,** 289 (1921). Extension of the ultraviolet spectrum.
4. de Gramont: CR **175**, 1025 (1922). "Raies ultimes".
5. Bowen and Millikan: PR **24,** 209 (1924). Extension of the doublet laws.
6. Millikan and Bowen: PR **23,** 1 (1924). Wave-lengths.
7. Russell: AJ **61,** 233 (1925). Ultimate and penultimate lines.
8. Bowen: PR **29,** 231 (1927). Series.
9. Nagoaka, Nukiyama and Futagami: PIAT **3,** 330 (1927). Explosion spectrum.
10. Sawyer: Nw **15,** 765 (1927). Series.
11. Sawyer and Smith: JOSA **14,** 287 (1927). Series.
12. Selwyn: PPS **41,** 392 (1928). Additions to analysis.
13. Majumdar: IJP **4,** 359 (1930). Prediction of certain terms.
14. Zener: PR **36,** 51 (1930). Analytic atomic wave functions.
15. Bartlett, Jr.: PR **37,** 327 (1931). Nuclear spin.


**B II**


1. Bowen and Millikan: PR **24,** 209 (1924). Extension of the doublet laws.
2. Bowen and Millikan: PR **25,** 884 (1925) (A); PR **26,** 150 (1925). *PP′* groups.
3. Bowen and Millikan: PR **26,** 310 (1925). Series.
4. Sawyer and Smith: JOSA **14,** 287 (1927). Series.
5. Unsöld: AP **82,** 355 (1927). Calculation of singlet-triplet separations.
6. Turner: PR **32,** 727 (1928). Ionizing potential and far ultraviolet lines.
7. Ericson and Edlen: ZP **59,** 656 (1930). Series.
8. Edlen: N **127,** 744 (1931). Singlets of B II.


**B III**


1. Bowen and Millikan: PR **24,** 209 (1924). Extension of the doublet laws.
2. Hartree: PCPS **22,** 409 (1924). Identification of lines. Term values.
3. Hartree: PRS **106,** 552 (1924). Term excess. Quantum defect.
4. Millikan and Bowen: PNAS **10,** 199 (1924). Series.
5. Schrödinger: AP **77,** 43 (1925). Hydrogen-like spectra and polarizability of the atom core.
6. Unsöld: ZP **36,** 92 (1926). Polarizability. Calculation of quantum defect.
7. Sawyer and Smith: JOSA **14,** 287 (1927). Series.
8. Unsöld: AP **82,** 355 (1927). Calculation of *s*-term.
9. Gibbs and White: PR **33,** 157 (1929). Doublets of stripped atoms.
10. Eckart: PR **36,** 878 (1930). Calculation of screening constants. Ionizing potential.
11. Ericson and Edlen: ZP **59,** 656 (1930). Series.
12. Guillemin and Zener: ZP **61,** 199 (1930). A simple eigenfunction for the ground state.
13. Edlen: ZP **72,** 763 (1931). Series.


**B IV**


1. Millikan and Bowen: PNAS **10,** 199 (1924). Series.
2. Kellner: ZP **44,** 110 (1927). Calculation of lowest term by wave mechanics.
3. Pauling: PR **29,** 285 (1927). Ionization potential.
4. Eckart: PR **36,** 878 (1930). Calculation of screening constants. Ionizing potentials.
5. Vinti: PR **37,** 448 (1931). Energies and wave functions of the ground state.


**B V**


1. Millikan and Bowen: PNAS **10,** 199 (1924). Series.


## CARBON 6

**C I**


1. de Gramont: CR **170,** 31 (1920). Variability of arc spectrum. Presence of spark lines.
2. de Gramont: CR **171,** 1106 (1920). Ultimate lines.
3. Hemsalech: PM **39,** 241 (1920). Excitation by thermoelectric currents. Furnace spectrum.
4. Millikan: AJ **52,** 47 (1920). Extension of the ultraviolet spectrum.

## Carbon 6

5. Bloch and Bloch: JPR **2,** 229 (1921). Ultraviolet spark spectrum.
6. de Gramont: CN **122,** 58 (1921). Ultimate lines.
7. McLennan and Petrie: TRSC **15,** 15 (1921). Extreme ultraviolet spectrum.
8. Millikan: PNAS **7,** 289 (1921). Extension of the ultraviolet spectrum.
9. Millikan, Bowen and Sawyer: AJ **53,** 150 (1921). Extreme ultraviolet spectrum.
10. Bloch and Bloch: CR **174,** 1456 (1922). Under water spark spectrum.
11. Hutchinson: AJ **58,** 280 (1923). Ultraviolet wave-lengths.
12. Merton and Johnson: PRS **103,** 383 (1923). Effect of helium on carbon spectrum. Wave-lengths.
13. St. Procopiu: CR **176,** 504 (1923). Flame, arc and spark lines from arcs in vacuo.
14. Shaver: TRSC **17,** 131 (1923). Ultraviolet wave-lengths.
15. Simeon: PRS **102,** 484 (1923); PRS **104,** 368 (1923). Ultraviolet wave-lengths.
16. Bowen and Millikan: PR **24,** 209 (1924). Wave-lengths. Extension of doublet laws.
17. Johnson: PRS **106,** 195 (1924). Effect of argon and helium on carbon spectrum.
18. Lang: PTRS **224,** 371 (1924). Ultraviolet wave-lengths.
19. Millikan and Bowen: PR **23, 1** (1924). Ultraviolet wave-lengths.
20. Johnson: PRS **108,** 343 (1925). Ultraviolet wave-lengths.
21. Nakamura and Fujioka: IPCR No. **34,** 155 (1925). Stark effect.
22. Bowen and Ingram: PR **28,** 444 (1926). Extreme ultraviolet standards.
23. Cameron: PM **1,** 405 (1926). Effect of neon on carbon spectrum.
24. McLennan and McLay: TRSC **20,** 355 (1926). Carbon spectrum and Heisenberg- Hund theory.
25. Rudy: JFI **202,** 659 (1926). Regularities in C I.
26. Smith and Lang: PR **28,** 36 (1926). Extreme ultraviolet standards.
27. Wolf: ZP **39,** 883 (1926). Low voltage vacuum furnace and the carbon line λ4267.
28. Bowen: PR **29,** 231 (1927). Series.
29. Hoag: AJ **66,** 225 (1927). Wave-lengths at grazing incidence.
30. Nagaoka, Nukiyama and Futagami: PIAT **3,** 330 (1927). Instantaneous spectrograms.
31. Ryde: PRS **117,** 164 (1927). Spectrum of carbon arcs in air at high current densities.
32. Fowler and Selwyn: PRS **118,** 34 (1928). Series.
33. Saha and Kichlu: IJP **2,** 319 (1928). Ionization potential.
34. Crew: PM **7,** 312 (1929). Influence of a hydrogen atmosphere upon the arc spectrum.
35. Ingram: PR **33,** 1092 (1929). (A) Infrared spectrum.
36. Ingram: PR **34,** 421 (1929). Series.
37. Jog: IJP **3,** 451 (1929). Carbon spectrum. An extension and resumé of past work.
38. Jog: N **123,** 318 (1929). Intercombinations in C I.
39. Newbold: PM **7,** 706 (1929). Spectrum emitted by a carbon plate under bombardment.
40. Hopfield: PR **35,** 1586 (1930). Ionization potential.
41. Ishida and Fukushima: IPCR **14,** No. 266, 123 (1930). Stark effect.
42. Paschen and Kruger: AP **7,** 1 (1930). Series.
43. Zener: PR **36,** 51 (1930). Analytic atomic wave functions.
44. Bartlett, Jr.: PR **37,** 327 (1931). Nuclear spin.
45. Gilles: CR **192,** 350 (1931). Dispersion of internal energy among certain triplet terms.
46. Zumstein and Marston: PR **38,** 305 (1931). Standards in the Schumann region.

**C II**

1. Millikan: AJ **52,** 47 (1920). Extension of the ultraviolet spectrum.
2. Millikan: PNAS **7,** 289 (1921). Extension of the ultraviolet spectrum.
3. Bowen and Millikan: PR **24,** 209 (1924). Extension of the doublet laws.
4. Fowler: PRS **105,** 299 (1924). Series.
5. Lang: PTRS **224,** 371 (1924). Wave-lengths.
6. Bowen and Millikan: PR **26,** 150 (1925). *PP′* groups.
7. Lang and Smith: N **116,** 244 (1925). Doublet separation.
8. Russell: AJ **61,** 223 (1925). Ultimate and penultimate lines.

## CARBON 6; NITROGEN 7


9. Hartree: PCPS **23,** 304 (1926). Quantum defect.
10. Smith and Lang: PR **28,** 36 (1926). Wave-lengths.
11. Bowen: PR **29,** 231 (1927). Series.
12. Mihul: CR **184,** 1648 (1927). Certain multiplets of C II.
13. Fowler and Selwyn: PRS **120,** 312 (1928). Series.
14. Bowen: PR **34,** 534 (1929). Series.
15. Jog: IJP **3,** 451 (1929). Series.

**C III**

1. Bowen and Millikan: PR **26,** 150 (1925). *PP′* groups.
2. Bowen and Millikan: PR **26,** 310 (1925). Series.
3. Bowen and Ingram: PR **28,** 444 (1926). *PP′* groups.
4. Unsöld: AP **82,** 355 (1927). Calculation of singlet-triplet separations.
5. Turner: PR **32,** 727 (1928). Ionizing potentials and far ultraviolet lines of light atoms.
6. Jog: IJP **3,** 451 (1929). Series.
7. Bowen: PR **38,** 128 (1931). Extension and revision of series.
8. Edlen: N **127,** 744 (1931). Singlets of C III.
9. Edlen: ZP **72,** 559 (1931). Series.

**C IV**

1. Bowen and Millikan: N **114,** 380 (1921). Series.
2. Simeon: PRS **102,** 484 (1923); PRS **104,** 368 (1923). Wave-lengths.
3. Bowen & Millikan: PR **24,** 209 (1924). Extension of the doublet laws.
4. Hartree: PCPS **22,** 409 (1924). Identification of lines. Term values.
5. Hartree: PRS **106,** 552 (1924). Term excess. Quantum defect.
6. Millikan & Bowen: N **114,** 380 (1924). Series.
7. Schrödinger: AP **77,** 43 (1925). Hydrogen-like spectra and polarizability of the atom core.
8. Hartree: PCPS **23,** 304 (1926). Quantum defect.
9. Unsöld: ZP **36,** 92 (1926). Polarizability. Calculation of quantum defect.
10. Unsöld: AP **82,** 355 (1927). Calculation of *S*-terms.
11. Gibbs and White: PR **33,** 157 (1929). Doublets of stripped atoms.
12. Jog: IJP **3,** 451 (1929). Series.
13. Eckart: PR **36,** 149 (1930). Calculation of energy levels.
14. Eckart: PR **36,** 878 (1930). Calculation of screening constants. Ionizing potentials.
15. Edlen and Ericson: ZP **64,** 64 (1930). Series.
16. Edlen and Stenman: ZP **66,** 328 (1930). New lines. Term system.
17. Guillemin and Zener: ZP **61,** 199 (1930). A simple eigenfunction for the ground state.

**C V**

1. Kellner: ZP **44,** 110 (1927). Calculation of lowest term by wave mechanics.
2. Eckart: PR **36,** 878 (1930). Calculation of screening constants. Ionizing potentials.
3. Edlen: N **127,** 405 (1931). New lines of C V.


## NITROGEN 7


**N I**

1. Found: PR **16,** 41 (1920). Ionization potentials.
2. de Gramont: CR **171,** 1106 (1920). Ultimate lines.
3. Merrill: AJ **51,** 236 (1920). Air lines in spark spectra. λ5927–λ8719.
4. Mohler and Foote: BSP **16,** No. 400, 669 (1920); JOSA **4,** 49 (1920); PR **15,** 555 (1920). (A). Ionization and resonance potentials.
5. de Gramont: CN **122,** 58 (1921). Ultimate lines.
6. Merrill, Hopper and Keith: AJ **54,** 76 (1921). Air lines in spark spectra.
7. Millikan: PNAS **7,** 289 (1921). Extension of the ultraviolet spectrum.
8. Seeliger and Schramm: ZP **7,** 93 (1921). Excitation by electron impact.
9. Wien: AP **66,** 229 (1921). Duration of light emission.

## NITROGEN 7

10. Boucher: PR **19,** 189 (1922). Resonance, radiation and ionizing potentials.
11. Brandt: ZP **8,** 32 (1921). Excitation and ionization potentials.
12. Compton: PAPS **61,** 212 (1922). Critical potentials.
13. Duffendack: PR **20,** 100 (A) and 665 (1922). Low-voltage arc.
14. Hopfield: PR **20,** 573 (1922). Extreme ultraviolet spectrum.
15. Steubing: PZ **23,** 427 (1922). Spectrum from nitrogen in an electric field.
16. Wien: AP **69,** 325 (1922). Method of separating arc and spark lines.
17. Hopfield and Leifson: AJ **58,** 59 (1923). Extreme ultraviolet standards.
18. Kimura and Nakamura: JJP **2,** 61 (1923). Line broadening and the Stark effect.
19. Smyth: N **111,** 810 (1923). Ionizing potential.
20. Wien: AP **70,** 1 (1923). Radiation from canal rays. Duration of light emission.
21. Bazzoni and Waldie: JFI **197,** 57 (1924). Critical potentials.
22. Bowen and Millikan: PM **48,** 259 (1924). Fine structure.
23. Bowen and Millikan: PR **24,** 209 (1924). Extension of the doublet laws.
24. Duffendack and Duncan: PR **23,** 295 (1924). (A) Excitation by electron impact.
25. Krefft: PZ **25,** 352 (1924). Doppler effect in arc and spark lines.
26. Millikan and Bowen: PR **23,** 1 (1924). Wave-lengths.
27. Pfund: JOSA **9,** 193 (1924). Infrared spectrum.
28. Ruark, Mohler, Foote and Chenault: BSP No. **490,** Vol. 19, 463 (1924). Series. Critical potentials.
29. Smyth: PRS **105,** 116 (1924). Ionizing potential.
30. Vegard: CR **178,** 1153 (1924). Origin of auroral spectrum.
31. Kiess: JOSA **11,** 1 (1925); S **61,** 468 (1925). Series.
32. King: AJ **62,** 238 (1925). Spectra in the high current arc.
33. Kwei: PR **26,** 537 (1925). Low voltage arcs in pure and mixed hydrogen and nitrogen.
34. McLennan, Smith and Peters: TRSC **19,** 39 (1925). Infrared wave-lengths.
35. Merton and Pilley: PRS **107,** 411 (1925). Series.
36. Bowen and Ingram: PR **28,** 444 (1926). Extreme ultraviolet standards.
37. Cameron: PM **1,** 405 (1926). Effect of neon on N spectrum.
38. Hopfield: PR **27,** 801 (1926). (A) Ultraviolet series.
39. Kondratjev: ZP **38,** 346 (1926). Excitation by electron impact.
40. Rudy: JFI **202,** 658 (1926). Excitation of N I. Use of inductance.
41. Bowen: PR **29,** 231 (1927). Series.
42. Levesley: TFS **23,** 552 (1927). Critical potentials.
43. McLennan and McLay: TRSC **21,** 63 (1927). Series.
44. Ryde: PRS **117,** 164 (1927). N-lines in the carbon arc.
45. Wolfe and Duffendack: PR **29,** 209 (1927). Excitation in low voltage arc.
46. Findlay: TRSC **22,** 341 (1928). Spectra excited by active nitrogen.
47. Kronig: Nw **16,** 335 (1928). Nuclear moment.
48. Locher: JOSA **17,** 91 (1928). Time intervals between the appearance of spectral lines.
49. Compton and Boyce: PR **33,** 145 (1929). Ultraviolet series.
50. Duffendack and Wolfe: PR **34,** 409 (1929). Excitation. Wave-lengths.
51. Hamada: SRTU **18,** 155 (1929). Low voltage arc.
52. Heitler and Herzberg: Nw **17,** 673 (1929). Symmetrical character of nitrogen nucleus.
53. Ingram: PR **33,** 1092 (1929). (A) Infrared spectrum.
54. Ingraim PR **34,** 421 (1929). Series.
55. Turner and Samson: PR **34,** 743 (1929). Dissociation by electron impact.
56. Ekefors: ZP **63,** 437 (1930). Series.
57. Majumdar: IJP **4,** 359 (1930). Prediction of certain terms.
58. Wien: AP **5,** 553 (1930). The separation of arc and spark lines.
59. van Wijk: ANSE **13,** 29 (1930). Nuclear spin.
60. Zener: PR **36,** 51 (1930). Analytic atomic wave functions.
61. Anderson and More: PR **37,** 1684 (1931) (A); PR **38,** 1995 (1931). Low voltage arc.
62. Beals: RAS **91,** 531 (1931). Wave-lengths.

## NITROGEN 7


63. Gibbs and Kruger: PR **37,** 1702 (1931). (A) Structure of arc and spark lines.
64. Gilles: CR **192,** 350 (1931). Dispersion of internal energy between certain quartet terms.
65. Kaplan: N **128,** 191 (1931). Nature of the aurora.
66. Kaplan: PR **37,** 1004 (1931). New source. Afterglow in uncondensed discharge.


**N II**


1. Fowler: RAS **80,** 692 (1920). Enhanced lines in region $H\beta$ to $H\epsilon$.
2. Bowen and Millikan: PR **24,** 209 (1924). Wave-lengths. Extension of doublet laws.
3. Croze: CR **179,** 1603 (1924). Series.
4. Kiess: S **60,** 249 (1924). Series.
5. Ruark, Mohler, Foote and Chenault: BSP No. **490,** Vol. 19, 463 (1924). A constant frequency difference.
6. Croze: CR **180,** 277 (1925). Series.
7. Fowler: PRS **107,** 31 (1925). Series.
8. Russell: AJ **61,** 223 (1925). Ultimate and penultimate lines.
9. Beams: PR **28,** 475 (1926). Time interval for excitation of spectra.
10. Laporte: JOSA **13,** 1 (1926). Interpretation of spectra. Vector model. Zeeman effect.
11. Rudy: JFI **202,** 658 (1926). Structure of N II.
12. Bowen: N **120,** 473 (1927). Origin of the nebular lines.
13. Bowen: PR **29,** 231 (1927). Series.
14. Croze and Gilles: CR **184,** 1053 (1927). Series.
15. Fowler and Freeman: PRS **114,** 662 (1927). Series.
16. Bowen: AJ **67,** 1 (1928). Origin of the nebular lines.
17. Turner: PR **32,** 727 (1928). Ionizing potential and far ultraviolet lines.
18. Bowen: PR **34,** 534 (1929). Series.
19. Freeman: PRS **124,** 654 (1929). Series.
20. Houston: PR **33,** 297 (1929). Calculation of energy levels from Schrödinger equation.
21. Asagoe: SRTU **1,** 47 (1930). Large displacements in N II.
22. Wien: AP **5,** 553 (1930). Separation of arc and spark lines.
23. Gibbs and Kruger: PR **37,** 1702 (1931). (A) Structure of arc and spark lines.
24. Gilles: CR **192,** 350 (1931). Dispersion of internal energy between certain triplet terms.


**N III**


1. Bowen and Millikan: PR **24,** 209 (1924). Extension of the doublet laws.
2. Bowen and Millikan: PR **26,** 150 (1925). *PP′* groups.
3. Bowen: PR **29,** 231 (1927). Series.
4. Freeman: PRS **121,** 318 (1928). Series.
5. Turner: PR **32,** 727 (1928). Ionizing potential and far ultraviolet lines of light atoms.
6. Asagoe: SRTU **1,** 47 (1930). Large displacements in N III.


**N IV**


1. Bowen and Millikan: PR **26,** 150 (1925). *PP′* groups.
2. Bowen and Ingram: PR **28,** 444 (1926). *PP′* groups.
3. Freeman: PRS **127,** 330 (1930). Series.
4. Edlen: N **127,** 744 (1931). Singlets of N IV.


**N V**


1. Bowen and Millikan: PR **24,** 209 (1924). Extension of the doublet laws.
2. Hartree: PCPS **22,** 409 (1924). Identification of lines. Term values.
3. Hartree: PRS **106,** 552 (1924). Term excess. Quantum defect. Spectra of Li like atoms.
4. Fues: AP **76,** 299 (1925). Calculation of terms.
5. Bowen and Millikan: PR **27,** 144 (1926). Ionization potential.
6. Gibbs and White: PR **33,** 157 (1929). Doublets of stripped atoms.
7. Eckart: PR **36,** 149 (1930). Calculation of energy levels.

## NITROGEN 7; OXYGEN 8


8. Eckart: PR **36,** 878 (1930). Calculation of screening constants. Ionizing potential.
9. Edlen and Ericson: ZP **64,** 64 (1930). Series.


## OXYGEN 8

O I


1. Böttcher and Tuczek: AP **61,** 107 (1920). Stark effect.
2. de Gramont: CR **171,** 1106 (1920). Ultimate lines.
3. Merrill: AJ **51,** 236 (1920). Air lines in spark spectra.
4. Mohler and Foote: BSP No. **400,** Vol. 16, 669 (1920); JOSA **4,** 49 (1920); PR **15,** 555 (1920). Ionization and resonance potentials.
5. de Gramont: CN **122,** 58 (1921). Ultimate lines.
6. Merrill, Hopper and Keith: AJ **54,** 76 (1921). Air lines in spark spectra.
7. Millikan: PNAS **7,** 289 (1921). Extension of the ultraviolet spectrum.
8. Rayleigh: N **107,** 137 (1921); N **108,** 208 (1921). The auroral line.
9. Boucher: PR **19,** 189 (1922). Resonance, radiation and ionizing potentials.
10. Hopfield: PR **20,** 573 (1922). Extreme ultraviolet lines.
11. Rayleigh: PRS **101,** 114 (1922). The auroral spectrum.
12. Vegard: FT **20,** 128 (1922). Green auroral line.
13. Wien: AP **69,** 325 (1922). Separation of arc and spark lines.
14. Babcock: AJ **57,** 209 (1923). Green auroral lines.
15. Hopfield: PR **21,** 710 (1923) (A); PR **22,** 523 (1923) (A). Series.
16. Hopfield and Leifson: AJ **58,** 59 (1923). Extreme ultraviolet standards.
17. Kimura and Nakamura: JJP **2,** 61 (1923). Line broadening and the Stark effect.
18. Rayleigh: PRS **103,** 45 (1923). Auroral spectrum.
19. Birge: JOSA **8,** 233 (1924). Series of divalent elements.
20. Bowen and Millikan: PM **48,** 259 (1924). Fine structure.
21. Hopfield: AJ **59,** 114 (1924). Series.
22. Johnson and Cameron: PRS **106,** 195 (1924). Effect of argon on oxygen spectrum.
23. Krefft: PZ **25,** 352 (1924). Doppler effect in arc and spark lines.
24. Landé: ZP **25,** 46 (1924). Absolute intervals of doublets and triplets. Doublet laws.
25. Laporte: Nw **12,** 598 (1924). Series.
26. Lockrow: PR **23,** 553 (1924). (A) Low voltage arc.
27. Millikan and Bowen: PR **23,** 1 (1924). Ultraviolet wave-lengths.
28. Turner: PM **48,** 384 (1924). Quantum defect.
29. Bungartz: AP **76,** 709 (1925). Series.
30. King: AJ **62,** 238 (1925). Spectra of the high-current arc.
31. Lockrow: PR **25,** 110 (1925). (A). Low-voltage arc.
32. McLennan and Shrum: PRS **108,** 501 (1925). Origin of the auroral green line.
33. Russell: AJ **61,** 223 (1925). Ultimate and penultimate lines.
34. Bowen and Ingram: PR **28,** 444 (1926). Extreme ultraviolet standards.
35. Cameron: PM **1,** 405 (1926). Effect of neon on oxygen spectrum.
36. Kerschbaum: AP **79,** 465 (1926). Duration of light emission.
37. Lockrow: AJ **63,** 205 (1926). Critical potentials and series.
38. McLennan, McLeod and McQuarrie: N **118,** 441 (1926). Auroral green line.
39. Cario: ZP **42,** 15 (1927). Green auroral line.
40. Hopfield: PR **29,** 923 (1927). (A) Unclassified lines.
41. Keys: TRSC **21,** 257 (1927). Excitation of the auroral green line.
42. McLennan, McLay and McLeod: PM **4,** 486 (1927). Series.
43. McLennan and McLeod: PRS **115,** 515 (1927). Wave-length of green auroral line.
44. McLennan, McLeod and McQuarrie: PRS **114,** 1 (1927). Auroral green line.
45. McLennan, Ruedy and McLeod: TRSC **21,** 27 (1927). Origin of the auroral green line.
46. Poettker: PR **30,** 812 (1927). Infrared spectrum.
47. Ryde: PRS **117,** 164 (1927). Carbon arcs in air at high current densities. Oxygen lines observed in the arc stream.

## OXYGEN 8


48. Jog: IJP **2,** 343 (1928). Regularities in spectra of six valence elements.
49. Kaplan: PNAS **14,** 882 (1928). Auroral red line.
50. McLennan: PRS **120,** 327 (1928). Aurora and its spectrum.
51. McLennan, McLeod and Ireton: TRSC **22,** 397 (1928). Intensity of the "green line" in light of the night sky.
52. McLennan, McLeod and Ruedy: PM **6,** 558 (1928). Zeeman effect of auroral green line.
53. Mihul: AsP **9,** 261 (1928). Line spectrum of oxygen.
54. Rayleigh: N **122,** 315, 351 and 373 (1928). The green line. Light of the night sky.
55. Sommer: ZP **51,** 451 (1928). Zeeman effect of auroral green line, and quantum mechanical interpretation.
56. Deodhar and Dutt: PM **8,** 617 (1929). Spectrum of oxygen under different conditions of excitation.
57. Frerichs: PR **34,** 1239 (1929). New terms.
58. Kaplan: PR **33,** 154 (1929). Excitation of the auroral green line.
59. Kiuti, Ochiai and Nishimura: JJP **5,** 139 (1929). Stark effect.
60. Kurt and Phipps: PR **34,** 1357 (1929). Magnetic moment.
61. McLennan and Crawford: N **124,** 874 (1929). Low energy levels.
62. Bowen: PR **36,** 600 (1930). Neutral oxygen in the gaseous nebulae. Quadrupole radiation.
63. Doi: PMSJ **12,** 75 (1930). Stark displacements.
64. Edlen and Ericson: CR **190,** 116 (1930). Condensed spark spectrum. Ionizing potential.
65. Frerichs: PR **36,** 398 (1930). Singlet system. Origin of auroral green line.
66. Frerichs and Campbell: PR **36,** 151 and 1460 (1930). Zeeman effect of green auroral line. Evidence of quadrupole radiation.
67. Hopfield: N **126,** 846 (1930). The red coronal line.
68. McLennan and Ireton: PRS **129,** 31 (1930). Spectroscopy of auroral green line radiation.
69. Mack and Sawyer: PR **35,** 299 (1930). Quantitative application of irregular doublet law.
70. Paschen: ZP **65,** 1 (1930). Series.
71. Rayleigh: PRS **129,** 458 (1930). Intensity of green line in light of the night sky.
72. Ruedy: Nw **18,** 401 (1930). Light of night sky and the oxygen green line.
73. Wien: AP **5,** 553 (1930). Separation of arc and spark lines.
74. Zener: PR **36,** 51 (1930). Analytic atomic wave functions.
75. Beals: RAS **91,** 531 (1931). Wave-lengths.
76. Heisenberg: AP **10,** 888 (1931). Pauli's exclusion principle.
77. Hopfield: PR **37,** 160 (1931). Revised values of terms; nebular and coronal lines.
78. Kaplan: N **128,** 304 (1931). Excitation of the auroral green line.
79. Kaplan: PR **38,** 1048 (1931). Light of the night sky.
80. Kiuti, Ochiai and Nishimura: PMSJ **13,** 65 (1931). Stark effect.
81. Matuyama: JOSA **21,** 792 (1931). Spectrum appearing in early stages of the spark. Stark effect of inter-ionic field.


**O II**


1. Bowen and Millikan: PR **24,** 209 (1924). Extension of the doublet laws.
2. Croze: CR **180,** 277 and 432 (1925). Multiplets of O II.
3. Bowen, Millikan and Fowler: N **118,** 410 (1926). Ionization potential.
4. Fowler: PRS **110,** 476 (1926). Series.
5. Fowler and Hartree: PRS **111,** 83 (1926). Series.
6. Mihul: CR **183,** 876 (1926). Series.
7. Bowen: PR **29,** 231 (1927). Series.
8. Croze and Mihul: CR **185,** 702 (1927). Anomalous multiplets and intercombinations.
9. Fowler: N **120,** 617 (1927). Origin of the nebulium spectrum.
10. Mihul: CR **185,** 937 (1927). Certain combinations in O II.
11. Bowen: AJ **67,** 1 (1928). Origin of the nebular lines.
12. Mihul: AsP **9,** 261 (1928). Zeeman effect.
13. Russell: PR **31,** 27 (1928). Series.

14. van Wijk: ZP **47,** 622 (1928). Intensities.
15. Edlen and Erickson: CR **190,** 116 (1930). Condensed spark spectrum. Ionizing potential.
16. Wien: AP **5,** 553 (1930). Separation of arc and spark lines.
17. Asagoe: TBDR **1,** 7–12. p. 105 (1931). Displacements in O II spectrum.
18. Gilles: CR **192,** 350 (1931). Dispersion of internal energy between certain quartet terms.
19. Kaplan: PR **38,** 1048 (1931). Light of the night sky.
20. Pretty: PPS **43,** 279 (1931). Displacement of certain lines of O II.

**O III**

1. Bowen and Millikan: PR **24,** 209 (1924). Wave-lengths. Extension of doublet laws.
2. Mihul: CR **183,** 1035 (1926). Series.
3. Bowen: N **120,** 473 (1927). Origin of the nebular lines.
4. Bowen: PR **29,** 231 (1927). Series.
5. Mihul: CR **184,** 89, 874 and 1055 (1927). Series.
6. Bowen: AJ **67,** 1 (1928). Origin of the nebular lines.
7. Fowler: PRS **117,** 317 (1928). Series.
8. Bartlett: PR **34,** 1247 (1929). Relative intensities of nebular lines. Quadrupole radiation.
9. Freeman: PRS **124,** 654 (1929). Series.
10. Gaunt: PRS **122,** 513 (1929); PTRS **228,** 151 (1929). Triplet separations from the standpoint of Dirac's electron theory.
11. Houston: PR **33,** 297 (1929). Calculation of energy levels from Schrödinger equation.
12. Edlen and Ericson: CR **190,** 116 (1930). Condensed spark spectrum. Ionizing potential.
13. Gilles: CR **192,** 350 (1931). Dispersion of internal energy between certain triplet terms.
14. Gilles: CR **193,** 584 (1931). Series.
15. Heisenberg: AP **10,** 888 (1931). Pauli's exclusion principle.
16. Pretty: PPS **43,** 279 (1931). Displacement of certain lines of O III.

**O IV**

1. Bowen and Millikan: PR **24,** 209 (1924). Extension of the doublet laws.
2. Bowen and Millikan: PR **26,** 150 (1925). *PP′* groups.
3. Bowen: PR **29,** 231 (1927). Series.
4. Edlen and Ericson: CR **190,** 116 (1930). Condensed spark spectra. Ionizing potentials.
5. Freeman: PRS **127,** 330 (1930). Series.

**O V**

1. Bowen and Millikan: PR **26,** 150 (1925). *PP′* groups.
2. Bowen and Millikan: PR **27,** 144 (1926). *PP′* group.
3. Edlen and Ericson: CR **190,** 116 (1930). Condensed spark spectra. Ionizing potentials.
4. Edlen: N **127,** 744 (1931). Singlets of O V.

**O VI**

1. Hartree: PCPS **22,** 409 (1924). Identification of lines. Term values.
2. Hartree: PRS **106,** 552 (1924). Term excess. Quantum defect.
3. Fues: AP **76,** 299 (1925). Calculation of terms.
4. Bowen and Millikan: PR **27,** 144 (1926). Series.
5. Gibbs and White: PR **33,** 157 (1929). Doublets of stripped atoms.
6. Eckart: PR **36,** 149 (1930). Calculation of energy levels.
7. Eckart: PR **36,** 878 (1930). Calculation of screening constants. Ionizing potentials.
8. Edlen and Ericson: CR **190,** 116 (1930). Condensed spark spectra. Ionizing potentials.
9. Edlen and Ericson: ZP **64,** 64 (1930). Lithium like spectra.

## FLUORINE 9

**F I**

1. de Gramont: CR **171,** 1106 (1920). Ultimate lines.
2. de Gramont: CN **122:** 58 (1921). Ultimate lines.

## FLUORINE 9; NEON 10

3. Millikan: PNAS **7,** 289 (1921). Extension of the ultraviolet spectrum.
4. Smythe: AJ **54,** 133 (1921). Wave-lengths.
5. Bowen and Millikan: PM **48,** 259 (1924). Fine structure.
6. Gale and Monk: AJ **59,** 125 (1924). Wave-lengths.
7. Millikan and Bowen: PR **23,** 1 (1924). Wave-lengths.
8. de Bruin: N **118,** 804 (1926). The double normal state of F I.
9. de Bruin: ZP **39,** 869 (1926). Series. Zeeman effect.
10. Carragan: AJ **63,** 145 (1926); PR **27,** 106 (1926). (A) Zeeman effect.
11. Bowen: PR **29,** 231 (1927). Series.
12. de Bruin: PKAA **30,** 20 and 944 (1927). Series.
13. Dingle: N **119,** 86 (1927); PRS **113,** 323 (1927); PRS **117,** 407 (1927). Series.
14. Laporte: PR **29,** 650 (1927). Screening constants.
15. de Bruin: ANSE **11,** 70 (1928). Series.
16. Turner: PR **32,** 727 (1928). Ionizing potentials and far ultraviolet lines of light atoms.
17. Majumdar: IJP **4,** 359 (1930). Prediction of certain terms.
18. Zener: PR **36,** 51 (1930). Analytic atomic wave functions.

**F II**

1. Bowen: PR **29,** 231 (1927). Series.
2. de Bruin: ANSE **11,** 70 (1928). Series.
3. Jog: IJP **2,** 343 (1928). Regularities in the spectra of six valence elements.
4. Turner: PR **32,** 727 (1928). Ionizing potentials and far ultraviolet lines of light atoms.
5. Dingle: PRS **128,** 600 (1930). Series.
6. Edlen and Ericson: CR **190,** 173 (1930). Extreme ultraviolet spectra.

**F III**

1. Bowen: PR **29,** 231 (1927). Series.
2. Dingle: PRS **122,** 144 (1929). Series.
3. Gilles: CR **192,** 350 (1931). Dispersion of internal energy between certain quartet terms.

**F IV**

1. Bowen: PR **29,** 231 (1927). Series.
2. Gilles: CR **192,** 350 (1931). Dispersion of internal energy between certain triplet terms.

**F V**

1. Noyes and Beckman: ChR **5,** 85 (1928). Ionization potential.

**F VII**

1. Fues: AP **76,** 299 (1925). Calculation of terms.
2. Bowen and Millikan: PR **27,** 144 (1926). Ionization potential.

## NEON 10

**Ne I**

1. de Gramont: CR **171,** 1106 (1920). Ultimate lines.
2. Grotrian: PZ **21,** 638 (1920). Regularities.
3. Hicks: PTRS **220,** 335 (1920). Series.
4. Horton and Davies: PRS **98,** 124 (1920). Critical electron velocities.
5. Paschen: AP **63,** 201 (1920). Series.
6. Sommerfeld: AP **63,** 221 (1920). Zeeman effect. Splitting rule.
7. Waran: PCPS **20,** 45 (1920). Effect of magnetic field on line intensity.
8. de Gramont: CN **122,** 58 (1921). Ultimate lines.
9. Horton and Davies: PM **41,** 921 (1921). Critical electron velocities.
10. Landé: PZ **22,** 417 (1921). Anomalous Zeeman effect and series systems.
11. Meggers: BSP **17,** 193 (1921); PR **18,** 160 (1921). Wave-lengths and frequency differences.
12. Meggers: JOSA **5,** 308 (1921). Standard wave-lengths.
13. Nagaoka: PPS **33,** 83 (1921). Zeeman effect and Runges' rule.

## Neon 10

14. Seeliger: PZ **22,** 610 (1921). Excitation by electron impact.
15. Seeliger and Mierdel: ZP **5,** 182 (1921). Excitation by electron impact.
16. Seeliger and Schramm: ZP **7,** 93 (1921). Excitation by electron impact.
17. Broughall: PM **44,** 204 (1922). Theoretical aspects of the neon spectrum.
18. Grotrian: ZP 8, 116 (1922). The $L$-doublet of neon.
19. Hertz: PKAA **25,** 179 and 442 (1922). Excitation and ionization potentials.
20. Meggers: JOSA **6,** 135 (1922). Standard wave-lengths.
21. Hertz: Nw **11,** 778 (1923); ZP **18,** 307 (1923). Excitation by electron impact
22. Hicks: PM **45,** 480 (1923). Radiation and ionization potentials.
23. Landé: ZP **17,** 292 (1923). Structure of the neon spectrum.
24. Nagaoka and Sugiura: JJP **2,** 167 (1923). Spectroscopic evidence of isotopy.
25. Perard: CR **176,** 375 (1923). Wave-length studies.
26. Wentzel: PZ **24,** 104 (1923). Two electron transitions.
27. Hertz: ZP **22,** 18 (1924). Excitation by electron impact.
28. Landé: ZP **27,** 149 (1924). Primed and displaced terms.
29. Landé and Heisenberg: ZP **25,** 279 (1924). Term structure of multiplets.
30. Meissner: AP **73,** 643 (1924). Lyman lines in the neon spectrum.
31. Nagaoka and Sugiura: N **113,** 532 (1924). Spectroscopic evidence of isotopes.
32. Turner: PM **48,** 1010 (1924). Quantum defect.
33. Wallerath: AP **75,** 37 (1924). Secondary wave-length standards.
34. Wentzel: PZ **25,** 182 (1924). Two electron transitions.
35. Back: AP **76,** 317 (1925). Zeeman effect.
36. Buisson and Jausseran: CR **180,** 505 (1925). Spontaneous reversal of certain lines.
37. Burns: JOSA **11,** 301 (1925). Red neon lines. Revision of terms.
38. Dorgelo: P **5,** 90 (1925); PZ **26,** 756 (1925). Intensities.
39. Dorgelo: P **5,** 429 (1925); PKAA **27,** 7 (1925); ZP **34,** 766 (1925). Life period of metastable states.
40. Goudsmit: P **5,** 70 (1925); ZP **32,** 111 (1925). The fundamental term.
41. Goudsmit: ZP **32,** 794 (1925). Zeeman effect.
42. Hertz: Nw **13,** 489 (1925); P **5,** 189 (1925). Extreme ultraviolet spectrum.
43. Hertz: PKAA **28,** 767 (1925). Excitation by electron impact.
44. Hertz: ZP **32,** 933 (1925). Resonance lines.
45. Hertz and Kloppers: ZP **31,** 463 (1925). Excitation and ionization potentials.
46. Hertz and de Visser: P **5,** 41 (1925); ZP **31,** 470 (1925). Excitation by electronic impact.
47. Hertzfeld and Wolf: AP **76,** 71 and 567 (1925). Test of the classical dispersion formula. The number of dispersion electrons.
48. Jordon: ZP **31,** 877 (1925). Absorption in excited neon.
49. Jordon: ZP **33,** 563 (1925). Term multiplicity and electron states.
50. Lyman and Saunders: N **116,** 385 (1925); PR **25,** 886 (1925) (A). Series.
51. Meissner: AP **76,** 124 (1925). Absorption in excited neon.
52. Monk: AJ **62,** 375 (1925). Secondary standards.
53. Russell: AJ **61,** 223 (1925). Ultimate and penultimate lines.
54. Unsöld: ZP **33,** 843 (1925). On the screening doublets of the Bowen-Millikan ultraviolet spectra.
55. von Wisniewski: PZ **26,** 255 (1925). Calculation of $s$-terms.
56. Dorgelo: PKAA **29,** 7 (1926); WNT **3,** 65 (1926). Life period of metastable states.
57. Dorgelo and Abbink: ZP **37,** 667 (1926). Extreme ultraviolet spectrum.
58. Dorgelo and de Groot: ZP **36,** 897 (1926). Intensity ratios of the $(2s-2p)$ combinations.
59. Goudsmit and Uhlenbeck: ZP **35,** 618 (1926). $g$-values.
60. de Groot: P **6,** 53 (1926). Resonance lines.
61. Heinrich: AP **80,** 349 (1926). Photometric measurements.
62. Hertz and Abbink: Nw **14,** 648 (1926). Resonance lines.
63. Hicks: AsP **6,** 294 (1926). Structure of rare gas spectra.
64. Johnson and Johnson: PM **2,** 593 (1926). Intensity variations.

## Neon 10

65. Lyman and Saunders: PNAS **12,** 92 (1926). Ultraviolet series.
66. Mohler: PR **28,** 46 (1926). Photoionization.
67. Swindler: PR **28,** 1136 (1926). Effect of potential and frequency on spectra.
68. Babcock: AJ **66,** 256 (1927). Secondary standards.
69. Dorgelo: P **7,** 33 (1927). Duration of metastable states.
70. Dorgelo and Washington: PKAA **30,** 33 (1927). Duration of metastable states.
71. Foster and Rowles: PR **29,** 925 (1927) (A). Stark effect.
72. Fujioka: IPCR **7,** 27 (1927). Resonance radiation.
73. Glaser: VPGW **52,** 14 (1927). Fine structure.
74. Goudsmit and Back: ZP **40,** 530 (1927). Vector coupling.
75. Hansen: N **119,** 237 (1927). Hyperfine structure.
76. Hansen: Nw **15,** 163 (1927). Zeeman effect.
77. Joos: AP **83,** 1054 (1927). Theory of isotope effect.
78. Laporte: PR **29,** 650 (1927). Screening constants from optical data.
79. Meissner: ZP **43,** 454 (1927). Objective demonstration of the Zeeman effect.
80. Meissner and Graffunder: AP **84,** 1009 (1927). Life of excited states.
81. Nagaoka and Mishima: PIAT **3,** 136 (1927). Reversal of neon lines.
82. Nagaoka and Mishima: PIAT **3,** 205 (1927). Inverse Zeeman effect.
83. Paschen: SAWB **29,** 207 (1927). Excitation through the metastable condition of the rare gas atom.
84. Saha: PM **4,** 223 (1927). Theory of complex spectra.
85. Eckstein: AP **87,** 1003 (1928). Influence of pressure and addition of other gases on absorption in excited neon.
86. Glaser and Böhm: VPGW, page 39 (1928). Zeeman effect.
87. Glaser and Notter: VPGW **52,** 14 (1928). Fine structure.
88. Gremmer: ZP **50,** 716 (1928). Series.
89. Ishida: IPCR **9,** (Aug. 7, 1928). Series.
90. Ishida: N **122,** 277 (1928). Stark effect at high fields.
91. Kopfermann and Ladenberg: ZP **48,** 26 and 51 (1928). Anomalous dispersion.
92. Atkinson: PRS **122,** 430 (1929). Probability of excitation by electron impact.
93. Ende: ZP **56,** 503 (1929). Intensity measurements.
94. Foster and Rowles: PRS **123,** 80 (1929). Patterns and Paschen-Back analogue in the Stark effect.
95. Hanle: VDPG **10,** 54 (1929). Intensity measurements.
96. Nagaoka and Mishima: PIAT **5,** 200 (1929). Isotope effect.
97. Anderson: CJR **2,** 13 (1930). Duration of metastable states.
98. Bakker: N **126,** 955 (1930); Nw **18,** 1100 (1930). Electron coupling.
99. Beeck AP **6,** 1001 (1930). Ionization by alkali ions.
100. Foster: N **126,** 845 (1930). Stark effect. Intersection of levels with equal $m$ values.
101. Hanle: ZP **65,** 512 (1930). Excitation functions.
102. Ishida: N **125,** 970 (1930). Stark effect.
103. Ladenburg and Levy: ZP **65,** 189 (1930). Absorption; anomalous dispersion; intensities and intensity distribution.
104. Laporte and Inglis: PR **35,** 1337 (1930). Resonance separations for $p^5s$ configuration.
105. Murakawa and Iwama: IPCR **13,** 283 (1930). Zeeman effect.
106. Nagaoka and Mishima: PIAT **6,** 143 (1930). Zeeman effect.
107. Ryde: ZP **59,** 836 (1930). Series of combination lines. Stark effect.
108. Sjögren: ZP **66,** 377 (1930). Stark effect.
109. Swenson: PR **35,** 126 (1930). (A). Intensity measurements.
110. Thomas: PM **10,** 128 (1930). Isotope effect.
111. Zener: PR **36,** 51 (1930). Analytic atomic wave functions.
112. van Atta: PR **38,** 876 (1931). Excitation probabilities for electrons in neon.
113. Bartlett, Jr.: PR **37,** 327 (1931). Nuclear spin.
114. Elenbaas: ZP **72,** 715 (1931). Intensity measurements.

## Neon 10; Sodium 11

115. Ende: ZP **67**, 292 (1931). Intensity measurements.
116. Hardy: PR **38**, 2162 (1931). New infrared lines. Classification.
117. Harrison and Johnson: PR **38**, 757 (1931). Test of intensity summation rules.
118. Humphreys: BSJ **7**, 453 (1931). Hyperfine structure.
119. Jackson: PRS **133**, 553 (1931). Interferometer measurements of wave-length.
120. Kronig and Frisch: PZ **32**, 457 (1931). Nuclear moments.
121. Nagaoka and Mishima: PIAT **7**, 192 (1931). Difference in the self-reversal of lines excited by direct and alternating currents.
122. Rasmussen and Swenson: N **128**, 188 (1931). Intensity anomalies.
123. Romig: PR **38**, 1709 (1931). Doppler effect in canal rays.
124. Ryde: ZP **71**, 124 (1931). Stark effect.
125. Sutton and Mouzon: PR **37**, 379 (1931). Ionization by alkali ions.
126. Womer: PR **38**, 454 (1931). Ionization by electron impact.

**Ne II**

1. Wentzel: PZ **24**, 104 (1923). Two-electron transitions.
2. Bloch, Bloch and Dejardin: CR **180**, 731 (1925). Wave-lengths.
3. Bloch, Bloch and Dejardin: JPR **7**, 129 and 203 (1926). Wave-lengths.
4. Dejardin: CR **182**, 452 (1926). Excitation by electron impact.
5. Mohler: PR **28**, 46 (1926). Photoionization in gases.
6. Mohler: S **63**, 405 (1926). Excitation potentials.
7. de Bruin: N **119**, 925 (1927); ZP **44**, 157 (1927). Series.
8. Kichlu: N **119**, 671 (1927); PPS **39**, 424 (1927). Series.
9. de Bruin: ANSE **11**, 70 (1928); PKAA **31**, 2 and 593 (1928); ZP **46**, 856 (1928). Series.
10. Compton and Boyce: JFI **205**, 497 (1928). Excitation by electron impact.
11. Ganesan: PR **32**, 580 (1928). Wave-lengths.
12. Kichlu: PPS **40**, 41 (1928). Series.
13. Russell, Compton and Boyce: PNAS **14**, 280 (1928). Series.
14. Russell, Compton and Boyce: PR **31**, 709 (1928). (A). Excitation by controlled electron impact.
15. Bakker: PKAA **32**, 515 (1929). Zeeman effect.
16. Frisch: ZP **64**, 499 (1930). Series.
17. Bakker: ANSE **13**, 121 (1931). Zeeman effect and anomalous coupling.
18. de Bruin and Bakker: ZP **69**, 19 (1931). Series and Zeeman effect.
19. Pretty: PPS **43**, 279 (1931). Displacement of certain lines of Ne II.
20. Romig: PR **38**, 1709 (1931). Doppler effect in canal rays.
21. Ryde: ZP **71**, 124 (1931). Stark effect.

**Ne III**

1. Bloch, Bloch and Dejardin: CR **182**, 451 (1926); JPR **7**, 129 (1926). Wave-lengths.
2. de Bruin: ANSE **11**, 70 (1928); ZP **46**, 856 (1928). Series.
3. Ganesan: PR **32**, 580 (1928). Wave-lengths.
4. Jog: IJP **2**, 343 (1928). Regularities in the spectra of six valence elements.
5. Turner: PR **32**, 727 (1928). Ionizing potentials and far ultraviolet lines of light atoms.
6. Boyce and Compton: PNAS **15**, 656 (1929). Series.
7. Edlen and Ericson: CR **190**, 173 (1930). Extreme ultraviolet spectrum.
8. Romig: PR **38**, 1709 (1931). Doppler effect in canal rays.

**Ne IV**

1. Boyce and Compton: PNAS **15**, 656 (1929). Series.

## Sodium 11

**Na I**

1. Campetti: AAL **29**, 385 (1920). Excitation potentials.
2. Fuchtbauer: PZ **21**, 322 (1920). Absorption in the light of quantum theory.

## Sodium 11

3. Fues: AP **63,** 1 (1920). Calculation of constants in Ritz formula, and of series limits.
4. Gouy: AsP **13,** 188 (1920). Intensity measurements.
5. de Gramont: CR **171,** 1106 (1920). Ultimate lines.
6. Strutt: PRS **96,** 272 (1920). Spectrum of sodium as excited by fluorescence.
7. Datta: PRS **99,** 69 (1921). Series from the vacuum arc.
8. de Gramont: CN **122,** 58 (1921). Ultimate lines.
9. Ladenburg: Nw **9,** 667 (1921); PZ **22,** 549 (1921). Action of an electric field on the *D* lines.
10. Ladenburg: ZP **4,** 451 (1921). Quantum mechanical interpretation of the number of dispersion electrons.
11. Ladenburg: ZP **4,** 469 (1921). Intensity ratio of the *D* lines.
12. Ladenburg and Minkowski: ZP **6,** 153 (1921). Transition probabilities.
13. Millikan: PNAS **7,** 289 (1921). Extension of the ultraviolet spectrum.
14. Minkowski: AP **66,** 206 (1921). Magnetic rotation of the plane of polarization by Na vapour. Number of dispersion electrons.
15. Moore: AJ **54,** 191 (1921). Excitation stages in the open arc.
16. Ramsauer and Wolf: AP **66,** 373 (1921). Duration of emission in quenched arc.
17. Rogestwensky: N **107,** 203 (1921). Intensities of the *D* lines.
18. Rogestwensky: VOIL **2,** No. 13 (1921). Intensity ratios.
19. Rogestwensky and Touroweroff: VOIL **2,** No. 14 (1921). Intensity ratio of *D* lines.
20. Seeliger and Thaer: AP **65,** 423 (1921). Displacement law. Study of excitation energies.
21. Becker: ZP **9,** 332 (1922). Stark effect.
22. Fues: ZP **11,** 364 (1922). Calculation of hydrogen-like terms.
23. Haber and Zisch: ZP **9,** 302 (1922). Excitation of gas spectra by chemical reaction.
24. King: AJ **55,** 380 (1922). Furnace absorption spectra.
25. Minkowski: PZ **23,** 69 (1922). Influence of foreign gases on the *D* lines.
26. Robertson: PR **19,** 470 (1922). Spectrum of electrodeless discharge.
27. Rogestwensky: JRPC **50,** 11 (1922). Intensity ratios.
28. Rogestwensky and Touroweroff; JRPC **50,** 57 (1922). Intensity ratio of *D* lines.
29. Sommerfeld: ZP **8,** 257 (1922). Theory of anomalous Zeeman effect.
30. Back: AP **70,** 333 (1923). Zeeman effect.
31. Bartels: ZP **14,** 169 (1923). Intensity ratios in sharp series.
32. Bartels: ZP **20,** 398 (1923). Intensity distribution, term sequence, and excitation functions.
33. Cario and Franck: ZP **17,** 202 (1923). Sensitized fluorescence of gases.
34. Dorgelo: ZP **13,** 206 (1923). Intensity ratios.
35. Foote, Ruark and Mohler: JOSA **7,** 415 (1923). $D_2$ Zeeman pattern for resonance radiation.
36. Fues: ZP **12,** 1 and 314 (1923). Calculation of hydrogen-like spectra.
37. Fues: ZP **13,** 211 (1923). Derivation of atomic potential function. Relationship of Na I, Mg II and Al III.
38. Gerlach and Schütz: Nw **11,** 637 (1923). Magneto-optical effects in weak fields.
39. Hartree: PCPS **21,** 625 (1923). Calculation of terms.
40. Hoyt: PM **46,** 135 (1923). Correspondence principle and intensity of spectral lines.
41. Kimura and Nakamura: JJP **2,** 61 (1923). Line broadening and the Stark effect.
42. Nagaoka and Suguira: JJP **2,** 167 (1923). Spectroscopic evidence of isotopy.
43. Newman: PM **45,** 181 and 293 (1923). Visibility of spectra.
44. Runge: Nw **11,** 433 (1923). Remarks on frequency difference of doublet lines.
45. Turner: AJ **58,** 176 (1923). Relation between spectra and sizes of alkali atoms.
46. van Urk: ZP **13,** 268 (1923). Normal orbits of the series electrons of the alkalies.
47. Wood and Ellett: PRS **103,** 396 (1923). Influence of magnetic fields on the polarization of resonance radiation.
48. Bartels: ZP **25,** 378 (1924). Spectrum of vacuum arc.
49. Bowen and Millikan: PR **24,** 209 (1924). Wave-lengths. Extension of doublet laws.
50. Breit: PM **47,** 832 (1924). Polarization of resonance radiation.
51. Dorgelo: ZP **22,** 170 (1924). Multiplet intensities.

## SODIUM 11

52. Eldridge: PR **24,** 234 (1924). Theoretical interpretation of the effect of a weak magnetic field on the polarization of fluorescent light.
53. Ellett: N **114,** 931 (1924). Polarization of resonance radiation in magnetic fields.
54. Frisch: JRPC **56,** 525 (1924). Partial Paschen-Back effect.
55. Gaviola and Pringsheim: ZP **25,** 367 (1924). Polarization of resonance radiation in magnetic fields.
56. Harrison: PR **24,** 466 (1924). Series limit absorption.
57. Hartree: PRS **106,** 552 (1924). Term excess. Quantum defect.
58. Hund: ZP **22,** 405 (1924). Rydberg correction and radius of the atom core.
59. Jones and Boyce: PRS **106,** 773 (1924). Constants of the Rydberg-Ritz equation. Quantum defect.
60. Joos: PZ **25,** 130, 298 and 400 (1924). Influence of a magnetic field on the polarization of resonance radiation.
61. Kimura and Nakamura: JJP **3,** 29 (1924). Cathode spectra of metals.
62. Ladenburg: Nw **12,** 414 (1924); VDPG **5,** 9 (1924); ZP **28,** 51 (1924). Second order Stark effect of *D* lines.
63. Landé: ZP **25,** 46 (1924). Absolute intervals of optical doublets. Doublet laws.
64. Lindsay: MIT **3,** 191 (1924). Electronic orbits of atoms.
65. Millikan and Bowen: PR **23,** 1 (1924). Wave-lengths.
66. Pringsheim: Nw **12,** 247 (1924); ZP **23,** 324 (1924). Polarization of resonance radiation by vapours.
67. Rasetti: AAL **33,** 38 (1924). Effect of magnetic field on polarization of resonance radiation.
68. Shaver: TRSC **18,** 23 (1924). Extreme ultraviolet spectrum.
59. Sugiura: JJP **3,** 155 (1924). Calculation of doublet frequency differences.
70. Thomas: ZP **24,** 169 (1924). Calculation of terms and transition probabilities.
71. Turner: AJ **60,** 81 (1924). On spectra and the sizes of atoms.
72. von Wisniewski: CR **179,** 1316 (1924). A formula expressing alkali doublet separation.
73. von Wisniewski: PZ **25,** 480 (1924). Calculation of term corrections.
74. Wood and Ellett: PR **24,** 243 (1924). Polarized resonance radiation. In weak magnetic fields.
75. Back: PZ **26,** 833 (1925). Zeeman effect.
76. Back: ZP **33,** 579 (1925). Paschen-Back effect.
77. Bartels: ZP **32,** 415 (1925). Distribution of transition probabilities in the alkali atoms.
78. Ellett: JOSA **10,** 427 (1925). Polarization of sodium resonance radiation in magnetic fields. Larmor precession of excited atoms.
79. Gaviola and Pringsheim: ZP **34,** 1 (1925). An explanation of the apparently too little polarization of resonance radiation in a magnetic field.
80. Gerlach and Schütz: PZ **26,** 33 (1925). Life of excited atoms. Wood-Ellett experiment.
81. Harrison: PR **25,** 768 (1925). Experimental determination of relative transition probabilities.
82. Harrison and Slater: PR **26,** 176 (1925). Line breadths and absorption probabilities.
83. Holtsmark: ZP **34,** 722 (1925). Breadth of absorption lines. Theoretical.
84. Hoyt: PR **26,** 749 (1925). Application of the correspondence principle to relative intensities.
85. King: AJ **62,** 238 (1925). Spectra in the high current arc.
86. Kopferman and Ladenburg: AP **78,** 659 (1925). Electro-optical researches.
87. Kossel and Gerthsen: AP **77,** 273 (1925). Polarization of resonance radiation.
88. Mensing: ZP **34,** 611 (1925). Theory of line broadening.
89. Mohler: BSP No. **505,** 167 (1925). Critical potentials.
90. Newman: PM **50,** 165 (1925). Low voltage spectrum.
91. Ruark and Chenault: PM **50,** 937 (1925). Fine structure.
92. Russell: AJ **61,** 223 (1925). Ultimate and penultimate lines.
93. Schrödinger: AP **77,** 43 (1925). Hydrogen-like spectra and polarizability of the atom core.
94. Sugiura: IPCR **3,** 1 (1925). Calculation of doublet frequency differences.

## Sodium 11

95. Tartakowsky: ZP **34,** 216 (1925). Diamagnetism and anomalous Zeeman effect.
96. Thomas: ZP **34,** 586 (1925). Formula for second order Stark effect.
97. Trumpy: ZP **34,** 715 (1925). Intensities and widths in the principal series.
98. Unsöld: ZP **33,** 843 (1925). On the screening doublets of the Bowen-Millikan ultraviolet spectra.
99. von Wisniewski: PZ **26,** 255 (1925). Calculation of *s* terms.
100. Datta: ZP **37,** 625 (1926). On the degree of polarization of resonance radiation.
101. Ellett, Foote and Mohler: JOSA **12,** 486 (1926); PR **27,** 31 (1926). Polarization of radiation excited by electron impact.
102. Fuchtbauer and Muir: PZ **27,** 853 (1926). Intensity ratios.
103. Gaviola and Pringsheim: ZP **39,** 75 (1926). Explanation of the apparently too little polarization of resonance radiation in a magnetic field.
104. Grotrian: Nw **14,** 144 (1926). Zeeman effect in strong fields.
105. Hori: IPCR No. **53,** 59 (1926). Explosion spectra.
106. Keussler: PZ **27,** 313 (1926). Depolarization of resonance radiation by weak magnetic fields.
107. Kuhn: ZP **38,** 440 (1926). Breadth of absorption lines.
108. Mannkopf: ZP **36,** 315 (1926). Quenching of resonance radiation by foreign gases.
109. Minkowski: ZP **36,** 839 (1926). Natural width and pressure-broadening.
110. Newman: PM **1,** 721 (1926). Enhanced lines produced by the interrupted arc.
111. Rayleigh: PRS **112,** 14 (1926). Studies on luminous vapour distilled from metallic arcs.
112. Schütz: ZP **35,** 260 (1926). Region of action of excited atoms. Polarization of resonance radiation.
113. Schütz: ZP **38,** 853 (1926). Orientation of atoms in magnetic fields.
114. Schütz: ZP **38,** 864 (1926). Accompaniments of Zeeman effects in weak fields and their influence by foreign gases.
115. Sowerby and Barrett: PRS **110,** 190 (1926). Absorption spectrum.
116. Swirles: PCPS **23,** 403 (1926). Polarizabilities of atom cores.
117. Taylor: PR **28,** 576 (1926). Magnetic moment.
118. Terenin: ZP **37,** 98 (1926). Excitation of atoms by radiation.
119. Thomas: ZP **35,** 556 (1926). Formula for second order Stark effect.
120. Unsöld: ZP **36,** 92 (1926). Polarizability. Calculation of quantum defect.
121. Ellett: PR **29,** 904 (1927). (A) Polarization of resonance radiation.
122. Hasche, Polanyi and Vogt: ZP **41,** 583 (1927). Intensity distribution in the *D* lines produced by chemiluminescence of Na vapour.
123. Leu: ZP **41,** 551 (1927). Magnetic moment.
124. Mohler: PR **29,** 419 (1927). Excitation by atomic hydrogen.
125. Newman: PM **3,** 364 (1927). Flash arc spectrum.
126. Schütz: ZP **45,** 30 (1927). Natural breadth of the *D* absorption lines and their broadening with increased density of the vapour and with the pressure of added gases.
127. Shrum, Carter and Fowler: PM **3,** 27 (1927). The $1s-md$ series.
128. Sugiura: PM **4,** 495 (1927). Calculation of transition probabilities by wave mechanics.
129. Trumpy: ZP **42,** 327 (1927). Intensities of series lines.
130. Dobrezov and Terenin: Nw **16,** 656 (1928). Fine structure of the *D* lines.
131. Fairley: AJ **67,** 114 (1928). Width of the *D* absorption lines.
132. Grotrian: ZP **49,** 541 (1928). Inverse Stark effect.
133. van der Held: P **8,** 165 (1928). Absolute intensity measurements.
134. Kiess: BSJ **1,** 75 (1928). Interferometer measurements of wave-lengths from the vacuum arc.
135. Kupper: AP **86,** 511 (1928). Comparison of experimental and theoretical intensities.
136. Ladenburg and Minkowski: AP **87,** 298 (1928). Measurements of the duration of life of excited sodium atoms by means of the brightness of sodium flames and the degree of dissociation of sodium salts in the flame.
137. Locher: JOSA **17,** 91 (1928). Time intervals between the appearance of spectral lines.

## Sodium 11


138. Lochte-Holtgreven: ZP **47**, 362 (1928). Intensity ratio of the *D* lines.
139. Ornstein and van der Held: AP **85**, 953 (1928). Absolute intensity measurements on a sodium flame.
140. Sambursky: ZP **49**, 731 (1928). Intensity ratios for principal series doublets.
141. Schüler: Nw **16**, 512 (1928). Fine structure of the *D* lines.
142. Wilson: PRS **118**, 362 (1928). Emission in Na flames.
143. Christensen and Rollefson: PR **34**, 1157 (1929). Influence of the method of excitation on transition probabilities.
144. Ferchmin and Frisch: ZP **53**, 326 (1929). Fine structure and inversion of the *D* terms.
145. Filippov and Prokofjew: ZP **56**, 458 (1929). Anomalous dispersion. Transition probabilities.
146. Gibbs and White: PR **33**, 157 (1929). Doublets of stripped atoms.
147. Korff PR **34**, 457 (1929). Dispersion and absorption line width.
148. Minowski: ZP **55**, 16 (1929). Intensity variations in pressure-widened lines.
149. Okubo and Hamada: PM **7**, 729 (1929). Excitation by active nitrogen.
150. Prokofjew: ZP **57**, 387 (1929). Probability of forbidden transitions.
151. Prokofjew: ZP **58**, 255 (1929). Calculation of number of dispersion electrons.
152. Webb and Wang: PR **33**, 329 (1929). Excitation of sodium by ionized mercury vapour.
153. Weiss: AP **1**, 565 (1929). Transition probabilities in 3 *P* state.
154. Deslandres: CR **190**, 1250 (1930). Properties of abnormal series.
155. Deslandres: CR **191**, 169 (1930). Ultimate rays.
156. Fermi: N **125**, 16 (1930); ZP **60**, 320 (1930). Nuclear moment.
157. Fermi: ZP **59**, 680 (1930). Intensity ratios of the alkali doublets. Effect of perturbations. Theoretical.
158. Frisch and Ferchmin: Nw **18**, 866 (1930). Nuclear moment.
159. Funk: AP **4**, 149 (1930). Ionization by slow electrons.
160. Minkowski: ZP **63**, 188 (1930). Influence of self-absorption on intensity measurements.
161. Stevenson: PRS **128**, 591 (1930). Intensity of quadrupole radiation.
162. Trumpy: ZP **61**, 54 (1930). Calculation of number of dispersion electrons.
163. Bartels: ZP **73**, 203 (1931). Continuum and forbidden series.
164. Berry and Rollefson: PR **38**, 1599 (1931). Transition probabilities and quenching in the 3 *P*-state.
165. Fermi: NC **8**, XIV (1931). Nuclear moment.
166. Jablonski and Pringsheim: ZP **70**, 593 (1931). *D* line emission in sodium vapour with yellow light excitation.
167. Jablonski and Pringsheim: ZP **73**, 281 (1931). Polarization of *D* line fluorescence at high vapor pressures.
168. Kastler: JPR **2**, 159 (1931). Non-existence of spin in photons. Zeeman effect.
169. Korff: PR **38**, 477 (1931). Absorption line width.
170. Kronig and Frisch: PZ **32**, 457 (1931). Nuclear moments. Bibliography.
171. Ladenburg and Thiele: ZP **72**, 697 (1931). The oscillator strength of the *D* lines. Life of resonance state.
172. Lucas: ZAC **195**, 321 (1931). Relative intensities of principal and subordinate series.
173. Michels: PR **38**, 712 (1931). Low voltage excitation.
174. Schuler and Keyston: ZP **68**, 174 (1931). Isotope abundance ratio and nuclear moment.
175. Segré and Bakker: Nw **19**, 738 (1931); ZP **72**, 724 (1931). Zeeman effect of quadrupole radiation.
176. Weingeroff: ZP **67**, 679 (1931). Natural width of the *D* lines by a compensation method.
177. Whitelaw and Stevenson: N **127**, 817 (1931). Intensity of forbidden transitions.
178. Zehden: Nw **19**, 826 (1931). The *f* value (oscillator strength) of *D* lines from absorption measurements.


**Na II**


1. Seeliger and Thaer: AP **65**, 423 (1921). Displacement law. Study of excitation energies.

## Sodium 11; Magnesium 12


2. Foote, Meggers and Mohler: AJ **55,** 145 (1922). Enhanced spectrum excited in the low-voltage arc.
3. Turner: PM **48,** 384 (1924). Quantum defect.
4. Mohler: BSP No. **505,** 167 (1925). Critical potentials.
5. Unsöld: ZP **33,** 843 (1925). On the screening doublets of the Bowen-Millikan ultraviolet spectra.
6. Bowen: PR **31,** 967 (1928). Series.
7. Frisch: ZP **49,** 52 (1928). Series.
8. Hartree: PCPS **24,** 111 (1928). Distribution of charge calculated from wave equation for a central field.
9. Laporte: N **121,** 941 (1928). Series.
10. Majumdar: IJP **2,** 345 (1928). Series.
11. Newman: N **122,** 97 (1928); PM **5,** 150 (1928). Series.
12. Turner: PR **32,** 727 (1928). Ionizing potential and far ultraviolet lines of light atoms.
13. Frisch: VOIL **5,** No. 46, 1 (1929). Series.
14. Schüler and Brück: ZP **58,** 735 (1929). Hyperfine structure.
15. Laporte and Inglis: PR **35,** 1337 (1930). Resonance separations for $p^5s$ configuration.
16. Frisch: ZP **70,** 498 (1931). Ground term and resonance lines. Hyperfine structure.
17. Kronig and Frisch: PZ **32,** 457 (1931). Nuclear moments. A review. Bibliography.


**Na III**


1. Saha and Kichlu: IJP **2,** 319 (1928). Prediction of new lines.
2. Turner: PR **32,** 727 (1928). Ionizing potentials and far ultraviolet lines of light atoms.
3. Edlen and Ericson: CR **190,** 173 (1930). Extreme ultraviolet spectra.
4. Mack and Sawyer: PR **35,** 299 (1930). New lines and levels.
5. Majumdar: IJP **4,** 359 (1930). Prediction of certain terms.
6. Sawyer and Mack: PR **35,** 661 (1930). (A) Quantitative application of the irregular doublet law.


**Na IV**


1. Edlen and Ericson: CR **190,** 173 (1930). Extreme ultraviolet spectra.


## Magnesium 12

**Mg I**


1. Fues: AP **63,** 1 (1920). Selection rules. Displacement law. Calculation of constants in Ritz formula, and of series limits.
2. de Gramont: CR **170,** 31 (1920). Variability of arc spectrum. Presence of spark lines.
3. de Gramont: CR **171,** 1106 (1920). Ultimate lines.
4. Hemsalech: PM **40,** 296 (1920). Character of lines emitted by vapours under selective action of thermochemical and thermoelectrical excitations.
5. McLennan, Young and Ireton: PRS **98,** 95 (1920). Wave-lengths.
6. Mohler, Foote and Meggers: BSP No. **403,** Vol. 16, 725 (1920); JOSA **4,** 364 (1920). Resonance potentials and low voltage arcs.
7. Polvani: NC **20,** 119 (1920). Time variations in the spectrum of an electric discharge.
8. Foote, Meggers and Mohler: PM **42,** 1002 (1921). Low voltage arc.
9. de Gramont: CN **122,** 58 (1921). Ultimate lines.
10. de Gramont and Hemsalech: CR **173,** 505 (1921). Electrical action and the appearance of certain lines.
11. Millikan: PNAS **7,** 289 (1921). Extension of the ultraviolet spectrum.
12. Moore: AJ **54,** 191 (1921). Excitation stages in the open arc.
13. Ramsauer and Wolf: AP **66,** 373 (1921). Duration of emission in quenched arc.
14. Seeliger and Thaer: AP **65,** 423 (1921). Displacement law. Study of excitation energies.
15. Bloch and Bloch: JPR **3,** 309 (1922). Wave-lengths from under-water spark.
16. Campetti and Corsi: NC **24,** 117 (1922). Spectra of sparks in the middle of a flame.
17. Carter: AJ **55,** 162 (1922). Vacuum spark spectra.

## MAGNESIUM 12

18. Hemsalech and de Gramont: PM **43**, 834 (1922). Occurrence of enhanced lines in the arc.
19. Back: AP **70**, 371 (1923). Zeeman effect.
20. Kimura and Nakamura: JJP **2**, 61 (1923). Line broadening and the Stark effect.
21. Moore: AJ **58**, 86 (1923). Excitation stages in the open arc.
22. St. Procopiu: CR **176**, 385 (1923); CR **176**, 504 (1923). Spectra from arcs on immersion in various media.
23. Sawyer and Becker: AJ **57**, 98 (1923). Explosion spectrum.
24. Barratt: PRS **105**, 221 (1924). Absorption in mixed metallic vapours.
25. Birge: JOSA **8**, 233 (1924). Series of divalent elements.
26. Bowen and Millikan: PR **24**, 209 (1924). Wave-lengths. Extension of doublet laws.
27. Dorgelo: P **4**, 281 (1924); ZP **22**, 170 (1924). Multiplet intensities.
28. Fues: ZP **21**, 265 (1924). Calculation of terms.
29. Green and Petersen: AJ **60**, 301 (1924). Doublet excitation spectra. Primed terms.
30. Hulburt: PR **24**, 129 (1924). Absorption in under-water spark.
31. Kimura and Nakamura: JJP **3**, 29 (1924). Cathode spectra of metals.
32. Landé: ZP **25**, 46 (1924). Absolute intervals of triplets. Doublet laws.
33. Millikan and Bowen: PR **23**, 1 (1924). Wave-lengths.
34. Nagaoka and Sugiura: JJP **3**, 45 (1924). Stark effect.
35. Narayan, Gunnayya and Rao: AJ **60**, 204 (1924). λ4571 in absorption.
36. St. Procopiu: AsP **1**, 89 (1924). Study of arc spectrum in various media and in vacuo.
37. Sugiura: JJP **3**, 155 (1924). Calculation of triplet separations.
38. Turner: PM **48**, 384 (1924). Quantum defect.
39. Back: ZP **33**, 579 (1925). Paschen-Back effect.
40. Bowen and Millikan: PR **26**, 150 (1925). *PP'* groups.
41. Brown and Beams: JOSA **11**, 11 (1925). Order of appearance of spectral lines.
42. van Geel: ZP **33**, 836 (1925). Intensities of Zeeman components.
43. Kapitza and Skinner: PRS **109**, 224 (1925). Zeeman effect in strong fields.
44. King: AJ **62**, 238 (1925). Spectrum of the high current arc.
45. Lowery: PM **49**, 1176 (1925). Line broadening and the Stark effect.
46. Narayan and Rao: PM **50**, 645 (1925). Absorption spectrum.
47. Peterson and Green: AJ **62**, 49 (1925). Wave-lengths and pressure shifts.
48. Ruark: JOSA **11**, 199 (1925). Excitation of *PP'* groups in low voltage discharge.
49. Ruark and Chenault: PM **50**, 937 (1925). Fine structure.
50. Russell: AJ **61**, 223 (1925). Ultimate and penultimate lines.
51. Schrödinger: AP **77**, 43 (1925). Hydrogen-like spectra and polarizability of the atom core.
52. Skinners: PRS **109**, 224 (1925). Zeeman effect.
53. Sugiura: IPCR **3**, 1 (1925). Calculation of triplet separations.
54. von Wisniewski: PZ **26**, 255 (1925). Calculation of *s*-terms.
55. Beams: PR **28**, 475 (1926). Time interval for excitation of spectra.
56. van Geel: ZP **39**, 877 (1926). Intensities in partial Paschen-Back effect.
57. Hori: IPCR No. **53**, 59 (1926). Explosion spectrum.
58. Nagaoka and Futagami: PIAT **2**, 387 (1926). Exploded-wire spectrum.
59. Rayleigh: PRS **112**, 14 (1926). Studies on luminous vapor distilled from metallic arcs.
60. Sawyer: JOSA **13**, 431 (1926). Low terms. *PP'* groups.
61. Unsöld: ZP **36**, 92 (1926). Polarizability. Calculation of quantum defect.
62. Fukuda: IPCR No. **85**, 1 (1927). Explosion spectra. Broadening and reversal of lines.
63. Kichlu and Saha: PM **4**, 193 (1927). Spectra of metals of group II.
64. Mohler: PR **29**, 419 (1927). Excitation by atomic hydrogen.
65. Paschen: SAWB **29**, 207 (1927). Excitation through the metastable condition of rare gas atoms.
66. Saha: PM **3**, 1265 (1927). Spectra of group II metals. Theoretical.
67. Walters and Barratt: PM **3**, 991 (1927). Absorption spectrum.
68. Campetti: NC **5**, 291 (1928). Under-water spark spectrum.
69. Locher: JOSA **17**, 91 (1928). Time intervals between the appearance of spectral lines.

## MAGNESIUM 12

70. Nagaoka and Futagami: PIAT **4**, 198 (1928). Exploded wire spectrum.
71. Okubo and Hamada: PM **5**, 372 (1928). Excitation by active nitrogen.
72. Prokofjew: ZP **50**, 701 (1928). Transition probabilities. Anomalous dispersion.
73. Selwyn: PPS **41**, 392 (1928). Additions to analysis.
74. Crew: PM **7**, 312 (1929). Influence of a hydrogen atmosphere upon the arc spectrum.
75. Frayne: PR **34**, 590 (1929). Influence of foreign gases on intensity of resonance lines.
76. Lundeghardi: AKMG **10**, 1A (1929). Flame spectrum.
77. Warga: PAO **6**, 151 (1929). Mg-triplets in arc and solar spectra.
78. Deslandres: CR **190**, 1250 (1930). Properties of abnormal series.
79. Deslandres: CR **191**, 169 (1930). Ultimate rays.
80. Green: PR **36**, 157 (1930). Incomplete Paschen-Back effect.
81. Querbach: ZP **60**, 109 (1930). Infrared series.
82. King: PR **38**, 590 (1931). (A) Spectra of high current arcs.
83. Murakawa: ZP **72**, 793 (1931). Hyperfine structure.

**Mg II**

1. Fues: AP **63**, 1 (1920). Selection rules. Displacement law. Calculation of constants in Ritz formula, and of series limits.
2. Foote, Meggers and Mohler: PM **42**, 1002 (1921); PR **18**, 128 (1921). Excitation in low-voltage arc.
3. Rogestwensky: VOIL **2**, No. 9 (1921). Series of Mg II and He II compared.
4. Hemsalech and de Gramont: PM **43**, 834 (1922). Occurrence of enhanced lines in the arc.
5. Rogestwensky: JRPC **50**, 1 (1922). Series of Mg II and He II compared.
6. Fues: ZP **13**, 211 (1923). Derivation of atomic potential function. Relationship of Na I, Mg II and Al III.
7. Sawyer and Becker: AJ **57**, 98 (1923). Explosion spectra.
8. Turner: AJ **58**, 176 (1923). Relation between spectra and sizes of atoms.
9. Bowen and Millikan: PR **24**, 209 (1924). Wave-lengths. Extension of doublet laws.
10. Hartree: PRS **106**, 552 (1924). Term excess. Quantum defect.
11. Hund: ZP **22**, 405 (1924). Rydberg correction and radius of the atom core.
12. Jones and Boyce: PRS **106**, 773 (1924). Constants of the Rydberg-Ritz equation. Quantum defect.
13. Kimura and Nakamura: JJP **3**, 197 (1924). Wave-lengths.
14. Landé: ZP **25**, 46 (1924). Absolute intervals of doublets. Doublet laws.
15. Lyman: N **114**, 641 (1924); S **60**, 388 (1924). Series.
16. Millikan and Bowen: PR **23**, 1 (1924). Wave-lengths.
17. Turner: AJ **60**, 81 (1924). On spectra and the sizes of atoms.
18. Turner: PM **48**, 384 (1924). Quantum defect.
19. de Wisniewski: CR **179**, 1316 (1924). A formula for doublet separation.
20. Brown and Beams: JOSA **11**, 11 (1925). Order of appearance of spectral lines.
21. Kapitza and Skinner: PRS **109**, 224 (1925). Zeeman effect in strong fields.
22. Ruark: JOSA **11**, 199 (1925). Excitation in low-voltage, low-current discharge.
23. Russell: AJ **61**, 223 (1925). Ultimate and penultimate lines.
24. Schrödinger: AP **77**, 43 (1925). Hydrogen-like spectra and polarizability of the atom core.
25. Unsöld: ZP **33**, 843 (1925). On the screening doublets of the Bowen-Millikan ultraviolet spectra.
26. von Wisniewski: PZ **26**, 255 (1925). Calculation of *s*-terms.
27. Beams: PR **28**, 475 (1926). Time interval for excitation of spectra.
28. Rayleigh: PRS **112**, 14 (1926). Studies on the luminous vapour distilled from metallic arcs.
29. Swirles: PCPS **23**, 403 (1926). Polarizabilities of atom cores.
30. Unsöld: ZP **36**, 92 (1926). Polarizability. Calculation of quantum defect.
31. Paschen: SAWB **29**, 207 (1927). Light excitation through the metastable condition of the rare gas atom.

## Magnesium 12; Aluminum 13

32. Saha and Kichlu: IJP **2,** 319 (1928). Extension of the irregular doublet law.
33. Duffendack, Henshaw and Goyer: PR **34,** 1132 (1929). Excitation by impacts of the second kind with metastable atoms and ions of the rare gases.
34. Gibbs and White: PR **33,** 157 (1929). Doublets of stripped atoms.
35. Dunnington and Lawrence: PR **35,** 134 (1930). (A) Stark effect.

**Mg III**

1. Unsöld: ZP **33,** 843 (1925). On the screening doublets of the Bowen-Millikan ultraviolet spectra.
2. Mack and Sawyer: S **68,** 306 and 1761 (1928). Series.
3. Saha and Kichlu: IJP **2,** 319 (1928). Prediction of new lines.
4. Turner: PR **32,** 727 (1928). Ionizing potentials and far ultraviolet lines of light atoms.
5. Edlen and Ericson: CR **190,** 116 (1930). Spectrum of the condensed spark.
6. Laporte and Inglis: PR **35,** 1337 (1930). Resonance separations for $p^5s$ configuration.

**Mg IV**

1. Edlen and Ericson: CR **190,** 173 (1930). Extreme ultraviolet spectra.
2. Mack and Sawyer: PR **35,** 299 and 661 (A) (1930). Quantitative application of irregular doublet law.

**Mg V**

1. Edlen and Ericson: CR **190,** 173 (1930). Extreme ultraviolet spectra.
2. Mack and Sawyer: PR **35,** 299 and 661 (A) (1930). Quantitative application of irergular doublet law.

## Aluminum 13

**Al I**

1. Fues: AP **63,** 1 (1920). Selection rules. Displacement law. Calculation of constants in Ritz formula, and of series limits.
2. de Gramont: CR **170,** 31 (1920). Variability of arc spectrum. Presence of spark lines.
3. de Gramont: CR **171,** 1106 (1920). Ultimate lines.
4. McLennan, Young and Ireton: PRS **98,** 95 (1920). Arc spectra in vacuo and spark spectra in helium.
5. Polvani: NC **20,** 119 (1920). Time variations in the spectrum of an electric discharge.
6. de Gramont: CN **122,** 58 (1921). Ultimate lines.
7. de Gramont and Hemsalech: CR **173,** 278 (1921). Conditions of emission of spark lines.
8. Millikan: PNAS **7,** 289 (1921). Extension of the ultraviolet spectrum.
9. Paschen and Back: P **1,** 261 (1921). Zeeman effect.
10. Ramsauer and Wolf: AP **66,** 373 (1921). Duration of emission in quenched arc.
11. Royds: KB **43,** 109 (1921). Different character of lines of the same series.
12. Walters: BSP No. **411,** Vol. 17, 161 (1921). Wave-lengths.
13. Bloch and Bloch: CR **174,** 1456 (1922); JPR **3,** 309 (1922). Wave-lengths from under-water spark.
14. Glaser: AP **68,** 73 (1922). Wave-lengths.
15. de Gramont: CR **175,** 1025 (1922). "Raies ultimes" and spectral series.
16. Shallenberger: PR **19,** 398 (1922). (A) Two new lines.
17. Grotrian: ZP **12,** 218 (1923); ZP **18,** 169 (1923). Absorption spectra of metallic vapours.
78. Hutchinson: AJ **58,** 280 (1923). Ultraviolet wave-lengths.
19. Mohler and Ruark: JOSA **7,** 819 (1923). Prediction of critical potentials.
20. Paschen: Nw **11,** 434 (1923). Frequency difference of doublet lines.
21. St. Procopiu: CR **176,** 385 and 504 (1923). Spectra from arcs on immersion in various media.
22. Sawyer and Becker: AJ **57,** 98 (1923). Explosion spectrum.
23. Hicks: PM **48,** 321 (1924). Application of the oun to series grouping.
24. Hulburt: PR **24,** 129 (1924). Absorption in under-water spark.

## Aluminum 13

25. Kimura and Nakamura: JJP **3,** 43 (1924). Cathode spectra of metals.
26. Landé: ZP **25,** 46 (1924). Absolute intervals of optical doublets. Doublet laws.
27. Millikan and Bowen: PR **23,** 1 (1924). Wave-lengths.
28. Nagaoka and Sugiura: JJP **3,** 45 (1924). Stark effect.
29. St. Procopiu: AsP **1,** 89 (1924). Study of arc spectrum in various media and in vacuo.
30. St. Procopiu: CR **178,** 1368 (1924). Ultimate lines from the electric arc.
31. St. Procopiu: JPR **5,** 220 (1924). Line width at various pressures.
32. Sugiura: JJP **3,** 155 (1924). Calculation of doublet separations.
33. Turner: PM **48,** 384 (1924). Quantum defect.
34. Bowen and Millikan: PR **26,** 150 (1925). *PP′* groups.
35. Kapitza and Skinner: PRS **109,** 224 (1925). Zeeman effect in strong fields.
36. King: AJ **62,** 238 (1925). Spectra in the high current arc.
37. McQuarrie: PM **50,** 819 (1925). Under-water spark spectrum.
38. Majumdar and Swe: N **115,** 459 (1925). Absorption spectrum.
39. Ruark and Chenault: PM **50,** 937 (1925). Fine structure.
40. Russell: AJ **61,** 223 (1925). Ultimate and penultimate lines.
41. Smith: AJ **61,** 186 (1925). Exploded wire spectrum.
42. Sugiura: IPCR **3,** 1 (1925). Calculation of doublet separations.
43. von Wisniewski: PZ **26,** 255 (1925). Calculation of *s*-terms.
44. Bowen and Ingram: PR **28,** 444 (1926). Extreme ultraviolet standards.
45. Frayne and Smith: PR **27,** 23 (1926). Ultraviolet absorption spectrum.
46. Hartree: PCPS **23,** 304 (1926). Quantum defect.
47. Sawyer: JOSA **13,** 431 (1926). Deep-lying terms in 2 and 3 electron spectra. *PP′* groups.
48. Sur and Majumdar: PM **1,** 451 (1926). Absorption spectrum.
49. Swirles: PCPS **23,** 403 (1926). Polarizabilities of atom cores.
50. Unsöld: ZP **36,** 92 (1926). Polarizability. Calculation of quantum defect.
51. Nagaoka, Nukiyama and Futagami: PIAT **3,** 319 and 330 (1927). Explosion spectra.
52. Paschen: SAWB **29,** 207 (1927). Excitation through the metastable condition of rare gas atoms.
53. Kiess: BSJ **1,** 75 (1928). Interferometer measurements of wave-length.
54. Nagaoka and Futagami: PIAT **4,** 361 (1928). Successive stages in excitation.
55. Williams: CR **187,** 761 (1928). Ultimate rays.
56. Crew: PM **7,** 312 (1929). Influence of a hydrogen atmosphere upon the arc spectrum.
57. Lansing: PR **34,** 597 (1929). New terms.
58. Paton and Lansing: PR **33,** 1099 (1929). (A) New terms.
59. Ishida and Fukushima: IPCR **14,** No. 266, 123 (1930). Stark effect.
60. Gibbs. and Kruger: PR **37,** 656 (1931). Nuclear spin of aluminum.
61. Söderqvist and Edlen: ZP **69,** 356 (1931). Wave-length normals in the extreme ultraviolet.
62. White: PR **37,** 1175 (1931). Hyperfine structure.

**Al II**

1. Paschen: AP **71,** 537 (1923). Series.
2. Bowen and Millikan: PR **24,** 209 (1924). Wave-lengths. Extension of doublet laws.
3. Hicks: PM **48,** 321 (1924). Application of the oun to series grouping.
4. Kimura: JJP **3,** 217 (1924). Wave-lengths.
5. Kimura and Nakamura: JJP **3,** 197 (1924). Wave-lengths.
6. Landé: ZP **25,** 46 (1924). Absolute intervals of optical doublets and triplets. Doublet laws.
7. Millikan and Bowen: PR **23,** 1 (1924). Wave-lengths.
8. Russell: N **113,** 163 (1924). Singlet series.
9. Turner: PM **48,** 384 (1924). Quantum defect.
10. de Wisniewski: PZ **25,** 477 (1924). Theoretical calculation of terms.
11. Bowen and Millikan: PR **26,** 150 (1925). *PP′* groups.
12. Ruark and Chenault: PM **50,** 937 (1925). Fine structure.

## Aluminum 13

13. Russell: AJ **61,** 223 (1925). Ultimate and penultimate lines.
14. Schrödinger: AP **77,** 43 (1925). Hydrogen-like spectra and polarizability of the atom core.
15. Bowen and Millikan: PR **27,** 144 (1926). New ultraviolet lines.
16. Sawyer: PR **27,** 106 (1926). (A) *PP′* groups.
17. Unsöld: ZP **36,** 92 (1926). Polarizability. Calculation of quantum defect.
18. Paschen: SAWB **29,** 207 (1927). Light excitation through the metastable condition of the rare gas atom.
19. Sawyer and Paschen: AP **84,** 1 (1927). Series.
20. Ekefors: ZP **51,** 471 (1928). New ultraviolet lines.
21. Paschen: SAWB **32,** 1 (1930). Extension of series.
22. White: PR **37,** 1175 (1931). Hyperfine structure.
23. Zumstein: PR **38,** 2214 (1931). Wave-length standards in the Schumann region.

**Al III**

1. Fues: ZP **13,** 211 (1923). Derivation of atomic potential function. Relationship of Na I, Mg II, and Al III.
2. Paschen: AP **71,** 152 (1923). Series.
3. Bowen and Millikan: PR **24,** 209 (1924). Wave-lengths. Extension of doublet laws.
4. Hartree: PRS **106,** 552 (1924). Term excess. Quantum defect.
5. Hicks: PM **48,** 321 (1924). Application of the oun to series grouping.
6. Hund: ZP **22,** 405 (1924). Rydberg correction and radius of the atom core.
7. Jones and Boyce: PRS **106,** 773 (1924). Constants of the Rydberg-Ritz equation. Quantum defect.
8. Kimura: JJP **3,** 217 (1924). Wave-lengths.
9. Kimura and Nakamura: JJP **3,** 197 (1924). Wave-lengths.
10. Lyman: N **114,** 641 (1924); S **60,** 388 (1924). Series in ultraviolet.
11. Millikan and Bowen: PR **23,** 1 (1924). Wave-lengths.
12. Turner: AJ **60,** 81 (1924). On spectra and the sizes of atoms.
13. Turner: PM **48,** 384 (1924). Quantum defect.
13a. von Wisniewski: PZ **25,** 477 (1924). Calculation of term corrections.
14. Russell: AJ **61,** 223 (1925). Ultimate and penultimate lines.
15. Schrödinger: AP **77,** 43 (1925). Hydrogen-like spectra and polarizability of the atom core.
16. Unsöld: ZP **33,** 843 (1925). On the screening doublets of the Bowen-Millikan ultraviolet spectra.
17. Bowen and Millikan: PR **27,** 144 (1926). New ultraviolet lines.
18. Hartree: PCPS **23,** 304 (1926). Quantum defect:
19. Swirles: PCPS **23,** 403 (1926). Polarizability of atom cores.
20. Unsöld: ZP **36,** 92 (1926). Polarizability. Calculation of quantum defect.
21. Ekefors: ZP **51,** 471 (1928). Extreme ultraviolet spectrum.
22. Gibbs and White: PR **33,** 157 (1929). Doublets of stripped atoms.
23. Zumstein: PR **38,** 2214 (1931). Wave-length standards in the Schumann region.

**Al IV**

1. Edlen and Ericson: CR **190,** 116 (1930). Condensed spark spectra. Ionizing potentials.

**Al V**

1. Edlen and Ericson: CR **190,** 116 (1930). Condensed spark spectra. Ionizing potentials.
2. Edlen and Ericson: CR **190,** 173 (1930). Extreme ultraviolet lines.

**Al VI**

1. Edlen and Ericson: CR **190,** 116 (1930). Condensed spark spectra. Ionizing potentials.
2. Edlen and Ericson: CR **190,** 173 (1930). Series.

## SILICON 14


### Si I

1. de Gramont: CR **171,** 1106 (1920). Ultimate lines.
2. de Gramont: CN **122,** 58 (1921). Ultimate lines.
3. Sawyer and Paton: PR **19,** 256 (1922). (A) Wave-lengths and constant frequency differences.
4. Nagaoka and Sugiura: JJP **2,** 167 (1923). Spectroscopic evidence of isotopy.
5. Sawyer and Paton: AJ **57,** 279 (1923). Wave-lengths from vacuum spark.
6. McLennan and Shaver: TRSC **18,** 1 (1924). Series.
7. Millikan and Bowen: PR **23,** 1 (1924). Wave-lengths.
8. Nagaoka and Sugiura: N **113,** 532 (1924). Spectroscopic evidence of isotopes.
9. Fowler: PTRS **225,** 1 (1925). Series.
10. Holweck: CR **180,** 658 (1925). Spectral frequencies in the region between visible light and x-rays.
11. McQuarrie: PM **50,** 819 (1925). A note on series.
12. Goudsmit and Back: ZP **40,** 530 (1927). Vector coupling.
13. Fowler: PRS **123,** 422 (1929). Series.
14. Houston: PR **33,** 297 (1929). Calculation of energy levels by Schrödinger equation.
15. Majumdar: IJP **4,** 359 (1930). Prediction of certain terms.
16. King: PR **38,** 590 (1931). Spectra of high-current vacuum arcs.
17. von Mathes: ZP **68,** 493 (1931). Zeeman effect.

### Si II

1. McLennan and Lewis: PRS **98,** 109 (1920). Extreme ultraviolet wave-lengths.
2. Kimura and Nakamura: JJP **3,** 197 (1924). Wave-lengths.
3. Bowen and Millikan: PR **26,** 150 (1925). *PP′* groups.
4. Fowler: PTRS **225,** 1 (1925). Series.
5. Saha: N **116,** 644 (1925). Certain multiplets.
6. Hartree: PCPS **23,** 304 (1926). Quantum defect.
7. Swirles: PCPS **23,** 403 (1926). Polarizabilities of atom cores.
8. Unsöld: ZP **36,** 92 (1926). Polarizability. Calculation of quantum defect.
9. Kichlu: JOSA **14,** 455 (1927). Series.
10. Bowen: PR **31,** 34 (1928). Series.
11. von Mathes: ZP **68,** 493 (1931). Zeeman effect.
12. Zumstein: PR **38,** 2214 (1931). Wave-length standards in the Schumann region.

### Si III

1. Bowen and Millikan: PR **24,** 209 (1924). Wave-lengths. Extension of doublet laws.
2. Kimura and Nakamura: JJP **3,** 197 (1924). Wave-lengths.
3. Bowen and Millikan: PR **26,** 150 (1925). *PP′* groups.
4. Fowler: PTRS **225,** 1 (1925). Series.
5. Schrödinger: AP **77,** 43 (1925). Hydrogen-like spectra and polarizability of the atom core.
6. Unsöld: ZP **36,** 92 (1926). Polarizability. Calculation of quantum defect.

### Si IV

1. Fowler: PRS **103,** 413 (1923). Series.
2. Bowen and Millikan: PR **24,** 209 (1924). Wave-lengths. Extension of doublet laws.
3. Hartree: PRS **106,** 552 (1924). Term excess. Quantum defect.
4. Jones and Boyce: PRS **106,** 773 (1924). Constants of the Rydberg-Ritz equation. Quantum defect.
5. Kimura and Nakamura: JJP **3,** 197 (1924). Wave-lengths.
6. McLennan and Shaver: TRSC **18,** 1 (1924). Series.
7. Millikan and Bowen: PR **23,** 1 (1924). Wave-lengths.
8. Sawyer and Paton: PR **23,** 108 (1924). (A) Series.
9. Turner: AJ **60,** 81 (1924). On spectra and the sizes of atoms.

## Silicon 14; Phosphorus 15


10. Turner: PM **48,** 384 (1924). Quantum defect.
11. Bowen and Millikan: PR **26,** 150 (1925). *PP'* groups.
12. Fowler: PTRS **225,** 1 (1925). Series.
13. Lang and Smith: N **116,** 244 (1925). Doublet separation.
14. Russell: AJ **61,** 223 (1925). Ultimate and penultimate lines.
15. Schrödinger: AP **77,** 43 (1925). Hydrogen-like spectra and polarizability of the atom core.
16. Unsöld: ZP **33,** 843 (1925). On the screening doublets of the Bowen-Millikan ultraviolet spectra.
17. Hartree: PCPS **23,** 304 (1926). Quantum defect.
18. Unsöld: ZP **36,** 92 (1926). Polarizability. Calculation of quantum defect.
19. Gibbs and White: PR **33,** 157 (1929). Doublets of stripped atoms.

**Si V**

1. Noyes and Beckman: ChR **5,** 85 (1928). Ionizing potential.
2. Edlen and Ericson: CR **190,** 116 (1930). Condensed spark spectra. Ionizing potentials.


## Phosphorus 15


**P I**

1. Foote and Mohler: BSP No. **400,** Vol. 16, 669 (1920); PR **15,** 321 (1920). (A) Ionization and resonance potentials.
2. de Gramont: CR **171,** 1106 (1920). Ultimate lines.
3. de Gramont: CN **122,** 58 (1921). Ultimate lines.
4. Millikan and Bowen: PR **23,** 1 (1924). Wave-lengths.
5. Ruark, Mohler, Foote and Chenault: BSP No. **490,** Vol. 19, 463 (1924). Critical potentials.
6. Saltmarsh: PM **47,** 874 (1924). Series.
7. Shaver: TRSC **18,** 145 (1924). Spectrum of electrodeless discharge.
8. Duffendack and Huthsteiner: PR **25,** 110 (1925). (A) Low-voltage arc.
9. Holweck: CR **180,** 658 (1925). Spectral frequencies in the region between visible light and x-rays.
10. Russell: AJ **61,** 223 (1925). Ultimate and penultimate lines.
11. Sur: N **116,** 542 (1925). Series.
12. McLennan and McLay: TRSC **21,** 63 (1927). Series.
13. Dhavale: N **123,** 799 (1929). Extension of term system.
14. Queney: JPR **10,** 299 (1929). Ultraviolet wave-lengths.
15. Majumdar: IJP **4,** 359 (1930). Prediction of certain terms.
16. Bartlett, Jr.: PR **37,** 327 (1931). Nuclear spin.

**P II**

1. Bowen: PR **29,** 510 (1927). Series.
2. Dejardin: CR **185,** 1453 (1927). Wave-lengths.
3. Gilles: CR **188,** 1158 (1929). 3*d* orbit in P II.

**P III**

1. Bowen and Millikan: PR **26,** 150 (1925). *PP'* groups.
2. Millikan and Bowen: PR **25,** 600 (1925). Series.
3. Saltmarsh: PRS **108,** 332 (1925). Series.
4. Hartree: PCPS **23,** 304 (1926). Quantum defect.
5. Dejardin: CR **185,** 1453 (1927). Series.
6. Bowen: PR **31,** 34 (1928). Series.

**P IV**

1. Bowen and Millikan: PR **24,** 209 (1924). Wave-lengths. Extension of doublet laws.
2. Bowen and Millikan: PR **25,** 591 (1925). Series.
3. Bowen and Millikan: PR **26,** 150 (1925). *PP'* groups.
4. Saltmarsh: PRS **108,** 332 (1925). Series.

## Phosphorus 15; Sulphur 16

**P V**

1. Bowen and Millikan: PR **24,** 209 (1924). Wave-lengths. Extension of doublet laws.
2. Hartree: PCPS **22,** 409 (1924). Identification of lines. Term values.
3. Hartree: PRS **106,** 552 (1924). Term excess. Quantum defect.
4. Millikan and Bowen: PR **23,** 1 (1924). Wave-lengths.
5. Bowen and Millikan: PR **25,** 295 (1925). Series.
6. Fues: AP **76,** 299 (1925). Calculation of terms.
7. Unsöld: ZP **33,** 843 (1925). On the screening doublets of the Bowen-Millikan ultraviolet spectra.
8. Unsöld: ZP **36,** 92 (1926). Polarizability. Calculation of quantum defect.
9. Gibbs and White: PR **33,** 157 (1929). Doublets of stripped atoms.

## Sulphur 16

**S I**

1. Foote and Mohler: BSP No. **400,** Vol. 16, 669 (1920); PR **15,** 321 (1920). (A) Ionization and resonance potentials.
2. de Gramont: CR **171,** 1106 (1920). Ultimate lines.
3. de Gramont: CN **122,** 58 (1921). Ultimate lines.
4. Hopfield: N **112,** 437 and 790 (1923). New triplets.
5. Hopfield: PR **22,** 523 (1923). (A) Series.
6. Birge: JOSA **8,** 233 (1924). Series of divalent elements.
7. Johnson: PRS **106,** 195 (1924). Effect of argon on sulfur spectrum.
8. Landé: ZP **25,** 46 (1924). Absolute intervals of doublets and triplets. Doublet laws.
9. Millikan and Bowen: PR **23,** 1 (1924). Wave-lengths.
10. Shaver: TRSC **18,** 145 (1924). Spectrum of electrodeless discharge.
11. Turner: PM **48,** 384 (1924). Quantum defect.
12. Bungartz: AP **76,** 709 (1925). Series.
13. Holweck: CR **180,** 658 (1925). Spectral frequencies in the region between visible light and x-rays.
14. Hopfield: PR **26,** 282 (1925). (A) Series.
15. Russell: AJ **61,** 223 (1925). Ultimate and penultimate lines.
16. Hopfield and Dieke: PR **27,** 638 (1926). (A) *PP′* groups.
17. McLennan, McLay and McLeod: PM **4,** 486 (1927). Series.
18. Lacroute: JPR **9,** 180 (1928). Wave-lengths.
19. McLennan, Ruedy and Howlett: TRSC **22,** 79 (1928). Influence of argon on the *S* spectrum.
20. McLennan and Crawford: N **124,** 874 (1929). Low terms.
21. Bartlett, Jr.: PR **37,** 327 (1931). Nuclear spin.

**S II**

1. Bloch and Bloch: CR **185,** 761 (1927). Wave-lengths.
2. Gilles: CR **186,** 1109 and 1354 (1928). Series.
3. Lacroute: JPR **9,** 180 (1928). Wave-lengths.
4. Ingram: PR **32,** 172 (1928). Series.
5. Lacroute: CR **187,** 975 (1928). Series.
6. Bhattacharyya: PRS **122,** 416 (1929). Series.
7. Bloch and Bloch: AsP **12,** 1 (1929); CR **188,** 160 (1929). Series.
8. Bowen: N **123,** 450 (1929). Origin of nebular lines.
9. Gilles: CR **188,** 1158 (1929). *3d* orbit in S II.
10. Gilles: AsP **15,** 267 (1931). Series and Zeeman effect.
11. Gilles: BSFP No. **305** (1931). Quantitative energy relations.

**S III**

1. Bloch and Bloch: CR **185,** 761 (1927). Wave-lengths.
2. Bowen: PR **31,** 34 (1928). Series.

## SULPHUR 16; CHLORINE 17

3. Saha and Kichlu: IJP **2,** 319 (1928). Identification of a multiplet.
4. Bloch and Bloch: AsP **12,** 1 (1929). Wave-lengths.
5. Gilles: CR **188,** 63 and 320 (1929). Series.
6. Gilles: CR **188,** 1158 (1929). *3d* orbit in S III.
7. Ingram: PR **33,** 907 (1929). Series.
8. Gilles: AsP **15,** 267 (1931). Series.
9. Gilles: BFSP No. 305 (1931). Quantitative energy relations.

**S IV**

1. Bowen and Millikan: PR **26,** 150 (1925). *PP′* groups.
2. Millikan and Bowen: PR **25,** 600 (1925). Series.
3. Hartree: PCPS **23,** 304 (1926). Quantum defect.
4. Bowen: PR **31,** 34 (1928). Series.
5. Gilles: AsP **15,** 267 (1931). Series and Zeeman effect.

**S V**

1. Bowen and Millikan: PR **25,** 591 (1925). Series.
2. Bowen and Millikan: PR **26,** 150 (1925). *PP′* groups.

**S VI**

1. Bowen and Millikan: PR **24,** 209 (1924). Wave-lengths. Extension of doublet laws.
2. Hartree: PCPS **22,** 409 (1924). Identification of lines. Term values.
3. Hartree: PRS **106,** 552 (1924). Term excess. Quantum defect.
4. Bowen and Millikan: PR **25,** 295 (1925). Series.
5. Fues: AP **76,** 299 (1925). Calculation of terms.
6. Unsöld: ZP **33,** 843 (1925). On the screening doublets of the Bowen-Millikan ultraviolet spectra.
7. Unsöld: ZP **36,** 92 (1926). Polarizability. Calculation of quantum defect.
8. Gibbs and White: PR **33,** 157 (1929). Doublets of stripped atoms.

## CHLORINE 17

**Cl I**

1. de Gramont: CR **171,** 1106 (1920). Ultimate lines.
2. Kimura and Fukuda: MKCS **4,** 159 (1920). Zeeman effect.
3. Dobbie and Fox: PRS **99,** 456 (1921). Absorption spectrum.
4. de Gramont: CN **122,** 58 (1921). Ultimate lines.
5. Jevons: PRS **103,** 193 (1923). Wave-lengths.
6. Nagaoka and Sugiura: JJP **2,** 167 (1923). Spectroscopic evidence of isotopy.
7. Narayan and Gunnayya: PM **45,** 827 (1923). Emission and absorption spectra.
8. Paschen: AP **71,** 537 (1923). Series.
9. Angerer: ZwP **22,** 200 (1924). Wave-lengths.
10. Lunt: RAS **85,** 148 (1924). Temperature displacements.
11. Millikan and Bowen: PR **23,** 1 (1924). Wave-lengths.
12. Nagaoka and Sugiura: N **113,** 532 (1924). Spectroscopic evidence of isotopes.
13. Holweck: CR **180,** 658 (1925). Spectral frequencies in the region between visible light and x-rays.
14. Hopfield: PR **26,** 282 (1925). (A) Series.
15. Asagoe: MKCS **10,** 15 (1926). Large displacements of certain lines.
16. de Bruin: ZP **39,** 869 (1926). Series.
17. Carragan: AJ **63,** 145 (1926). Zeeman effect.
18. Jenkins: N **117,** 893 (1926). Line spectra of isotopes.
19. Swindler: PR **28,** 1136 (1926). Effect of potential and frequency on spectra.
20. Turner: PR **27,** 397 (1926). Wave-lengths and frequency differences.
21. Bloch and Bloch: AsP **8,** 397 (1927). Wave-lengths.
22. de Bruin: PKAA **30,** 20 (1927). Regularities in Cl I.

## Chlorine 17

23. Jenkins: PR **29,** 50 (1927). Spectra of isotopes.
24. Laporte: PR **29,** 650 (1927). Screening constants from optical data.
25. Bloch and Bloch: AsP **9,** 554 (1928). Wave-lengths.
26. Kiess and de Bruin: S **68,** 356 (1928). Series.
27. Laporte: N **121,** 1021 (1928). Series.
28. Asagoe: IPCR No. **206,** 243 (1929). Stark effect.
29. Asagoe: MKCS **12,** 275 (1929). Classification of lines according to degree of ionization.
30. Kiess and de Bruin: BSJ **2,** 1117 (1929). Series.
31. Majumdar: N **123,** 131 (1929); PRS **125,** 60 (1929). Series.
32. Majumdar: IJP **4,** 359 (1930). Prediction of certain terms.

**Cl II**

1. Paschen: AP **71,** 537 (1923). Some triplets of Cl II.
2. Hopfield: PR **23,** 766 (1924). (A) Wave-lengths.
3. Bloch and Bloch: CR **180,** 1740 (1925). Wave-lengths.
4. Bowen and Millikan: PR **26,** 150 (1925). *PP'* groups.
5. Hopfield: PR **26,** 282 (1925). Series and multiplets.
6. Hopfield and Dieke: PR **27,** 638 (1926). (A) *PP'* groups.
7. Bloch and Bloch: AsP **8,** 397 (1927). Wave-lengths.
8. Vaudet: CR **185,** 1270 (1927). Wave-lengths.
9. Bloch and Bloch: AsP **9,** 554 (1928). Wave-lengths.
10. Bowen: PR **31,** 34 (1928). Series.
11. Asagoe: MKCS **12,** 275 (1929). Classification of lines according to degree of ionization.
12. Néel: JPR **10,** 263 (1929). Zeeman effect.
13. Murakawa: IPCR **15,** 41 and 105 (1930). Series.
14. Murakawa: IPCR **15,** 105 (1931); ZP **69,** 507 (1931). Series.

**Cl III**

1. Bloch and Bloch: CR **180,** 1740 (1925). Wave-lengths.
2. Bloch and Bloch: AsP **8,** 397 (1927). Wave-lengths.
3. Bloch and Bloch: AsP **9,** 554 (1928). Wave-lengths.
4. Bowen: PR **31,** 34 (1928). Series.
5. Majumdar and Deb: IJP **3,** 445 (1928). Series.
6. Asagoe: MKCS **12,** 275 (1929). Classification of lines according to degree of ionziation.
7. Gilles: CR **188,** 1158 (1929). $3d$ orbit in Cl III.
8. Murakawa: IPCR **15,** 105 (1931). Series.

**Cl IV**

1. Bowen: PR **31,** 34 (1928). Series.
2. Deb: N **124,** 513 (1929). Series.

**Cl V**

1. Bowen and Millikan: PR **26,** 150 (1925). *PP'* groups.
2. Millikan and Bowen: PR **25,** 600 (1925). Series.
3. Bowen: PR **31,** 34 (1928). Series.

**Cl VI**

1. Bowen and Millikan: PR **25,** 591 (1925). Series.
2. Bowen and Millikan: PR **26,** 150 (1925). *PP'* groups.

**Cl VII**

1. Bowen and Millikan: PR **25,** 295 (1925). Series.
2. Fues: AP **76,** 299 (1925). Calculation of terms. Displacement law.
3. Unsöld: ZP **33,** 843 (1925). On the screening doublets of the Bowen-Millikan ultraviolet spectra.

## Chlorine 17; Argon 18

4. Bowen and Millikan: PR **27,** 144 (1926). Ionization potential.
5. Gibbs and White: PR **33,** 157 (1929). Doublets of stripped atoms.

## Argon 18

A I

1. Böttcher and Tuczek: AP **61,** 107 (1920). Stark effect.
2. Found: PR **16,** 41 (1920). Ionization potential.
3. de Gramont: CR **171,** 1106 (1920). Ultimate lines.
4. Hicks: PTRS **220,** 335 (1920). Series.
5. Horton and Davies: PRS **97,** 1 (1920). Critical and ionization potentials.
6. Merrill: AJ **51,** 236 (1920). Air lines in spark spectra.
7. Nissen: PZ **21,** 25 (1920). Series.
8. Stead and Gossling: PM **40,** 413 (1920). Relative ionization potentials.
9. Dejardin: CR **172,** 1347 and 1482 (1921); Excitation by impacts of slow electrons.
10. Franck: PZ **22,** 466 (1921). Excitation by electron impact.
11. de Gramont: CN **122,** 58 (1921). Ultimate lines.
12. Meggers: BSP Vol. 17, No. **414,** 193 (1921); PR **18,** 160 (1921). Interferometer measurements of wave-length. Constant frequency differences.
13. Meggers: JOSA **5,** 308 (1921). Standard wave-lengths. A review.
14. Merrill, Hopper and Keith: AJ **54,** 76 (1921). Identification of air lines in spark spectra.
15. Seeliger: ZP **5,** 182 (1921); ZP **7,** 93 (1921). Radiation from glow discharge.
16. Seeliger and Mierdel: ZP **5,** 182 (1921). Excitation by electron impact.
17. Seeliger and Schramm: ZP **7,** 93 (1921). Excitation by electron impact.
18. Dik and Zeeman: PKAA **25,** 67 (1922). A relation between K II and A I.
19. Horton and Davies: PRS **102,** 131 (1922). Excitation by electron impact.
20. Seeliger: AP **67,** 352 (1922). Radiation from glow discharge.
21. Shaver: TRSC **16,** 135 (1922). Arc, spark and absorption spectra.
22. Steubing: PZ **23,** 427 (1922). Stark effect.
23. Dejardin: CR **176,** 894 (1923). Resonance and ionization potentials.
24. Hertz: PKAA **25,** 179 and 442 (1923); ZP **18,** 307 (1923). Excitation and ionization potentials.
25. Hicks: PM **45,** 480 (1923). Series.
26. Nagaoka and Sugiura: JJP **2,** 167 (1923). Spectroscopic evidence of isotopy.
27. Zeeman and Dik: AP **71,** 199 (1923). Similarity of K II and A I.
28. Bloch, Bloch and Dejardin: AsP **2,** 461 (1924); CR **178,** 766 (1924). Wave-lengths.
29. Dejardin: AsP **2,** 241 (1924); CR **178,** 1069 (1924). Excitation by electron impacts.
30. Lowe and Rose: TRSC **18,** 313 (1924). Intensities.
31. Nagaoka and Sugiura: N **113,** 532 (1924). Spectroscopic evidence of isotopes.
32. Turner: PM **48,** 1010 (1924). Quantum defect.
33. Hertz and Kloppers: ZP **31,** 463 (1925). Excitation and ionization potentials.
34. Herzfeld and Wolf: AP **76,** 71 and 567 (1925). A test of the classical dispersion formula. The number of dispersion electrons.
35. Lyman and Saunders: N **116,** 358 (1925). Extreme ultraviolet spectrum.
36. Ruark and Chenault: PM **50,** 937 (1925). Fine structure.
37. Hertz and Abbink: Nw **14,** 648 (1926). Resonance lines.
38. Hicks: AsP **6,** 294 (1926). Structure of rare gas spectra.
39. Kahanowicz: AAL **4,** 285 (1926). Pickering spectrum in argon.
40. Meissner: ZP **37,** 238 (1926). Ground term; comparison with Ne I.
41. Meissner: ZP **39,** 172 (1926). Series.
42. Mohler: PR **28,** 46 (1926). Photoionization in gases.
43. Saunders: PNAS **12,** 556 (1926). Series.
44. Dorgelo and Abbink: ZP **41,** 753 (1927); P **7,** 343 (1927). Wave-lengths. Excitation potentials.

## Argon 18

45. Dorgelo and Washington: PKAA **30,** 33 (1927). Duration of metastable states.
46. Goudsmit and Back: ZP **40,** 530 (1927). Vector coupling.
47. Grotrian: ZP **40,** 10 (1927). The *M* doublet of argon.
48. Laporte: PR **29,** 650 (1927). Screening constants from optical data.
49. McLennan and McLay: TRSC **21,** 63 (1927). Series.
50. Meissner: ZP **40,** 839 (1927). Series.
51. Meissner: ZP **43,** 449 (1927). Resonance radiation.
52. Meissner and Graffunder: AP **84,** 1009 and 1041 (1927). Life of excited states.
53. Paschen: SAWB **29,** 207 (1927). Light excitation through the metastable condition of the rare gas atom.
54. Saunders: PNAS **13,** 596 (1927). Series.
55. Gremmer: ZP **50,** 716 (1928). Series.
56. Williams: PPS **40,** 312 (1928); UNLP No. **82,** 253 (1928). Series.
57. Schulze: ZP **56,** 378 (1929). Excitation by electron impact.
58. Anderson: CJR **2,** 13 (1930). Duration of metastable states.
59. Bakker: N **126,** 955 (1930); Nw **18,** 1100 (1930). Electron coupling in the rare gases.
60. Beeck: AP **6,** 1001 (1930). Ionization by alkali ions.
61. Laporte and Inglis: PR **35,** 1337 (1930). Resonance separations for $p^5s$ configuration.
62. Rasmussen: Nw **18,** 1112 (1930). Bergmann series in A I.
63. Rosenthal: AP **4,** 49 (1930). Series.
64. Anderson: CJR **4,** 312 (1931). Duration of metastable states.
65. van Atta: PR **38,** 876 (1931). Excitation probabilities for electrons in argon.
66. Fischer and Hanle: ZwP **30,** 141 (1931). Photographic measurement of excitation functions.
67. Rasmussen and Swenson: N **128,** 188 (1931). Intensity anomalies.
68. Sutton and Mouzon: PR **37,** 379 (1931). Ionization by alkali ions.
69. Womer: PR **38,** 454 (1931). Ionization by electron impact.

**A II**

1. Seeliger and Schramm: ZP **7,** 93 (1921). Excitation by electron impact.
2. Bloch, Bloch and Dejardin: AsP **2,** 461 (1924); CR **178,** 766 (1924). Wave-lengths.
3. Barton: PR **25,** 469 (1925). Ionization by electron impact.
4. Mohler: PR **28,** 46 (1926). Photoionization. Critical potentials.
5. Mohler: S **63,** 405 (1926). Excitation potentials.
6. Dorgelo and Abbink: ZP **41,** 753 (1927). Ultraviolet series.
7. Bakker: PKAA **31,** 1041 (1928). Anomalous *g* values.
8. Bakker, de Bruin and Zeeman: PKAA **31,** 780 (1928); ZP **51,** 114 (1928); Zeeman effect.
9. de Bruin: N **121,** 576 (1928); Nw **16,** 238 (1928); PKAA **31,** 593 and 771 (1928); ZP **48,** 62 (1928); ZP **51,** 108 (1928). Series spectrum and Zeeman effect.
10. Compton, Boyce and Russell: PR **32,** 179 (1928). Ultraviolet spectrum excited by controlled electron impact.
11. Russell, Compton and Boyce: PR **31,** 709 (1928). New lines. Ionization potential.
12. Bakker, de Bruin and Zeeman: ZP **52,** 299 (1928). Zeeman effect.
13. Schulze: ZP **56,** 378 (1929). Excitation of the red and blue spectra by electron collisions.
14. Bakker and de Bruin: ZP **62,** 32 (1930). Zeeman effect.
14a. de Bruin: PKAA **33,** 198 (1930); ZP **61,** 307 (1930). Series.
15. Rosenthal: AP **4,** 49 (1930). Wave-lengths and analysis.
16. Bakker: ANSE **13,** 121 (1931). Zeeman effect and anomalous coupling.
17. Fischer and Hanle: ZwP **30,** 141 (1931). Photographic measurement of excitation functions.
18. Pretty: PPS **43,** 279 (1931). Displacement of certain lines of A II.

**A III**

1. Seeliger and Schramm: ZP **7,** 93 (1921). Excitation by electron impact.

## Argon 18; Potassium 19

2. Bloch, Bloch and Dejardin: AsP **2**, 461 (1924); CR **178**, 766 (1924). Wave-lengths.
3. Barton: PR **25**, 469 (1925). Ionization by electron impact.
4. Hopfield and Dieke: PR **27**, 638 (1926). (A) *PP′* groups.
5. Dorgelo and Abbink: ZP **41**, 753 (1927). Extreme ultraviolet spectrum.
6. Boyce and Compton: PNAS **15**, 656 (1929). Extreme ultraviolet spectrum.
7. Majumdar: IJP **4**, 359 (1930). Prediction of certain terms.
8. Deb and Dutt: ZP **67**, 138 (1931). Extension of series.

**A IV**

1. Seeliger and Schramm: ZP **7**, 93 (1921). Excitation by electron impact.
2. Bloch, Bloch and Dejardin: AsP **2**, 461 (1924); CR **178**, 766 (1924). Wave-lengths.
3. Boyce and Compton: PNAS **15**, 656 (1929). Series.
4. Jog: N **124**, 303 (1929). Series.

**A V**

1. Compton and Boyce: S **69**, 528 (1929). Excitation of A V.

## Potassium 19

**K I**

1. Campetti: AAL **29**, 385 (1920). Excitation potentials.
2. Fues: AP **63**, 1 (1920). Selection rules. Displacement law. Calculation of constants in Ritz formula, and of series limits.
3. Gouy: AsP **13**, 188 (1920). Intensity measurements.
4. de Gramont: CR **171**, 1106 (1920). Ultimate lines.
5. Datta: PRS **99**, 69 (1921). Vacuum arc spectrum.
6. de Gramont: CN **122**, 58 (1921). Ultimate lines.
7. Ladenburg: ZP **4**, 451 (1921). Quantum mechanical interpretation of the number of dispersion electrons.
8. Moore: AJ **54**, 191 (1921). Excitation stages in the open arc.
9. Ramsauer and Wolf: AP **66**, 373 (1921). Duration of emission in quenched arc.
10. Rogestwensky: N **107**, 203 (1921). Doublets in spectral series.
11. Rogestwensky: VOIL 2, No. **13** (1921). Intensity ratios.
12. Seeliger and Thaer: AP **65**, 423 (1921). Displacement law. Study of excitation energies.
13. Becker: ZP **9**, 332 (1922). Stark effect.
14. Datta: PRS **101**, 539 (1922). Absorption spectrum.
15. Foote, Meggers and Mohler: PM **43**, 659 (1922). $1s-3d$ transition.
16. King: AJ **55**, 380 (1922). Furnace absorption spectra.
17. Robertson: PR **19**, 470 (1922). Spectrum of electrodeless discharge.
18. Rogestwensky: JRPC **50**, 11 (1922). Intensity ratios.
19. Dorgelo: ZP **13**, 206 (1923). Intensity ratios.
20. Hartree: PCPS **21**, 625 (1923). Calculation of terms.
21. Narayan and Gunnayya: AJ **57**, 191 (1923). Absorption at high temperatures.
22. Narayan and Gunnayya: PM **45**, 831 (1923). Absorption spectrum.
23. Newman: PM **45**, 181 and 293 (1923). Visibility of spectra.
24. Nissen: AJ **57**, 185 (1923). Series.
25. Runge: Nw **11**, 433 (1923). Remarks on frequency difference of doublet lines.
26. Turner: AJ **58**, 176 (1923). Relation between spectra and sizes of the alkali atoms.
27. van Urk: ZP **13**, 268 (1923). Normal orbits of the series electrons of the alkalies.
28. Bartels: ZP **20**, 398 (1923). Intensity distribution, term sequence and excitation functions for alkali spectra.
29. Dorgelo: ZP **22**, 170 (1924). Intensities.
30. Hund: ZP **22**, 405 (1924). Rydberg correction and radius of the atom core.
31. Jones and Boyce: PRS **106**, 773 (1924). Constants of the Rydberg-Ritz equation. Quantum defect.

## Potassium 19

32. Landé: ZP **25**, 46 (1924). The absolute intervals of optical doublets. Doublet laws.
33. Lindsay: MIT **3**, 191 (1924). Electronic orbits in the alkali metals.
34. Millikan and Bowen: PR **23**, 1 (1924). Wave-lengths.
35. Narayan and Gunnayya: PR **23**, 46 (1924). Absorption spectrum.
36. Narayan and Subrahmanyan: IACS **9**, 15 (1924). Absorption of electrically luminescent vapour.
37. Rasetti: NC **1**, 115 (1924). Anomalous dispersion in alkali vapours.
38. Shaver: TRSC **18**, 23 (1924). Extreme ultraviolet wave-lengths.
39. Sugiura: JJP **3**, 155 (1924). Calculation of doublet frequency differences.
40. Turner: PM **48**, 384 (1924). Quantum defect.
41. de Wisniewski: CR **179**, 1316 (1924). A formula expressing alkali doublet separation.
42. Mohler: BSP **505**, 167 (1925). Critical potentials.
43. Newman: PM **50**, 796 (1925). Low voltage spectrum.
44. Russell: AJ **61**, 223 (1925). Ultimate and penultimate lines.
45. Schrödinger: AP **77**, 43 (1925). Hydrogen-like spectra and polarizability of the atom core.
46. Sugiura: IPCR **3**, 1 (1925). Calculation of doublet separations.
47. Sur and Ghosh: PM **49**, 60 (1925). Absorption at high temperatures.
48. Tartakowsky: ZP **34**, 216 (1925). Diamagnetism and anomalous Zeeman effect.
49. von Wisniewski: PZ **26**, 255 (1925). Calculation of *s*-terms.
50. Bleeker: TFS **21**, 479 (1926); ZPC **120**, 63 (1926). Intensity measurements.
51. de Bruin: PKAA **29**, 711 (1926). Electrodeless discharge in K vapour.
52. Gibbs and White: PNAS **12**, 448 and 598 (1926). Doublets of stripped atoms.
53. Mohler: PR **28**, 46 (1926). Photoionization in gases.
54. Sowerby and Barratt: PRS **110**, 190 (1926). Absorption spectrum.
55. Taylor: PR **28**, 576 (1926). Magnetic moment.
56. Unsöld: ZP **36**, 92 (1926). Polarizability. Calculation of quantum defect.
57. Filippov: ZP **42**, 495 (1927). Intensities.
58. Grotrian and Ramsauer: PZ **28**, 846 (1927). Inverse Stark effect.
59. Leu: ZP **41**, 551 (1927). Magnetic moment.
60. Mohler: PR **29**, 419 (1927). Excitation by atomic hydrogen.
61. Prokofjew: PM **3**, 1010 (1927). Ratio of the numbers of resonating electrons for the potassium doublets.
62. Prokofjew and Gamow: ZP **44**, 887 (1927). Anomalous dispersion. Transition probabilities.
63. Rasetti: AAL **6**, 54 (1927). Intensity of a forbidden transition.
64. Rasetti: AAL **6**, 503 (1927). Principal series.
65. Russell: AJ **66**, 184 (1927). Related lines in the spectra of the iron group. Homologous terms.
66. Russell: AJ **66**, 233 (1927). Series and potentials for iron group.
67. Shrum, Carter and Fowler: PM **3**, 27 (1927). $1s-md$ series.
68. Jakob: AP **86**, 449 (1928). Intensity ratios of the principal series.
69. Kupper: AP **86**, 511 (1928). Comparison of experimental and theoretical intensities.
70. Mohler: PR **31**, 187 (1928). Recombination spectra.
71. Okubo and Hamada: PM **5**, 372 (1928). Excitation by active nitrogen.
72. Ramdas: IJP **3**, 31 (1928). Spectrum of potassium excited by combination with chlorine.
73. Sambursky: ZP **49**, 731 (1928). Intensity ratios for principal series doublets.
74. Taylor: PM **5**, 166 (1928). Intensities of forbidden multiplets.
75. Weiler: ZP **50**, 436 (1928). Intensity measurements.
76. Ferchmin and Frisch: ZP **53**, 326 (1929). Fine structure of $D$ terms.
77. Gibbs and White: PR **33**, 157 (1929). Doublets of stripped atoms.
78. Loyarte and Grinfeld: UNLP **89**, 103 (1929). Quantized rotation of the potassium atom.
79. Lundegardhi: AKMG **10**, No. 1 (1929). Quantitative analysis by flame spectrum.
80. Okubo and Hamada: PM **7**, 729 (1929). Excitation by active nitrogen.
81. Prokofjew: ZP **57**, 387 (1929). Probability of forbidden transitions.

## POTASSIUM 19

82. Schüler and Brück: ZP **58,** 735 (1929). Hyperfine structure and nuclear moment.
83. Weiler: AP **1,** 361 (1929). Intensity measurements.
84. Deslandres: CR **191,** 7 (1930). Properties of abnormal series.
85. Deslandres: CR **191,** 169 (1930). Ultimate rays.
86. Fermi: ZP **59,** 680 (1930). Intensity ratios of the alkali doublets. Effect of perturbations.
87. Funk: AP **4,** 149 (1930). Ionization by slow electrons.
88. Kuhn: ZP **61,** 805 (1930). Effect of electric field on limit of series lines in absorption.
89. Sambursky: ZP **61,** 660 (1930). Fermi intensity formula for the principal series doublets.
90. Segré: N **126,** 882 (1930). Evidence for quadripole radiation.
91. Segré: ZP **66,** 827 (1930). Zeeman effect of quadrupole lines.
92. Stevenson: PRS **128,** 591 (1930). Intensity of quadrupole radiation.
93. Ekefors: ZP **71,** 53 (1931). Vacuum spark spectra in the region 100 to 1100A.
94. Kronig and Frisch: PZ **32,** 457 (1931). Nuclear moments. A review. Bibliography.
95. Loomis and Wood: PR **38,** 854 (1931). Nuclear spin of potassium.
96. Lucas: ZAC **195,** 321 (1931). Relative intensities of principal and subordinate series.
97. Segré and Bakker: Nw **19,** 738 (1931); ZP **72,** 724 (1931). Zeeman effect of quadrupole radiation.
98. Whitelaw and Stevenson: N **127,** 817 (1931). Intensity of forbidden transitions.

### K II

1. McLennan: PRS **100,** 182 (1921). Wave-lengths.
2. Seeliger and Thaer: AP **65,** 423 (1921). Displacement law. Study of excitation energies.
3. Dik and Zeeman: PKAA **25,** 67 (1922). A relation between K II and A I. Wave-lengths.
4. Foote, Meggers and Mohler: AJ **55,** 145 (1922). Excitation of enhanced spectra in a low voltage arc.
5. Dik and Zeeman: PKAA **26,** 498 (1923). Wave-lengths.
6. Nissen: AJ **57,** 185 (1923). Series.
7. Zeeman and Dik: AP **71,** 199 (1923). Relation of K II and A I spectra.
8. Dahmen: ZP **29,** 264 (1924). Series.
9. Dahmen: VDPG **6,** 19 (1925). Series.
10. Dik: ANSE **9,** 29 (1925). Excitation in electrodeless discharge.
11. Mohler: BSP No. **505,** 167 (1925). Critical potentials.
12. de Bruin: PKAA **29,** 713 (1926); ZP **38,** 94 (1926). Series.
13. Dahmen: ZP **35,** 528 (1926). Series.
14. Mohler: PR **28,** 46 (1926). Photoionization in gases.
15. Newman: PM **1,** 721 (1926). Enhanced lines produced in the interrupted arc.
16. Newman: PM **2,** 1042 (1926). Flash arc spectrum.
17. Rudy: JFI **202,** 659 (1926). Regularities in K II.
18. Bowen: PR **31,** 497 (1928). Series.
19. de Bruin: ANSE **11,** 70 (1928). Series. Zeeman effect.
20. Majumdar and Toshniwal: N **121,** 828 (1928). Prediction of new levels.
21. Schüler and Brück: ZP **58,** 735 (1929). Hyperfine structure.
22. Laporte and Inglis: PR **35,** 1337 (1930). Resonance separations for $p^5s$ configuration.
23. Ekefors: ZP **71,** 53 (1931). Vacuum spark spectra in the region 100 to 1100A.

### K III

1. Bowen: PR **31,** 497 (1928). Series.
2. de Bruin: S **69,** 47 (1929); ZP **53,** 658 (1929). Series.
3. Majumdar: IJP **4,** 359 (1930). Prediction of certain terms.
4. Ekefors: ZP **71,** 53 (1931). Vacuum spark spectra in the region 100 to 1100A.

### K IV

1. Hopfield and Dieke: PR **27,** 638 (1926). (A) *PP'* groups.
2. Bowen: PR **31,** 497 (1928). Series.

## CALCIUM 20

**Ca I**

1. Fues: AP **63,** 1 (1920). Selection rules. Displacement law. Calculation of constants in Ritz formula, and of series limits.
2. Gouy: AsP **13,** 188 (1920). Intensity measurements.
3. de Gramont: CR **171,** 1106 (1920). Ultimate lines.
4. King: AJ **51,** 13 and 179 (1920). Furnace spectra, in the infrared.
5. McLennan, Young and Ireton: PRS **98,** 95 (1920). Arc spectra in vacuo and spark spectra in He.
6. Mohler, Foote and Meggers. BSP No. 403, Vol. **16,** 725 (1920); JOSA **4,** 364 (1920). Resonance potentials and low voltage arcs.
7. Mohler, Foote and Stimson. BSP No. 368, Vol. **15,** 723 (1920); PM **40,** 73 (1920). Ionization and resonance potentials.
8. Polvani: NC **20,** 119 (1920). Time variations in the spectrum of an electric discharge.
9. Saunders: AJ **52,** 265 (1920). Revision of series.
10. Chrisler: AJ **54,** 273 (1921). The low current arc.
11. Datta: PRS **99,** 436 (1921). Spectra of alkaline earth flourides.
12. Franck: PZ **22,** 409 (1921). Excitation by electron impact.
13. Gale and Miller: PR **17,** 428 (1921). (A). Pressure shift in arc.
14. Götze: AP **66,** 285 (1921). Line groups and inner quanta.
15. de Gramont: CN **122,** 58 (1921). Ultimate lines.
16. McCauley: PR **17,** 430 (1921). (A). Wave-lengths.
17. Miller: AJ **53,** 224 (1921). Pressure shifts.
18. Moore: AJ **54,** 191 (1921). Excitation stages in the open arc.
19. Paschen and Back: P **1,** 261 (1921). Zeeman effect.
20. Ramsauer and Wolf: AP **66,** 373 (1921). Duration of emission in quenched arc.
21. Seeliger and Thaer: AP **65,** 423 (1921). Displacement law. Study of excitation potentials.
22. Stern: ZP **7,** 249 (1921). Space quantization in a magnetic field.
23. Bloch and Bloch: CR **174,** 1456 (1922); JPR **3,** 309 (1922). Under-water spark spectrum.
24. Campetti and Corsi: NC **24,** 117 (1922). Spectra of sparks in the middle of a flame.
25. Carter: AJ **55,** 162 (1922). Vacuum spark spectra.
26. Foote and Mohler: JOSA **6,** 54 (1922). Meaning of 1/2 terms in spectral series formula.
27. King: AJ **55,** 380 (1922). Furnace absorption spectra.
28. Saunders: AJ **56,** 73 (1922). Series.
29. Kimura and Nakamura: JJP **2,** 61 (1923). Line broadening and the Stark effect.
30. Moore: AJ **58,** 86 (1923). Excitation stages in the open arc.
31. Nagaoka and Sugiura: JJP **2,** 167 (1923). Spectroscopic evidence of isotopy.
32. St. Procopiu: CR **176,** 385 (1923). Spectra from arcs on immersion in various media.
33. Saunders and Russell: PR **22,** 201 (1923). (A) Series.
34. Sawyer and Becker: AJ **57,** 98 (1923). Explosion spectrum.
35. Wentzel: PZ **24,** 104 (1923). Two-electron transitions.
36. Birge: JOSA **8,** 233 (1924). Series of divalent elements.
37. Dorgelo: P **4,** 281 (1924); ZP **22,** 170 (1924). Intensities.
38. Green and Petersen: AJ **60,** 301 (1924). Double excitation spectra. Primed terms.
39. Harris: AJ **59,** 261 (1924). Pole effects and pressure shifts.
40. Kimura and Nakamura: JJP **3,** 29 (1924). Cathode spectra of metals.
41. Landé: ZP **25,** 46 (1924). Absolute intervals of optical triplets. Doublet laws.
42. Landé: ZP **27,** 149 (1924). Primed and displaced terms.
43. Lang : PTRS **224,** 371 (1924). Wave-lengths.
44. Millikan and Bowen: PR **23,** 1 (1924). Wave-lengths.
45. Nagaoka and Sugiura: N **113,** 532 (1924). Stark effect.
46. St. Procopiu: AsP **1,** 89 (1924). Study of arc spectrum in various media and in vacuo.
47. St. Procopiu: JPR **5,** 220 (1924). Line width at various pressures.
48. Sugiura: JJP **3,** 155 (1924). Calculation of triplet frequency differences.
49. Takamine: N **114,** 433 (1924). Stark effect in fundamental series.

## Calcium 20

50. Turner: PM **48,** 384 (1924), Quantum defect.
51. Wentzel: PZ **25,** 182 (1924). Two-electron transitions.
52. Back: ZP **33,** 579 (1925). Anomalous Zeeman effect.
53. Dorgelo: P **5,** 27 (1925); or ZP **31,** 827 (1925). Intensities.
54. Frerichs: ZP **31,** 305 (1925). Intensities.
55. Kapitza and Skinner: PRS **109,** 224 (1925). Zeeman effect in strong fields.
56. King: AJ **62,** 238 (1925). Spectra in the high current arc.
57. Kronig: ZP **31,** 885 (1925). Intensity of multiplet lines and their Zeeman components.
58. Laporte and Wentzel: ZP **31,** 335 (1925). Primed and displaced terms. Interpretation of P′, $D'$ terms of Ca I.
59. Ruark and Chenault: PM **50,** 937 (1925). Fine structure.
60. Russell: AJ **61,** 223 (1925). Ultimate and penultimate lines.
61. Russell and Saunders: AJ **61,** 38 (1925). Summary of normal series relationships. Regularities in alkaline earth spectra.
62. Sandvik and Spence: AJ **62,** 265 (1925). New lines in infrared.
63. Schrödinger: AP **77,** 43 (1925). Hydrogen-like spectra and polarizability of the atom core.
64. Sugiura: IPCR **3,** 1 (1925). Calculation of triplet separations.
65. Wentzel: ZP **34,** 730 (1925). Interpretation of alkaline earth spectra.
66. von Wisniewski: PZ **26,** 255 (1925). Calculation of $s$-terms.
67. Frerichs: AP **81,** 807 (1926). Intensity measurements.
68. Hori: IPCR No. **53,** 59 (1926). Explosion spectra.
69. Lang: AJ **64,** 167 (1926). New terms.
70. Laporte: ZP **39,** 123 (1926). Ground terms of spectra of first and second long periods.
71. Rayleigh: PRS **112,** 14 (1926). Spectroscopic studies on the luminous vapour distilled from metallic arcs.
72. Unsöld: ZP **36,** 92 (1926). Polarizability. Calculation of quantum defect.
73. Fukuda: IPCR No. **85,** 1 (1927). Explosion spectra. Broadening and reversal of lines.
74. Gibbs and White: PR **29,** 426 (1927). Multiplets in two electron systems.
75. Kerschbaum: AP **83,** 287 (1927). Duration of luminosity.
76. Kichlu and Saha: PM **4,** 193 (1927). Spectra of metals of group II.
77. Ornstein and Burger: ZP **40,** 403 (1927). Intensities.
78. Russell: AJ **66,** 184 (1927). Related lines in the spectra of the iron group. Homologous terms. Remarks on spectral structure.
79. Russell: AJ **66,** 233 (1927). Series and potentials for iron group.
80. Saha: PM **3,** 1265 (1927). Spectra of group II metals. Theoretical.
81. Walters and Barratt: PM **3,** 991 (1927). Absorption spectrum.
82. Gentile: AAL **7,** 910 (1928). Primed terms of calcium.
83. Kiess: BSJ **1,** 75 (1928). Interferometer measurements of wave-lengths.
84. Locher: JOSA **17,** 91 (1928). Time intervals between the appearance of spectral lines.
85. Okubo and Hamada: PM **5,** 372 (1928). Excitation by active nitrogen.
86. Prokofjew: ZP **50,** 701 (1928). Transition probabilities. Anomalous dispersion.
87. White: PR **33,** 538 (1929). Ca I-like isoelectronic sequence.
88. Bleeker: ZP **63,** 760 (1930). Relation between the intensity of the resonance line and the intercombination line of Ca.
89. Deslandres: CR **190,** 1250 (1930). Properties of abnormal series.
90. Deslandres: CR **191,** 169 (1930). Ultimate rays.
91. Querbach: ZP **60,** 109 (1930). Infrared spectrum.
92. Bender: PR **38,** 588 (1931). (A). Asymmetric Zeeman patterns at intermediate strengths of field.
93. Ekefors: ZP **71,** 53 (1931). Vacuum spark spectra in the region 100 to 1100A.
94. White: PR **38,** 1786 and 2016 (1931). Auto-ionization.

**Ca II**

1. Fues: AP **63,** 1 (1920). Calculation of constants in Ritz formula, and of series limits.

## CALCIUM 20


2. Paschen and Back: P **1,** 261 (1921). Zeeman effect.
3. Sawyer and Becker: PR **18,** 164 (1921). (A); S **54,** 305 (1921). Exploded wire spectrum.
4. Seeliger and Thaer: AP **65,** 423 (1921). Arc and spark spectra of the alkaline earths. Study of excitation potentials.
5. Hartree: PCPS **21,** 625 (1923). Calculation of terms.
6. Sawyer and Becker: AJ **57,** 98 (1923). Explosion spectra.
7. Turner: AJ **58,** 176 (1923). Relation between spectra and sizes of atoms.
8. Anderson: AJ **59,** 76 (1924). Wave-lengths.
9. Dorgelo: P **4,** 281 (1924). Intensity of triplet components.
10. Hund: ZP **22,** 405 (1924). Rydberg correction and radius of the atom core.
11. Jones and Boyce: PRS **106,** 773 (1924). Constants of the Rydberg-Ritz equation. Quantum defect.
12. Landé: ZP **25,** 46 (1924). Absolute intervals of optical doublets. Doublet laws.
13. Lang: PTRS **224,** 371 (1924). Wave-lengths.
14. Turner: PM **48,** 384 (1924). Quantum defect.
15. Dorgelo: P **5,** 27 (1925); or ZP **31,** 827 (1925). Intensities in ultraviolet.
16. Kapitza and Skinner: PRS **109,** 224 (1925). Zeeman effect in strong fields.
17. Russell: AJ **61,** 223 (1925). Ultimate and penultimate lines.
18. Sandvik and Spence: AJ **62,** 265 (1925). New lines in infrared.
19. Saunders and Russell: AJ **62,** 1 (1925). Series.
20. von Wisniewski: PZ **26,** 255 (1925). Calculation of *s*-terms.
21. Gibbs and White: PNAS **12,** 448 and 598 (1926). Doublets of stripped atoms.
22. Grotrian: Nw **14,** 144 (1926). Zeeman effect in strong fields.
23. Lang: AJ **64,** 167 (1926). New terms.
24. Rayleigh: PRS **112,** 14 (1926). Spectroscopic studies on the luminous vapour distilled from metallic arcs.
25. Russell: AJ **66,** 233 (1927). Series and potentials for iron group.
26. Kerschbaum: AP **83,** 287 (1927). Duration of emission.
27. Russell: AJ **66,** 184 (1927). Related lines in the spectra of the iron group. Homologous terms.
28. Gibbs and White: PR **33,** 157 (1929). Doublets of stripped atoms.
29. White: PR **33,** 538 (1929). K I like isoelectronic sequence.
30. Zwaan: ANSE **12,** 1 (1929). Intensities.
31. Zwaan: Nw **17,** 121 (1929). Transition probabilities.
32. Ekefors: ZP **71,** 53 (1931). Vacuum spark spectra in the region 100 to 1100A.
33. Frisch: ZP **68,** 758 (1931). Hyperfine structure.
34. Kronig and Frisch: PZ **32,** 457 (1931). Nuclear moments. A review. Bibliography.


**Ca III**


1. Bowen: PR **31,** 497 (1928). Series.
2. Majumdar and Toshniwal: N **121,** 828 (1928). Prediction of new levels.
3. Laporte and Inglis: PR **35,** 1337 (1930). Resonance separations for $p^5s$ configuration.
4. Majumdar: IJP **4,** 359 (1930). Prediction of certain terms.
5. Ekefors: ZP **71,** 53 (1931). Vacuum spark spectra in the region 100 to 1100A.


**Ca IV**


1. Bowen: PR **31,** 497 (1928). Series.
2. Ekefors: ZP **71,** 53 (1931). Vacuum spark spectra in the region 100 to 1100A.


**Ca V**


1. Bowen: PR **31,** 497 (1928). Series.
2. Ekefors: ZP **71,** 53 (1931). Vacuum spark spectra in the region 100 to 1100A.

# Scandium 21

## Sc I

1. de Gramont: CR **171,** 1106 (1920). Ultimate lines.
2. de Gramont: CN **122,** 58 (1921). Ultimate lines.
3. King: AJ **54,** 28 (1921); CN **123,** 179 (1921). (A). Furnace spectrum.
4. Catalan: AFQ **20,** 606 (1922). Series.
5. Catalan: AFQ **21,** 464 (1923). A system of quartets.
6. Catalan: AFQ **20,** 497 (1924). Series.
7. Gieseler and Grotrian: ZP **25,** 342 (1924). Absorption spectrum.
8. Goudsmit: Nw **12,** 743 (1924). Zeeman effect.
9. Goudsmit and Zeeman: N **114,** 432 (1924). Zeeman effect.
10. Ireton: TRSC **18,** 103 (1924). Extreme ultraviolet wave-lengths.
11. Meggers: JWAS **14,** 419 (1924). Series.
12. de Rubies: AFQ **22,** 49 (1924). Wave-lengths.
13. Goudsmit, van der Mark and Zeeman: PKAA **28,** 127 (1925). Zeeman effect.
14. de Rubies: CR **181,** 108 (1925). Series.
15. Russell: AJ **61,** 223 (1925). Ultimate and penultimate lines.
16. Laporte: ZP **39,** 123 (1926). Ground terms of spectra of first and second long periods
17. McLennan and Liggett: TRSC **20,** 377 (1926). Wave-lengths and intensities.
18. de Rubies: AFQ **24,** 41 (1926). Wave-lengths.
19. Gibbs and White: PR **29,** 655 (1927). Multiplets in 3-electron systems.
20. Meggers: BSP No. 549, Vol. **22,** 61 (1927). Wave-lengths.
21. Russell: AJ **66,** 184 (1927). Related lines in the spectra of the iron group.
22. Russell: AJ **66,** 233 (1927). Series and potentials for iron group.
23. Russell and Meggers: BSP No. 558 Vol. **22,** 329 (1927). Series.
24. White: PR **33,** 672 (1929). Sc I like isoelectronic sequence.

## Sc II

1. King: AJ **54,** 28 (1921). Electric furnace spectrum.
2. Bohr: ZP **9,** 46 (1922). Normal state of Sc II.
3. Catalan: AFQ **20,** 606 (1922). Series.
4. Catalan: AFQ **20,** 497 (1924). Series.
5. Ireton: TRSC **18,** 103 (1924). An extension of scandium spectra.
6. Meggers: JWAS **14,** 419 (1924). Series.
7. Meggers, Kiess and Walters: JOSA **9,** 355 (1924). Displacement law. Various multiplets
8. Goudsmit, van der Mark and Zeeman: PKAA **28,** 127 (1925). Zeeman effect.
9. Hund: ZP **33,** 350 (1925). Term scheme of Sc II.
10. Russell: AJ **61,** 223 (1925). Ultimate and penultimate lines.
11. Wentzel: ZP **34,** 730 (1925). Interpretation of alkaline earth spectra.
12. Gibbs and White: PR **29,** 426 (1927). Multiplets in two electron systems.
13. Kichlu and Saha: PM **4,** 193 (1927). Spectra of metals of group II.
14. Russell: AJ **66,** 184 (1927). Related lines in the spectra of the iron group.
15. Russell: AJ **66,** 233 (1927). Series and potentials for iron group.
16. Russell and Meggers: BSP No. 558, Vol. **22,** 329 (1927). Series.
17. White: PR **33,** 538 (1929). Ca I-like isoelectronic sequence.

## Sc III

1. Jones and Boyce: PRS **106,** 773 (1924). Constants of the Rydberg-Ritz equation. Quantum defect.
2. Gibbs and White: PNAS **12,** 448 and 598 (1926). Doublets of stripped atoms.
3. Russell and Lang: AJ **66,** 13 (1927). Discussion of Sc III spectrum.
4. Smith: PNAS **13,** 65 (1927). Note on extension of series.
5. Gibbs and White: PR **33,** 157 (1929). Doublets of stripped atoms.
6. Majumdar: IJP **4,** 359 (1930). Prediction of certain lines.

## Scandium 21; Titanium 22

**Sc IV**

1. Majumdar and Toshniwal: N **121,** 828 (1928). Application of the irregular doublet law.

## Titanium 22

**Ti I**

1. de Gramont: CR **171,** 1106 (1920). Ultimate lines.
2. Hemsalech: PM **39,** 241 (1920). Excitation by thermoelectric currents. Furnace spectrum.
3. Kiess and Meggers: BSP **16,** No. 372, 51 (1920). Wave-lengths in red and infrared.
4. de Gramont: CN **122,** 58 (1921). Ultimate lines.
5. Brown: AJ **56,** 53 (1922). Interferometer measurements of wave-length.
6. Carter: AJ **55,** 162 (1922). Vacuum spark spectra.
7. Kiess and Kiess: JWAS **13,** 270 (1923). Series.
8. Catalan: N **114,** 192 (1924). Relation between pressure shift, temperature class, and spectral terms.
9. Crew: AJ **60,** 108 (1924). Wave-lengths from vacuum arc.
10. Gieseler and Grotrian: Nw **12,** 438 (1924). Normal state of vanadium.
11. Gieseler and Grotrian: ZP **25,** 342 (1924). Absorption spectrum.
12. Kiess and Kiess: JOSA **8,** 607 (1924). Series.
13. King: AJ **59,** 155 (1924). Electric furnace spectrum.
14. Lang: PTRS **224,** 371 (1924). Ultraviolet wave-lengths.
15. Behner: ZwP **23,** 325 (1925). Wave-lengths.
16. King: AJ **62,** 238 (1925). Spectra in the high current arc.
17. Russell: AJ **61,** 223 (1925). Ultimate and penultimate lines.
18. Frerichs: AP **81,** 807 (1926). Intensity measurements.
19. Laporte: ZP **39,** 123 (1926). Ground terms of spectra of first and second long periods.
20. Russell: AJ **66,** 184 (1927). Related lines in the spectra of the iron group. Homologous terms.
21. Russell: AJ **66,** 233 (1927). Series and potentials of the iron group.
22. Babcock: AJ **67,** 256 (1928). Pressure effect for Ti terms.
23. Harrison: JOSA **17,** 389 (1928). Intensity measurements.
24. Kiess: BSJ **1,** 75 (1928). Interferometer measurements of wave-lengths.
25. Harrison: JOSA **19,** 109 (1929); PR **33,** 271 (1929). (A). Intensity relations.
26. Harrison and Engwicht: JOSA **18,** 287 (1929); Intensity relations.
27. White: PR **33,** 914 (1929). Ti I like isoelectronic sequence.
28. Harrison and Johnson, Jr.: PR **38,** 773 (1931). Intensities in complex spectra.
29. Heisenberg: AP **10,** 888 (1931). Pauli's exclusion principle.
30. King: PR **38,** 590 (1931). Spectra of high current vacuum arcs.

**Ti II**

1. Meggers, Kiess and Walters: JOSA **9,** 355 (1924). Displacement law. Various multiplets.
2. Sur: N **114,** 611 (1924). Series.
3. Russell: AJ **61,** 223 (1925). Ultimate and penultimate lines.
4. Gibbs and White: PR **29,** 655 (1927). Multiplets in 3-electron systems.
5. Russell: AJ **66,** 184 (1927). Related lines in the spectra of the iron group. Homologous terms.
6. Russell: AJ **66,** 233 (1927). Series and potentials for iron group.
7. Russell: AJ **66,** 283 (1927). Series. Zeeman effect.
8. Harrison: JOSA **17,** 389 (1928). Intensity measurements.
9. White: PR **33,** 672 (1929). Sc I like isoelectronic sequence.

**Ti III**

1. Gibbs and White: PR **29,** 426 (1927). Multiplets in two-electron systems.
2. Russell and Lang: AJ **66,** 13 (1927). Series.
3. White: PR **33,** 538 (1929). Ca I like isoelectronic sequence.

## TITANIUM 22; VANADIUM 23

### Ti IV


1. Jones and Boyce: PRS **106,** 773 (1924). Constants of the Rydberg-Ritz equation. Quantum defect.
2. Gibbs and White: PNAS **12,** 448 and 598 (1926). Doublets of stripped atoms.
3. Russell and Lang: AJ **66,** 13 (1927). Series.
4. Majumdar and Toshniwal: N **121,** 828 (1928). Prediction of new levels.
5. Gibbs and White: PR **33,** 157 (1929). Doublets of stripped atoms.
6. Ekefors: ZP **71,** 53 (1931). Wave-lengths.


## VANADIUM 23

### V I


1. de Gramont: CR **171,** 1106 (1920). Ultimate lines.
2. Hemsalech: PM **39,** 241 (1920). Excitation by thermoelectric currents. Furnace spectrum.
3. Kiess and Meggers: BSP No. 372, Vol. **16,** 51 (1920). Wave-lengths in red and infrared.
4. King: AJ **51,** 107 (1920). Zeeman effect for furnace spectra.
5. de Gramont: CN **122,** 58 (1921). Ultimate lines.
6. Laporte: Nw **11,** 779 (1923); PZ **24,** 510 (1923). Series.
7. Meggers: JWAS **13,** 317 (1923). Series.
8. Catalan: AFQ **22,** 72 (1924). A method of determining the relative values of terms and and its application to V I.
9. Gieseler and Grotrian: Nw **12,** 438 (1924). Normal state of Ti atom.
10. Gieseler and Grotrian: ZP **25,** 342 (1924). Absorption spectrum.
11. King: AJ **60,** 282 (1924). Electric furnace spectrum.
12. Lang: PTRS **224,** 371 (1924). Ultraviolet wave-lengths.
13. Meggers: JWAS **14,** 151 (1924). Multiplets and Zeeman effect.
14. Meggers, Kiess and Walters, Jr.: JOSA **9,** 355 (1924). Multiplet structure.
15. Nagaoka and Sugiura: JJP **3,** 45 (1924). Stark effect.
16. Bechert and Sommer: ZP **31,** 145 (1925). Multiplet structure and Zeeman effect.
17. Russell: AJ **61,** 223 (1925). Ultimate and penultimate lines.
18. Frerichs: AP **81,** 807 (1926). Intensity measurements.
19. Laporte: ZP **39,** 123 (1926). Ground terms of spectra of first and second long periods.
20. Freed: JACS **49,** 2456 (1927). Magnetic moment.
21. Russell: AJ **66,** 184 (1927). Related lines in the spectra of the iron group. Homologous terms.
22. Russell: AJ **66,** 233 (1927). New terms.
23. Russell: AJ **66,** 347 (1927). Series.
24. Kiess: BSJ **1,** 75 (1928). Interferometer measurements of wave-lengths.
25. Gilroy: PR **37,** 1704 (1931) (A); PR **38,** 2217 (1931). V I-like isoelectronic sequence. New lines and term values.
26. Harrison: PR **38,** 1921 (1931) (A). Quantitative intensities.


### V II


1. Lang: PTRS **224,** 371 (1924). Wave-lengths.
2. Meggers, Kiess and Walters, Jr.: JOSA **9,** 355 (1924). Displacement law. Various multiplets.
3. Meggers: ZP **33,** 509 (1925). Multiplets. Zeeman effect.
4. Meggers: ZP **39,** 114 (1926). Multiplets.
5. Russell: AJ **66,** 184 (1927). Related lines in the spectra of the iron group. Homologous terms.
6. White: PR **33,** 914 (1929). Ti I-like isoelectronic sequence. New lines and energy levels.
7. Harrison: PR **38,** 1921 (1931). Quantitative intensities.

## VANADIUM 23; CHROMIUM 24

**V III**

1. Gibbs and White: PR **29,** 655 (1927). Multiplets in 3-electron systems.
2. White: PR **33,** 672 (1929). Sc I-like isoelectronic sequence. New lines and energy levels.

**V IV**

1. Gibbs and White: PR **29,** 426 (1927). Multiplets in two-electron systems.
2. White: PR **33,** 538 (1929). Ca I-like isoelectronic sequence. New lines and levels.

**V V**

1. Gibbs and White: PNAS **12,** 448 and 598 (1926). Doublets of stripped atoms.
2. Gibbs and White: PR **33,** 157 (1929). Doublets of stripped atoms. New wave-lengths.
3. Ekefors: ZP **71,** 53 (1931). Wave-lengths.

## CHROMIUM 24

**Cr I**

1. de Gramont: Cr **171,** 1106 (1920). Ultimate lines.
2. Kiess and Meggers: BSP No. 372, Vol. **16,** 51 (1920). Wave-lengths.
3. de Gramont: CN **122,** 58 (1921). Ultimate lines.
4. Catalan: PTRS **223,** 127 (1922). Series.
5. Gieseler: AP **69,** 147 (1922). Series relationships and Zeeman effect.
6. de Gramont: CR **175,** 1025 (1922). "Raies Ultimes" and spectral series.
7. Kiess and Kiess: S **56,** 666 (1922). Series.
8. Kiess and Knudson: S **51,** 666 (1922). Series.
9. Babcock: AJ **58,** 149 (1923). Zeeman effect.
10. Catalan: AFQ **21,** 84 (1923); CR **176,** 84, 247 and 1063 (1923). Series.
11. de Gramont: CR **176,** 216 (1923). Series.
12. Kimura and Nakamura: JJP **2,** 61 (1923). Line broadening and the Stark effect.
13. McLay: TRSC **17,** 137 (1923). Ultraviolet spectrum.
14. Sommerfeld: AP **70,** 32 (1923). Interpretation of series by use of inner quantum numbers.
15. Sommerfeld: PZ **24,** 360 (1923). Spectroscopic magneton numbers.
16. Wentzel: PZ **24,** 104 (1923). Two-electron transitions.
17. Gieseler: ZP **22,** 228 (1924). Series and Zeeman effect.
18. Gieseler and Grotrian: Nw **12,** 438 (1924). Normal state of Cr I.
19. Gieseler and Crotrian: ZP **22,** 245 (1924). Absorption spectrum.
20. Hulburt: PR **24,** 129 (1924). Absorption in under-water spark.
21. King: AJ **60,** 282 (1924). Electric furnace spectra.
22. Landé: ZP **27,** 149 (1924). Primed and displaced terms.
23. Lang: PTRS **224,** 371 (1924). Wave-lengths.
24. Millikan and Bowen: PR **23,** 1 (1924). Wave-lengths.
25. Nagaoka and Sugiura: JJP **3,** 45 (1924). Stark effect.
26. Bloch and Bloch: JPR **6,** 105 and 154 (1925). Wave-lengths in Schumann region.
27. Frerichs: ZP **31,** 305 (1925). Intensity measurements.
28. van Geel: ZP **33,** 836 (1925). Intensities of Zeeman components.
29. Kiess: JOSA **10,** 287 (1925) (A). Series.
30. Kronig: ZP **31,** 885 (1925). Intensity of multiplet lines and their Zeeman components.
31. McLennan and McLay: TRSC **19,** 89 (1925). Absorption spectrum.
32. Ruark and Chenault: PM **50,** 937 (1925). Fine structure.
33. Russell: AJ **61,** 223 (1925). Ultimate and penultimate lines.
34. Frerichs: AP **81,** 807 (1926). Intensity measurements.
35. Kiess and Laporte: S **63,** 234 (1926). A displaced series in Cr.
36. Laporte: ZP **39,** 123 (1926). Ground terms of spectra of first and second long periods.
37. Zumstein: PR **27,** 562 (1926). Absorption spectrum.
38. Russell: AJ **66,** 184 (1927). Related lines in the spectra of the iron group. Homologous terms.

## Chromium 24; Manganese 25

39. Russell: AJ **66**, 233 (1927). Series and potentials of the iron group.
40. Smith and Muskat: PR **29**, 663 (1927). Absorption spectrum.
41. Foster: AJ **67**, 16 (1928). Wave-lengths.
42. Kiess: BSJ **1**, 75 (1928). Interferometer measurements of wave-lengths.
43. Deslandres: CR **191**, 7 (1930). Properties of abnormal series.
44. Hesthal: PR **35**, 126 (1930). (A) Intensity relations.
45. Kiess: BSJ **5**, 775 (1930). Series.
46. Catalan and Sancho: AFQ **29**, 327 (1931). Series. Ionization potential.
47. Schuler and Keyston: ZP **68**, 174 (1931). Isotope abundance ratio and nuclear moment.

**Cr II**

1. Wentzel: PZ **24**, 104 (1923). Two-electron transitions.
2. Lang: PTRS **224**, 371 (1924). Wave-lengths.
3. Meggers, Kiess and Walters, Jr.: JOSA **9**, 355 (1924). Displacement law. Various multiplets.
4. Bloch and Bloch: JPR **6**, 154 (1925). Ultraviolet wave-lengths.
5. Kiess: JOSA **10**, 287 (1925). Series.
6. Kiess and Laporte: S **63**, 234 (1926). Displaced series in Cr II.
7. Laporte: JOSA **13**, 1 (1926). Interpretation of spectra. Vector model. Zeeman effect.
8. Laporte: ZP **39**, 123 (1926). Ground terms of spectra of first and second long periods.
9. Russell: AJ **66**, 184 (1927). Related lines in the spectra of the iron group.
10. Dunham and Moore: AJ **68**, 37 (1928). Predicted lines of Cr II in the sun and $\alpha$ Persei.
11. Krömer: ZP **52**, 531 (1928). Series and Zeeman effect.
12. Catalan: AFQ **28**, 611 (1930). Series.
13. Hesthal: PR **35**, 126 (1930). (A). Intensity relations.
14. Kiess: BSJ **5**, 775 (1930). Series.
15. Gilroy: PR **37**, 1704 (1931) (A); PR **38**, 2217 (1931). New lines and term values.

**Cr III**

1. Gibbs and White: PNAS **13**, 525 (1927); PR **29**, 917 (1927). (A). New multiplets.
2. White: PR **33**, 914 (1929). Ti I like isoelectronic sequence. New lines and energy levels.

**Cr IV**

1. Gibbs and White: PR **29**, 655 (1927). Multiplets in 3-electron systems.
2. White: PR **33**, 672 (1929). Sc I like isoelectronic sequence. New lines and energy levels.

**Cr V**

1. Gibbs and White: PR **29**, 426 (1927). Multiplets in two-electron systems.
2. White: PR **33**, 538 (1929). Ca I like isoelectronic sequence. New lines and levels.

**Cr VI**

1. Gibbs and White: PNAS **12**, 675 (1926). Extension of doublet laws. New lines.
2. Gibbs and White: PR **33**, 157 (1929). Doublets of stripped atoms. New wave-lengths.

## Manganese 25

**Mn I**

1. de Gramont: CR **171**, 1106 (1920). Ultimate lines.
2. Hemsalech: PM **40**, 296 (1920). Character of lines emitted by vapours under selective action of thermochemical and thermoelectrical excitations.
3. Kiess and Meggers: BSP No. 372, Vol. **16**, 51 (1920). Wave-lengths in infrared.
4. Brendel-Wirminghaus: ZwP **20**, 229 (1921). Pole effect in Mn.
5. de Gramont: CN **122**, 58 (1921). Ultimate lines.
6. King: AJ **53**, 133 (1921). Electric furnace spectrum.
7. Brown: AJ **56**, 53 (1922). Interferometer measurements of wave-length.

## MANGANESE 25

8. Campetti and Corsi: NC **24,** 117 (1922). On the spectra of sparks in the middle of a flame.
9. Catalan: PTRS **223,** 127 (1922). Series.
10. Sommerfeld: VDPG **3,** 45 (1922). Line structure in the spectrum of Mn.
11. Back: ZP **15,** 206 (1923). Zeeman effect.
12. Grotrian: ZP **18,** 169 (1923). Absorption spectrum.
13. Monk: AJ **57,** 222 (1923); PR **21,** 215 (1923). (A) Pressure shift, pole effect and wave-lengths.
14. Sommerfeld: AP **70,** 32 (1923). Interpretation of series spectrum by use of inner quantum numbers.
15. Sommerfeld: PZ **24,** 360 (1923). Magneton numbers.
16. Wentzel: PZ **24,** 104 (1923). Two-electron transition.
17. Dorgelo: ZP **22,** 170 (1924). Multiplet intensities. Experimental.
18. Goudsmit: N 113, 238 (1924). Series.
19. Hicks: PM **48,** 321 (1924). Application of the oun to series grouping.
20. Landé: ZP **25,** 46 (1924). The absolute intervals of optical doublets and triplets. Doublet laws.
21. Lang: PTRS **224,** 371 (1924). Ultraviolet wave-lengths.
22. Nagaoka and Sugiura: JJP **3,** 45 (1924). Stark effect.
23. Back: PZ **26,** 833 (1925). Experimental basis of Zeeman effect.
24. van Geel: ZP **33,** 836 (1925). Intensities of Zeeman components.
25. McLennan and McLay: TRSC **19,** 89 (1925). Absorption spectrum.
26. Royds: PRS **107,** 360 (1925). Apparent tripling of certain lines in the arc.
27. Ruark and Chenault: PM **50,** 937 (1925). Fine structure.
28. Russell: AJ **61,** 223 (1925). Ultimate and penultimate lines.
29. Zumstein: PR **26,** 765 (1925). Absorption spectrum.
30. Frerichs: AP **81,** 807 (1926). Intensity measurements.
31. Laporte: ZP **39,** 123 (1926). Ground terms of spectra of first and second long periods.
32. McLennan, Cohen and Liggett: TRSC **20,** 365 (1926). Absorption spectrum.
33. McLennan and McLay: TRSC **20,** 89 (1926). Series.
34. Nagaoka and Futagami: PIAT **2,** 387 (1926). Exploded wire spectrum.
35. Sawyer: N **117,** 155 (1926). A metastable *P* term.
36. de Rubies: AFQ **25,** 494 (1927). Wave-lengths.
37. de Rubies and Dorronsoro: AFQ **25,** 211 and 374 (1927). Wave-lengths.
38. Russell: AJ **66,** 184 (1927). Related lines in the spectra of the iron group. Homologous terms.
39. Russell: AJ **66,** 233 (1927). Series and potentials for the iron group.
40. Smith and Muskat: PR **29,** 663 (1927). Absorption spectrum.
41. Catalan: AFQ **26,** 67 (1928). Series.
42. Kiess: BSJ **1,** 75 (1928). Interferometer measurements of wave-length.
43. Nagaoka and Fuagtami: PIAT **4,** 198 (1928). Exploded wire spectrum.
44. Loyarte and Williams: PZ **30,** 68 (1929). Absorption spectrum.
45. Fridrichson: ZP **64,** 43 (1930). Resonance radiation of Mn vapour.
46. Goudsmit: PR **35,** 440 (1930). Predictions of Mn hyperfine structure.
47. White: PR **35,** 441 (1930). Nuclear spin and hyperfine structure.
48. White: PR **36,** 1800 (1930). Relative intensities in hyperfine structure multiplets.
49. White and Ritschl: PR **35,** 1146 (1930). Hyperfine structure.
50. Fridrichson: BIAS **2,** 69 (1931). Fluorescence radiation in Mn vapour.
51. Fridrichson: ZP **68,** 550 (1931). Resonance radiation.
52. Goudsmit: PR **37,** 663 and 1014 (1931). (A) Theory of hyperfine structure separations.
53. Goudsmit and Fisher: PR **37,** 107 (1931). (A) Hyperfine structure patterns.
54. Kronig and Frisch: PZ **32,** 457 (1931). Nuclear moments. A review. Bibliography.
55. Seward. PR **37,** 344 (1931). Intensity measurements.
56. Williams. CR **193,** 358 (1931). Ultimate rays and absorption lines.

## MANGANESE 25; IRON 26

**Mn II**

1. Catalan. PTRS **223,** 127 (1922). Series.
2. Back. ZP **15,** 206 (1923). Zeeman effect.
3. Wentzel: PZ **24,** 104 (1923). Two-electron transitions.
4. Hicks: PM **48,** 321 (1924). Application of the oun to series grouping.
5. Lang: PTRS **224,** 371 (1924). Wave-lengths.
6. Meggers, Kiess and Walters, Jr.: JOSA **9,** 355 (1924). Displacement law. Various multiplets.
7. Bloch and Bloch: JPR **6,** 154 (1925). Ultraviolet wave-lengths.
8. Hartree: N **116,** 356 (1925). Ionization potential.
9. Laporte: ZP **39,** 123 (1926). Ground terms of spectra of first and second long periods.
10. Black and Duffendack: S **66,** 401 (1927). Mn II spectrum excited by rare gas ions.
11. Russell: AJ **66,** 184 (1927). Related lines in the spectra of the iron group. Homologous terms.
12. Russell: AJ **66,** 233 (1927). Series and potentials of iron group.
13. Duffendack and Black: PR **34,** 35 (1929). Spectrum of Mn II by means by a vacuum tungsten furnace.
14. Seward: PR **37,** 344 (1931). Intensity measurements.

**Mn III**

1. Gibbs and White: PNAS **13,** 525 (1927); PR **29,** 917 (1927). (A) New multiplets.
2. Gilroy: PR **37,** 1704 (1931) (A); PR **38,** 2217 (1931). New lines and term values.

**Mn IV**

1. White: PR **33,** 914 (1929). Ti I like isoelectronic sequence. New lines and energy levels.

**Mn V**

1. White: PR **33,** 672 (1929). Sc I like isoelectronic sequence. New lines and energy levels.

**Mn VII**

1. Gibbs and White: PNAS **12,** 675 (1926). Extension of doublet laws to Mn VII.

## IRON 26

**Fe I**

1. Anderson: AJ **51,** 37 (1920). Spectrum of electrically exploded wires.
2. de Gramont: CR **171,** 1106 (1920). Ultimate lines.
3. King: AJ **51,** 13 (1920). Furnace absorption spectra.
4. King: AJ **51,** 107 (1920). Preliminary observations of the Zeeman effect for electric furnace spectra.
5. King: AJ **52,** 187 (1920). Influence of potential difference on the radiation of the tube resistance furnace.
6. King: PNAS **6,** 65 (1920). Effect of a magnetic field on electric furnace spectra.
7. Millikan: AJ **52,** 47 (1920). Extension of the ultraviolet spectrum.
8. Bloch and Bloch: JPR **2,** 250 (1921). Ultraviolet wave-lengths.
9. Gehrcke: AP **65,** 640 (1921). Symmetrical line groups.
10. de Gramont: CN **122,** 58 (1921). Ultimate lines.
11. King: PR **18,** 335 (1921). Absorption spectrum.
12. Meggers: JOSA **5,** 308 (1921). Standard wave-lengths. A review.
13. Millikan, Bowen and Sawyer: AJ **53,** 150 (1921). Extreme ultraviolet spectrum.
14. Nagaoka: AJ **53,** 329 (1921). Measurement of pole effect. Relation of pole effect to Zeeman effect.
15. Nagaoka and Sugiura: N **111,** 431 (1921). Stark effect.
16. St. John and Babcock: AJ **53,** 260 (1921). Grating and interferometric measurements of wave-length.

## Iron 26


17. Annual report of the director of the Mt. Wilson Observatory, yearbook Carnegie Inst. **20,** 215 (1921).
18. Bloch and Bloch: JPR **3,** 309 (1922). Wave-lengths from under-water spark.
19. Brown: AJ **56,** 53 (1922). Interferometer measurements of wave-length.
20. Carter: AJ **55,** 162 (1922). Vacuum spark spectrum.
21. King: AJ **55,** 380 (1922). Electric furnace spectra involving ionization phenomena.
22. King: AJ **56,** 318 (1922). Electric furnace spectrum.
23. King: PNAS **8,** 123 (1922). Ionization and absorption effects in the electric furnace.
24. Merrill: AJ **56,** 475 (1922). Classification of arc lines by relative strengthening at the positive pole.
25. Muller: ZwP **22,** 1 (1922). Establishment of wave-length normals.
26. Nagaoka: JJP **1,** 18 (1922). (A) Pole effects.
27. Takahashi: JJP **1,** 5 (1922). (A) Zeeman effect.
28. Hagenbach & Schumacher: AP **71,** 19 (1923). Series.
29. Nagaoka and Mishima: AJ **57,** 92 (1923). Fine structure.
30. Nagaoka and Sugiura: JJP **2,** 1 (1923). Stark and Zeeman effect regularities.
31. Nagaoka and Sugiura: N **112,** 359 (1923). Series.
32. Walters, Jr.: JWAS **13,** 243 (1923). Series.
33. Angerer and Joos: AP **74,** 743 (1924). Absorption spectrum.
34. Angerer and Joos: Nw **12,** 140 (1924). Normal state of iron atom.
35. Babcock: PR **24,** 205 (1924). (A) Note on secondary standards.
36. Catalan: AFQ **22,** 398 (1924). Structure of the iron spectrum.
37. Catalan: N **113,** 889 (1924); N **114,** 192 (1924). Relation between pressure shift, temperature class, and spectral terms.
38. Gieseler and Grotrian: ZP **22,** 245 (1924). Absorption spectrum.
39. Gieseler and Grotrian: ZP **25,** 165 (1924). Multiplet structure.
40. Goudsmit: N **113,** 604 (1924). Series.
41. Goudsmit: P **4,** 64 (1924). Line groups in the iron spectrum.
42. Goudsmit: PKAA **27,** 572 (1924). Term names of some multiplets.
43. Grotrian: Nw **12,** 945 (1924). Interpretation of the iron spectrum.
44. Hulburt: PR **24,** 129 (1924). Absorption in under-water spark.
45. Laporte: ZP **23,** 135 (1924); ZP **26,** 1 (1924). Multiplet structure and Zeeman effect.
46. Meggers: AJ **60,** 60 (1924). Standard wave-lengths and regularities.
47. Meggers and Kiess: BSP No. 479, Vol. **19,** 273 (1924). Interferometer measurements in infrared.
48. Meggers, Kiess and Burns: BSP No. 478, Vol. **19,** 263 (1924). Redetermination of secondary standards.
49. Nagaoka and Sugiura: JJP **3,** 45 (1924). Stark effect.
50. Sommerfeld: P **4,** 115 (1924). Structure of the iron spectrum.
51. Wallerath: AP **75,** 37 (1924). Secondary wave-length standards.
52. Walters, Jr.: JOSA **8,** 245 (1924). Multiplet structure.
53. Beals: PRS **109,** 369 (1925). Zeeman effect.
54. Bloch and Bloch: JPR **6,** 105 and 154 (1925). Ultraviolet wave-lengths.
55. Gerlach: AP **76,** 163 (1925). Magnetic moments.
56. King: AJ **62,** 238 (1925). Spectra in the high current arc.
57. Lowery: PM **49,** 1176 (1925). Line broadening and the Stark effect.
58. McLennan and McLay: TRSC **19,** 89 (1925). Absorption spectrum.
59. van Milaan: ZP **34,** 921 (1925). Intensities.
60. Monk: AJ **62,** 375 (1925). Secondary standards of wave-length.
61. Ornstein and Burger: ZP **31,** 355 (1925). Intensities.
62. Russell: AJ **61,** 223 (1925). Ultimate and penultimate lines.
63. Bloch and Bloch: AsP **6,** 409 (1926). Wave-lengths.
64. Bloch and Bloch: PM **1,** 704 (1926). Spectrum of under-water spark.
65. Déchene: JPR **7,** 59 (1926). Exploded wire spectrum.

## Iron 26


66. Frerichs: AP **81**, 807 (1926). Intensities.
67. Hori: IPCR No. 48, Vol. **4**, 59 (1926); MKCS **9**, 379 (1926). Explosion spectrum.
68. Laporte: N **117**, 721 (1926). Fundamental level of the iron atom.
69. Laporte: PNAS **12**, 496 (1926). Series and ionization potentials.
70. Laporte: ZP **39**, 123 (1926). Ground terms of spectra of first and second long periods.
71. van Milaan: ZP **38**, 427 (1926). Intensities.
72. Nagaoka and Futagami: PIAT **2**, 387 (1926). Exploded wire spectrum.
73. Sur: N **117**, 380 (1926). Fundamental level of the iron atom.
74. Sur: PM **1**, 433 (1926). Absorption spectrum.
75. Babcock: AJ **66**, 256 (1927). Secondary standards.
76. Kleinewefers: ZP **42**, 211 (1927). New measurements of secondary standrads.
77. Meggers and Walters, Jr.: BSP No. 551, Vol. **22**, 205 (1927). Absorption spectrum.
78. Menzies: PRS **117**, 88 (1927). Shifts and reversals in fuse spectra.
79. Ornstein and Minnaert: ZP **43**, 404 (1927). Intensity distribution within spectral lines.
80. Polvani: NC **4**, 365 (1927). Doppler effect.
81. Russell: AJ **66**, 184 (1927). Related lines in the spectra of the iron group. Homologous terms.
82. Russell: AJ **66**, 233 (1927). Series and potentials for iron group.
83. Wolf: Nw **15**, 981 (1927). On the question of secondary normals.
84. Wolf: ZP **44**, 170 (1927). A new vacuum discharge and its application to excitation of the iron spectrum.
85. Babcock: AJ **67**, 240 (1928). Effect of pressure on the iron arc.
86. Kiess: BSJ **1**, 75 (1928). Interferometer measurements of wave-lengths.
87. Moore and Russell: AJ **68**, 151 (1928). Presence of predicted iron lines in the solar spectrum and the terms in the arc spectrum.
88. Nagaoka and Futagami: PIAT **4**, 198 (1928). Exploded wire spectrum.
89. Burns and Walters: PAO **6**, 159 (1929); PR **33**, 1098 (1929). (A) Wave-lengths and atomic levels in spectrum of vacuum arc.
90. Kahanowicz: AAL **9**, 761 (1929). A new series. The second Stark effect.
91. Maring: ZwP **26**, 47 (1929). Arc spectrum at reduced pressure.
92. St. John: AJ **70**, 312 (1929). The unit character of multiplets.
93. Babcock: PR **36**, 784 (1930). (A) Classification of iron lines.
94. Brodersen: ZP **60**, 43 (1930). Intensity distribution in arc spectra.
95. Catalan: AFQ **28**, 1239 (1930). Structure of the Fe spectrum.
96. Deslandres: CR **191**, 7 (1930). Properties of abnormal series.
97. Holmes: PR **35**, 652 (1930). Temperature shift and pole effect in vacuum arc.
98. McLennan and Quinlan: TRSC **24**, 47 (1930). Interferometer measurements in the infrared region.
99. Pressentin: ZP **60**, 125 (1930). Secondary normals.
100. Querbach: ZP **60**, 109 (1930). Wave-lengths in infrared.
101. Burns and Walters: PAO **8**, 39 (1931). Wave-lengths and atomic levels in spectrum of vacuum arc.
102. Jackson: PRS **130**, 395 (1931); PRS **133**, 553 (1931). Interferometric measurement of wave-length.
103. King: PR **38**, 590 (1931). (A) Spectra of high current vacuum arcs.
104. Setna: IJP **6**, 29 (1931). Infrared spectrum of under-water spark.


**Fe II**


1. Bloch and Bloch: CR **172**, 851 (1921); JPR **2**, 229 (1921). Ultraviolet wave-lengths.
2. Millikan, Bowen and Sawyer: AJ **53**, 150 (1921). Vacuum spark spectrum.
3. Nagaoka and Sugiura: JJP **2**, 1 (1923). Stark and Zeeman effect regularities.
4. Bloch and Bloch: CR **179**, 1396 (1924). Ultraviolet wave-lengths.
5. Meggers, Kiess and Walters, Jr.: JOSA **9**, 355 (1924). Displacement law. Various multiplets.

## Iron 26; Cobalt 27


6. Bloch and Bloch: JPR **6,** 105 (1925). Ultraviolet wave-lengths.
7. Catalan: MB page 15 (1925). Normal state. Multiplet structure.
8. Russell: AJ **61,** 223 (1925). Ultimate and penultimate lines.
9. Bloch and Bloch: AsP **6,** 409 (1926). Wave-lengths.
10. Narayan and Rao: PPS **38,** 354 (1926). Absorption and series spectra.
11. Russell: AJ **64,** 194 (1926). Multiplets.
12. Russell: AJ **66,** 184 (1927). Related lines in the spectra of the iron group. Homologous terms.
13. Merrill: AJ **67,** 391 and 405 (1928). Forbidden multiplets.
14. Clarkson: PM **7,** 98 (1929). Intensities of some multiplets in arc and chromosphere spectra.
15. Rubinowicz: ZP **65,** 662 (1930). Intensity and sum rules in normal quadrupole multiplets.

**Fe III**

1. Bloch and Bloch: AsP **6,** 409 (1926); CR **182,** 1018 (1926). Wave-lengths.

**Fe IV**

1. Gilroy: PR **37,** 1704 (1931) (A); PR **38,** 2217 (1931). V I-like isoelectronic sequence. New lines and term values.

**Fe V**

1. White: PR **33,** 914 (1929). Ti I-like isoelectronic sequence. New lines and energy levels.


## Cobalt 27


**Co I**

1. Dhein: ZwP **19,** 289 (1920). Wave-lengths.
2. de Gramont: CR **171,** 1106 (1920). Ultimate lines.
3. King: AJ **51,** 13 (1920). Furnace absorption spectrum.
4. King: AJ **51,** 179 (1920). Electric furnace spectrum.
5. Bloch and Bloch; CR **172,** 803 and 851 (1921); JPR **2,** 229 (1921). Ultraviolet wave-lengths.
6. de Gramont: CN **122,** 58 (1921). Ultimate lines.
7. Merrill: AJ **56,** 475 (1922). Classification of arc lines by relative strengthening at the positive pole.
8. Kimura and Nakamura. JJP **2,** 61 (1923). Line broadening and the Stark effect.
9. Angerer and Joos. AP **74,** 743 (1924). Absorption spectrum.
10. Hulburt: PR **24,** 129 (1924). Absorption in under-water spark.
11. Lang: PTRS **224,** 371 (1924). Ultraviolet wave-lengths.
12. Nagaoka and Sugiura: JJP **3,** 45 (1924). Stark effect.
13. Walters, Jr.: JWAS **14,** 407 (1924). Series.
14. Bloch and Bloch: JPR **6,** 105 (1925). Wave-lengths.
15. Buffam and Ireton: TRSC **19,** 113 (1925). Under-water spark spectrum.
16. Catalan and Bechert: ZP **32,** 336 (1925). Series.
17. McLennan and McLay: TRSC **19,** 89 (1925). Absorption spectrum.
18. Ruark and Chenault: PM **50,** 937 (1925). Fine structure.
19. Russell: AJ **61,** 223 (1925). Ultimate and penultimate lines.
20. Laporte: ZP **39,** 123 (1926). Ground terms of spectra of first and second long periods.
21. McLennan and Cooley: TRSC **20,** 349 (1926). Absorption spectrum.
22. Sur and Majumdar: PM **1,** 451 (1926). Absorption spectrum.
23. Meggers and Walters, Jr.: BSP No. 551, **22,** 205 (1927). Absorption spectrum.
24. Russell: AJ **66,** 184 (1927). Related lines in the spectra of the iron group. Homologous terms.
25. Russell: AJ **66,** 233 (1927). New terms.
26. Smith and Muskat: PR **29,** 663 (1927). Absorption spectrum.
27. Sur: PM **4,** 36 (1927). Origin of terms.

## COBALT 27; NICKEL 28


28. Catalan: ZP **47,** 89 (1928). Series.
29. Catalan: AFQ **27,** 832 (1929). Series.
30. Ornstein and Bouma: PR **36,** 679 (1930). Intensity measurements.
31. Vatter: ZP **73,** 260 (1931). Magnetic moment.


**Co II**


1. Bloch and Bloch: CR **172,** 851 (1921); JPR **2,** 229 (1921). Wave-lengths.
2. Lang: PTRS **224,** 371 (1924). Wave-lengths.
3. Bloch and Bloch: JPR **6,** 105 (1925). Wave-lengths.
4. Laporte: ZP **39,** 123 (1926). Ground terms of spectra of first and second long periods.
5. Russell: AJ **66,** 184 (1927). Related lines in the spectra of the iron group. Homologous terms.
6. Meggers: JWAS **18,** 325 (1928). Certain multiplets.
7. Findlay: PR **36,** 5 (1930). Series spectrum and Zeeman effect.


**Co V**


1. Gilroy: PR **37,** 1704 (1931) (A); PR **38,** 2217 (1931). V I isoelectronic sequence. New lines and term values.


## NICKEL 28

**Ni I**


1. Bloch and Bloch: CR **170,** 320 (1920). Wave-lengths.
2. de Gramont: CR **171,** 1106 (1920). Ultimate lines.
3. King: AJ **51,** 179 (1920). Furnace spectra in the infrared.
4. Millikan: AJ **52,** 47 (1920). Extension of the ultraviolet spectrum.
5. Bloch and Bloch: JPR **2,** 229 (1921). Ultraviolet wave-lengths.
6. de Gramont: CN **122,** 58 (1921). Ultimate lines.
7. Millikan, Bowen and Sawyer: AJ **53,** 150 (1921). Vacuum spark spectrum.
8. Merrill: AJ **56,** 475 (1922). Classification of arc lines by relative strengthening at the positive pole.
9. Kimura and Nakamura: JJP **2,** 61 (1923). Line broadening and the Stark effect.
10. Angerer and Joos: AP **74,** 743 (1924). Absorption spectrum.
11. Hulburt: PR **24,** 129 (1924). Absorption in under-water spark.
12. Nagaoka and Sugiura: JJP **3,** 45 (1924). Stark effect.
13. Beals: PRS **109,** 369 (1925). Zeeman effect.
14. Bechert: AP **77,** 537 (1925). Series.
15. Bechert and Sommer: AP **77,** 351 (1925). Series.
16. Bloch and Bloch: JPR **6,** 105 and 154 (1925). Wave-lengths.
17. Buffam and Ireton: TRSC **19,** 113 (1925). Under-water spark spectrum.
18. Gerlach: AP **76,** 163 (1925). Magnetic moments.
19. Holtsmark and Trumpy: ZP **31,** 803 (1925). Line broadening and the Stark effect.
20. Lowery: PM **49,** 1176 (1925). Line broadening and the Stark effect.
21. McLennan and McLay: TRSC **19,** 89 (1925). Absorption spectrum.
22. Walters, Jr.: JWAS **15,** 88 (1925). Series.
23. Barnes: AJ **63,** 127 (1926). Interferometer measurements of pressure-shift.
24. Déchêne: JPR **7,** 59 (1926). Exploded wire spectrum.
25. Laporte: ZP **39,** 123 (1926). Ground terms of spectra of first and second long periods.
26. McLennan, Cohen and Liggett: TRSC **20,** 365 (1926). Absorption spectrum.
27. McLennan and Cooley: TRSC **20,** 349 (1926). Absorption spectrum.
28. Majumdar: ZP **39,** 562 (1926). Absorption spectrum.
29. Narayan and Rao: PPS **38,** 354 (1926). Absorption and series spectrum.
30. Meggers and Walters, Jr.: BSP No. 551, Vol. **22,** 205 (1927). Absorption spectrum.
31. Russell: AJ **66,** 184 (1927). Related lines in the spectra of the iron group. Homologous terms.
32. Russell: AJ **66,** 233 (1927). Series and potentials for iron group.

## NICKEL 28; COPPER 29

33. Smith and Muskat: PR **29,** 663 (1927). Under-water spark absorption spectrum.
34. Kiess: BSJ **1,** 75 (1928). Interferometer measurements of wave-lengths.
35. Mack, Laporte and Lang: PR **31,** 748 (1928). Survey of Ni like spectra.
36. Menzies: PM **6,** 1210 (1928). Reversals in Ni I. Establishment of ground level.
37. Loyarte and Williams: PZ **30,** 634 (1929). Absorption spectrum.
38. Mack: PR **34,** 17 (1929). Vector coupling in Ni like spectra.
39. Russell: PR **34,** 821 (1929). Series.
40. Dekkers and Kruithof: ZP **66,** 491 (1930). Intensity measurements.
41. Laporte and Inglis: PR **35,** 1337 (1930). Resonance separations for $d^9s$ configuration.
42. Ornstein and Bouma: PR **36,** 679 (1930). Intensity measurements.
43. Heisenberg: AP **10,** 888 (1931). Pauli's exclusion principle.

**Ni II**

1. Bloch and Bloch: JPR **2,** 229 (1921). Wave-lengths.
2. Bloch and Bloch: JPR **6,** 105 (1925). Wave-lengths.
3. Laporte: ZP **39,** 123 (1926). Ground terms of spectra of first and second long periods.
4. Russell: AJ **66,** 184 (1927). Related lines in the spectra of the iron group. Homologous terms.
5. Russell: AJ **66,** 233 (1927). Series and potentials for iron group.
6. Shenstone: PR **30,** 255 (1927). Series and Zeeman effect.
7. Lang: PR **31,** 773 (1928). Lowest terms.
8. Lang: PR **33,** 547 (1929). Series.
9. Menzies: PRS **122,** 134 (1929). Ground terms.
10. Ornstein and Bouma: PR **36,** 679 (1930). Intensity measurements.

**Ni VI**

1. Gilroy: PR **37,** 1704 (1931) (A); PR **38,** 2217 (1931). V I isoelectronic sequence. New lines and term values.

## COPPER 29

**Cu I**

1. Fues: AP **63,** 1 (1920). Selection rules. Displacement law. Calculation of constants in Ritz formula, and of series limits.
2. de Gramont: CR **171,** 1106 (1920). Ultimate lines.
3. Hemsalech: PM **40,** 296 (1920). Character of lines emitted by vapours under selective action of thermochemical and thermoelectrical excitations.
4. Hicks: PM **39,** 457 (1920). Series.
5. McLennan, Young and Ireton: PRS **98,** 95 (1920). Arc spectra in vacuo and spark spectra in He.
6. Bloch and Bloch: JPR **2,** 229 (1921). Ultraviolet wave-lengths.
7. Dunstan and Wooten: AJ **54,** 65 (1921). A study of arc cathode spectra.
8. de Gramont: CN **122,** 58 (1921). Ultimate lines.
9. Moore: AJ **54,** 246 (1921). Stages of excitation in arc spectra.
10. Ramsauer and Wolf; AP **66,** 373 (1921). Duration of emission in quenched arc.
11. Bloch and Bloch: JPR **3,** 309 (1922). Wave-lengths from under-water spark.
12. Campetti and Corsi: NC **24,** 117 (1922). On the spectra of sparks in the middle of a flame.
13. Dauvillier: JPR **3,** 154 and 221 (1922). Analysis of the electronic structure of the elements.
14. Back: AP **70,** 333 (1923). Zeeman effect.
15. Grotrian: ZP **18,** 169 (1923). Absorption spectrum.
16. Kimura and Nakamura: JJP **2,** 61 (1923). Line broadening and the Stark effect.
17. Mitra: AsP **19,** 315 (1923). Ultraviolet standards.
18. Nagaoka and Sugiura: JJP **2,** 167 (1923). Spectroscopic evidence of isotopy.
19. St. Procopiu: CR **176,** 385 and 504 (1923). Spectra from arcs on immersion in different media.
20. Shenstone: N **112,** 100 (1923). Ionization potential.

## Copper 29

21. Gerlach and Cilliers: ZP **26,** 106 (1924). Magnetic moments.
22. Hulburt: PR **24,** 129 (1924). Absorption in under-water spark.
23. Hund: ZP **22,** 405 (1924). Rydberg correction and radius of the atom core.
24. Kimura and Nakamura: JJP **3,** 29 (1924). Cathode spectra of metals.
25. Landé: ZP **25,** 46 (1924). The absolute intervals of optical doublets. Doublet laws.
26. Lowery: PM **48,** 1122 (1924). Pole lines in the interrupted arc.
27. Millikan and Bowen: PR **23,** 1 (1924). Wave-lengths.
28. Nagaoka and Sugiura: JJP **3,** 45 (1924). Stark effect.
29. Nagaoka and Sugiura: N **113,** 532 (1924). Spectroscopic evidence of isotopes.
30. St. Procopiu: AsP **1,** 89 (1924). Study of arc spectrum in various media and in vacuo.
31. Simeon and Dreblow: N **114,** 751 (1924). Observations on the Cu arc.
32. Sugiura: JJP **3,** 155 (1924). Calculation of doublet frequency differences.
33. Turner: PM **48,** 384 (1924). Quantum defect.
34. Bloch and Bloch: JPR **6,** 105 and 154 (1925). Ultraviolet wave-lengths.
35. Buffam and Ireton: TRSC **19,** 113 (1925). Wave-lengths from underwater spark.
36. Gerlach: AP **76,** 163 (1925). Magnetic moments.
37. Holtsmark and Trumpy: ZP **31,** 803 (1925). Line broadening and the Stark effect.
38. Kichlu: IACS **9,** 137 (1925). Absorption spectrum.
39. King: AJ **62,** 238 (1925). Spectra in the high current arc.
40. Lowery: PM **49,** 1176 (1925). Line broadening and the Stark effect.
41. McLennan and McLay: TRSC **19,** 89 (1925). Absorption spectrum.
42. Ruark and Chenault: PM **50,** 937 (1925). Fine structure.
43. Russell: AJ **61,** 223 (1925). Ultimate and penultimate lines.
44. Shenstone: N **116,** 467 (1925); PM **49,** 951 (1925). Series.
45. Smith: AJ **61,** 186 (1925). Spectra of exploded wires.
46. Stücklen: ZP **34,** 562 (1925). Absorption spectrum.
47. Sugiura: IPCR Vol. 3, No. **28,** 1 (1925). Calculation of doublet separations.
48. Zumstein: PR **25,** 523 (1925). Absorption spectrum.
49. Beals: PRS **111,** 168 (1926). Series and Zeeman effect.
50. Bedreag: BB **10,** 95 (1926); CR **182,** 1209 and 1333 (1926). Series.
51. Déchêne: JPR **7,** 59 (1926). Exploded wire spectrum.
52. Hartree: PCPS **23,** 304 (1926). Quantum defect.
53. Hicks: PM **2,** 194 (1926). Series.
54. Hori: IPCR No. 48, Vol. **4,** 59 (1926); MKCS **9,** 379 (1926). Explosion spectrum.
55. Kichlu: ZP **39,** 572 (1926). Series.
56. Laporte: ZP **39,** 123 (1926). Ground terms of spectra of first and second long periods.
57. Nagaoka and Futagami: PIAT **2,** 153 (1926). Occurrence of harmonics in spectral series.
58. Nagaoka and Futagami: PIAT **2,** 387 (1926). Exploded wire spectrum.
59. Rayleigh: PRS **112,** 14 (1926). Studies on the luminescent vapour distilled from metallic arcs.
60. Shenstone: PR **27,** 511 (1926). (A) Series.
61. Shenstone: PR **28,** 449 (1926). Series and Zeeman effect.
62. Shenstone: S **63,** 641 (1926). Quartet and doublet terms.
63. Simeon and Dreblow: N **117,** 17 (1926). Principal series.
64. Sommer: ZP **39,** 711 (1926). Series and Zeeman effect.
65. Thibaud: CR **182,** 1141 (1926). Wave-lengths. Grazing incidence.
66. Wolfsohn: AP **80,** 415 (1926). Wave-lengths. Pressure shift.
67. Zumstein: PR **27,** 562 (1926). Absorption spectrum.
68. Fujioka and Nakamura: AJ **65,** 201 (1927); IPCR **7,** 263 (1927). Stark effect.
69. Fukuda: IPCR No. 85, Vol. **6,** 1 (1927). Explosion spectra. Broadening and reversal of lines.
70. Hicks: PM **4,** 1161 (1927). Series.
71. Kichlu: IJP **1,** 401 (1927). Series.
72. Laporte: PR **29,** 650 (1927). Screening constants from optical data.
73. Menzies: PRS **117,** 88 (1927). Shifts and reversals in fuse spectra.

## Copper 29


74. Nagaoka, Nukiyama and Futagami: PIAT **3,** 319 (1927). Explosion spectrum.
75. Russell: AJ **66,** 184 (1927). Related lines in the spectra of the iron group. Homologous terms.
76. Russell: AJ **66,** 233 (1927). Series and potentials for iron group.
77. Thibaud: JPR **8,** 13 (1927). Extreme ultraviolet wave-lengths at grazing incidence.
78. Kiess: BSJ **1,** 75 (1928). Interferometer measurements of wave-lengths.
79. Nagaoka and Futagami: PIAT **4,** 361 (1928). Time-lag in emission. Successive stages of excitation.
80. Nagaoka and Futagami: PIAT **4,** 198 (1928). Exploded wire spectrum.
81. Wahlin: PR **32,** 277 (1928). Critical potentials.
82. Duffendack and Black: PR **34,** 35 (1929). Furnace spectrum.
83. Lundeghardh: AKMG **10A,** No. 7 (1929). Quantitative analysis by flame spectra.
84. Shenstone: PR **34,** 1623 (1929). An unusual spectral series.
85. Burns and Walters, Jr.: PAO **8,** 27 (1930). Interferometer measurements of wave-length.
86. Chalklin: PM **10,** 711 (1930). Extreme ultraviolet series.
87. Green: PR **36,** 157 (1930). Zeeman effect.
88. Ornstein and Vermeulen: ZP **64,** 657 (1930); ZP **66,** 490 (1930). Intensity measurements.
89. Frisch: ZP **71,** 89 (1931). Hyperfine structure.
90. Green and Wulff: N **127,** 891 (1931). Hyperfine structure.
91. King: PR **38,** 590 (1931). (A) Spectra of high current vacuum arcs.
92. Kronig and Frisch. PZ **32,** 457 (1931). Nuclear moments. A review. Bibliography.
93. Loyarte and Williams: UNLP **5,** 392 (1931). Absorption spectrum.
94. Nottingham: ZP **68,** 824 (1931). Intensity measurements.
95. Ornstein and Vermeulen: ZP **70,** 564 (1931). Intensity measurements.
96. Ritschl: Nw **19,** 690 (1931). Hyperfine structure.
97. Sambursky: Nw **19,** 309 (1931). Anomalous structure of $4^2F$ terms.
98. Sambursky: ZP **68,** 774 (1931). Intensity ratio for multipole lines.
99. Setna: IJP **6,** 29 (1931). Infrared spectrum of under-water spark.
100. Shenstone: PR **37,** 1023 (1931). (A) Hyperfine structure.
101. Shenstone: PR **37,** 1701 (1931) (A). Auger effect.
102. Williams: CR **193,** 358 (1931). Ultimate rays and absorption lines.


**Cu II**


1. Bloch and Bloch: CR **171,** 909 (1920). Wave-lengths.
2. Bloch and Bloch: JPR **2,** 229 (1921). Wave-lengths.
3. Mitra: AsP **19,** 315 (1923). Ultraviolet standards.
4. Kimura & Nakamura: JJP **3,** 197 (1924). Wave-lengths.
5. Bloch and Bloch: JPR **6,** 154 (1925). Wave-lengths.
6. Russell: AJ **66,** 184 (1927). Related lines in the spectra of the iron group. Homologous terms.
7. Russell: AJ **66,** 233 (1927). Series and potentials for iron group.
8. Shenstone: PR **29,** 380 (1927). Series.
9. Lang: PR **31,** 773 (1928). Lowest terms.
10. Mack, Laporte and Lang: PR **31,** 748 (1928). Survey of Ni like spectra.
11. Menzies: PRS **119,** 249 (1928). Series.
12. Thibaud: PZ **29,** 241, (1928). Ultraviolet lines.
13. Duffendack and Black: PR **34,** 35 (1929). Furnace spectrum.
14. Kruger: PR **34,** 1122 (1929). Extension of series.
15. Mack: PR **34,** 17 (1929). Vector coupling in Ni like spectra.
16. Laporte and Inglis: PR **35,** 1337 (1930). Resonance separations for $d^9s$ configurations.
17. Kato: IPCR Vol. **15,** No. 294, 161 (1931). Absorption spectrum.


**Cu III**


1. Kimura and Nakamura: JJP **3,** 197 (1924). Wave-lengths.
2. Gibbs and Vieweg: PR **33,** 1092 (1929) (A). Some multiplets of Cu III.

# ZINC 30

**Zn I**


1. Fues: AP **63,** 1 (1920). Selection rules. Displacement law. Calculation of constants in Ritz formula, and of series limits.
2. de Gramont: CR **170,** 31 (1920). Variability of arc spectrum. Presence of spark lines.
3. de Gramont: CR **171,** 1106 (1920). Ultimate lines.
4. Millikan: AJ **52,** 47 (1920). Extension of the ultraviolet spectrum.
5. Mohler; Foote and Meggers: BSP No. 403, Vol. **16,** 725 (1920); JOSA **4,** 364 (1920). Resonance potentials and low voltage arcs.
6. Polvani: NC **20,** 119 (1920). Time variations in the spectrum of an electric discharge.
7. Sawyer: AJ **52,** 286 (1920). Ultraviolet wave-lengths.
8. Bloch and Bloch: JPR **2,** 229 (1921). Ultraviolet wave-lengths.
9. de Gramont: CN **122,** 58 (1921). Ultimate lines.
10. Moore: AJ **54,** 246 (1921). Excitation stages in the open arc.
11. Paschen and Back: P **1,** 261 (1921). Zeeman effect.
12. Ramsauer and Wolf: AP **66,** 373 (1921). Duration of emission in quenched arc.
13. Seeliger and Thaer: AP **65,** 423 (1921). Displacement law. Study of excitation energies.
14. Walters, Jr.: BSP No. 411, Vol. **17,** 161 (1921). Wave-lengths in red and infrared.
15. Bloch and Bloch: JPR **3,** 309 (1922). Wave-lengths from under-water spark.
16. Campetti and Corsi: NC **24,** 117 (1922). Spectra of sparks in the middle of a flame.
17. Hemsalech and de Gramont: PM **43,** 834 (1922). Occurrence of enhanced lines in the arc.
18. Hutchinson: AJ **58,** 280 (1923). Ultraviolet wave-lengths.
19. Nagaoka and Sugiura: JJP **2,** 167 (1923). Spectroscopic evidence of isotopy.
20. St. Procopiu: CR **176,** 385 and 504 (1923). Spectra from arcs on immersion in various media.
21. Takamine and Fukuda: JJP **2,** 111 (1923). Spectrum of constricted arc.
22. Birge: JOSA **8,** 233 (1924). Series of divalent elements.
23. Dorgelo: ZP **22,** 170 (1924). Intensity measurements.
24. Harris: AJ **59,** 261 (1924). Pole effects and pressure shifts.
25. Hertz: ZP **22,** 18 (1924). Excitation by electron impact.
26. Hulburt: PR **24,** 129 (1924). Absorption in under-water spark.
27. Kimura and Nakamura: JJP **3,** 29 and 43 (1924). Cathode spectra of metals.
28. Landé: ZP **25,** 46 (1924). The absolute intervals of optical triplets. Doublet laws.
29. Mohammad: PM **48,** 586 (1924). Zeeman effect of λ6364.
30. Nagaoka and Sugiuria: JJP **3,** 45 (1924). Stark effect.
31. Nagaoka and Sugiuria: N **113,** 532 (1924). Spectroscopic evidence of isotopes.
32. Randall and St. Peter: PR **23,** 766 (1924). (A) Infrared spectrum.
33. St. Procopiu: AsP **1,** 89 (1924). Study of arc spectrum in various media and in vacuo.
34. St. Procopiu: CR **178,** 1368 (1924). Ultimate lines from the electric arc.
35. St. Procopiu: JPR **5,** 220 (1924). Line width at various pressures.
36. Sawyer and Martin: PR **23,** 766 (1924) (A). Wave-lengths from vacuum spark.
37. Sugiura: JJP **3,** 155 (1924). Calculation of doublet and triplet frequency differences.
38. Turner: PM **48,** 384 (1924). Quantum defect.
39. Back: PZ **26,** 833 (1925); ZP **33,** 579 (1925). Zeeman effect.
40. Foote, Takamine and Chenault: PR **26,** 165 (1925). Excitation of forbidden lines.
41. Fukuda: IPCR **3,** No. 37, 183 (1925). Change of wave-lengths of lines in condensed discharge.
42. Hertz: PKAA **28,** 767 (1925). Excitation by electron impact.
43. Hertzfeld and Wolf: AP **76,** 71 and 567 (1925). A test of the classical dispersion formula. The number of dispersion electrons.
44. Kapitza and Skinner: PRS **109,** 224 (1925). Zeeman effect in strong fields.
45. Ornstein, Burger and van Geel: ZP **32,** 681 (1925). Intensities of Zeeman components.
46. Ruark and Chenault: PM **50,** 937 (1925). Fine structure.
47. Russell: AJ **61,** 223 (1925). Ultimate and penultimate lines.
48. Sawyer and Beese: N **116,** 936 (1925). A *PP′* group.
49. Sugiura: IPCR **3,** No. 28, 1 (1925). Calculation of triplet separations.

## Zinc 30

50. von Wisniewski: PZ **26**, 255 (1925). Calculation of *s*-terms.
51. Beams: PR **28**, 475 (1926). Time interval for excitation of spectra.
52. Deppermann: AJ **63**, 33 (1926). Stark effect.
53. Frayne and Smith: PM **1**, 732 (1926). Absorption spectrum.
54. Fujioka: IPCR No. 68, **5**, 45 (1926). Stark effect.
55. Fukuda: IPCR No. 55, **4**, 171 (1926). New lines.
56. Fukuda, Kuyama and Uchida: IPCR No. 56, Vol. **4**, 177 (1926). Spectra under heavy current excitation. Forbidden lines.
57. Hori: IPCR No. 48, Vol. **4**, 59 (1926). Explosion spectrum.
58. Nagaoka and Futagami: PIAT **2**, 153 (1926). Occurrence of harmonies in spectral series.
59. Ponomarev and Terenin: ZP **37**, 95 (1926). Optical excitation of Zn vapour.
60. Rayleigh: PRS **112**, 14 (1926). Studies on the luminescent vapour distilled from metallic arcs.
61. Sawyer: JOSA **13**, 431 (1926). On deep-lying terms in 2 and 3 electron spectra. *PP′* groups.
62. Sawyer: PR **27**, 106 (1926) (A). *PP′* groups.
63. Sawyer and Beese: S **64**, 44 (1926). New terms.
64. Schüler: ZP **35**, 323 (1926). Stark effect.
65. Unsöld: ZP **36**, 92 (1926). Polarizability. Calculation of quantum defect.
66. Wood: PM **2**, 611 (1926). Structure of resonance lines.
67. Fukuda: IPCR No. 85, Vol. **6**, 1 (1927). Explosion spectra. Broadening and reversal of lines.
68. Kichlu and Saha: PM **4**, 193 (1927). Spectra of metals of group II.
69. Leu: ZP **41**, 551 (1927). Magnetic moment.
70. Menzies: PRS **117**, 88 (1927). Shifts and reversals in fuse spectra.
71. Mohler: PR **29**, 419 (1927). Excitation by atomic hydrogen.
72. Mohler and Moore: JOSA **15**, 74 (1927). Absorption spectrum.
73. Nagaoka, Nukiyama and Futagami: PIAT **3**, 324 (1927). Explosion spectrum.
74. Russell: AJ **66**, 184 (1927). Related lines in the spectra of the iron group. Homologous terms.
75. Russell: AJ **66**, 233 (1927). Series and potentials for iron group.
76. Soleillet: CR **184**, 149 (1927). Resonance lines.
77. Unsöld: AP **82**, 355 (1927). Calculation of terms.
78. van Geel: ZP **51**, 51 (1928). Intensities of forbidden lines in magnetic fields.
79. Locher: JOSA **17**, 91 (1928). Time intervals between the appearance of spectral lines.
80. Okubo and Hamada: PM **5**, 372 (1928). Excitation by active nitrogen.
81. Prokofjew: ZP **50**, 701 (1928). Transition probabilities. Anomalous dispersion.
82. Soleillet: CR **187**, 723 (1928). Polarization of resonance lines.
83. Zwaan: ZP **51**, 62 (1928). Intensities in the incipient Paschen-Back effect. Theoretical.
84. Black, Nash and Poole: PR **34**, 1138 (1929). Influence of argon and hydrogen on zinc spectrum.
85. Crew: PM **7**, 312 (1929). Influence of a hydrogen atmosphere upon the arc spectrum.
86. Schüler and Brück: ZP **56**, 291 (1929). Hyperfine structure.
87. Takahashi: AP **3**, 49 (1929). Excitation in the negative glow of a helium discharge.
88. Hoffmann: ZP **60**, 457 (1930). Absorption spectrum.
89. Kapuscinski: BIAS Nos. 9/10, p. 453 (1930). Fluorescence of Zn vapour.
90. Mohammad and Sharma: PM **10**, 916 (1930). Hyperfine structure.
91. Campbell and Houston: PR **28**, 581 (1931) (A). Zeeman effect.
92. Knorr: PR **37**, 1611 (1931). Time interval for the appearance of lines in a condensed spark.
93. Larche: PZ **32**, 180 (1931). Excitation functions.
94. Larche: ZP **67**, 440 (1931). Voltage intensity relations.
95. Majorana: NC **8**, 107 (1931). Theory of anomalous *P′* triplet.
96. Mitchell: JFI **212**, 305 (1931). Comparison of sources for Zn resonance radiation.
97. Mohammad and Sharma: PM **12**, 726 (1931). Fine structure and energy levels.
98. Murakawa: ZP **72**, 793 (1931). Hyperfine structure.
99. Okubo and Matuyama: N **128**, 224 (1931); PR **38**, 1651 (1931). Appearance of forbidden lines and intensity modifications under high frequency excitation.

100. Schüler and Keyston: ZP **68**, 174 (1931). Isotope abundance ratio and nuclear moment.
101. Setna: IJP **6**, 29 (1931). Infrared spectrum of under-water spark.

**Zn II**

1. Bloch and Bloch: CR **171**, 909 (1920). Wave-lengths.
2. Fues: AP **63**, 1 (1920). Selection rules. Displacement law. Calculation of constants in Ritz formula, and of series limits.
3. Bloch and Bloch: CR **172**, 803 (1921); JPR **2**, 229 (1921). Wave-lengths.
4. Bloch and Bloch: CR **174**, 1456 (1922). Under-water spark spectrum.
5. Hemsalech and de Gramont: PM **43**, 834 (1922). Occurrence of enhanced lines in the arc.
6. Bloch and Bloch: CR **177**, 1025 (1923). Wave-lengths.
7. Hund: ZP **22**, 405 (1924). Rydberg correction and radius of the atom core.
8. Kimura: JJP **3**, 217 (1924). Wave-lengths.
9. Kimura and Nakamura: JJP **3**, 197 (1924). Wave-lengths.
10. Landé: ZP **25**, 46 (1924). The absolute intervals of optical doublets. Doublet laws.
11. Turner: PM **48**, 384 (1924). Quantum defect.
12. Russell: AJ **61**, 223 (1925). Ultimate and penultimate lines.
13. Salis: AP **76**, 145 (1925). Series.
14. Beams: PR **28**, 475 (1926). Time interval for excitation of spectra.
15. Hartree: PCPS **23**, 304 (1926). Quantum defect.
16. Rayleigh: PRS **112**, 14 (1926). Studies on the luminous vapour distilled from metallic arcs.
17. Paschen: SAWB **29**, 207 (1927). Excitation through the metastable condition of the rare gas atom.
18. Russell: AJ **66**, 184 (1927). Related lines in the spectra of the iron group. Homologous terms.
19. Russell: AJ **66**, 233 (1927). Series and potentials for iron group.
20. Lang: PNAS **15**, 414 (1929). Series.
21. McLennan and Allin: PM **8**, 515 (1929). Hyperfine structure.
22. Takahashi: AP **3**, 27 (1929). Series.
23. Takahashi: AP **3**, 49 (1929). Excitation in the negative glow of a helium discharge.
24. Dunnington and Lawrence: PR **35**, 134 (1930 (A). Stark effect in spark discharge.
25. Larche: ZP **67**, 440 (1931). Voltage-intensity relations.

**Zn III**

1. Kimura and Nakamura: JJP **3**, 197 (1924). Wave-lengths.
2. Laporte and Lang: PR **30**, 378 (1927). Series.
3. Mack, Laporte and Lang: PR **31**, 748 (1928). Survey of Ni like spectra.
4. Mack: PR **34**, 17 (1929). Vector coupling in Ni like spectra.
5. Laporte and Inglis: PR **35**, 1337 (1930). Resonance separations for $d^9s$ configurations.

## GALLIUM 31

**Ga I**

1. de Gramont: CR **171**, 1106 (1920). Ultimate lines.
2. de Gramont: CN **122**, 58 (1921). Ultimate lines.
3. de Gramont: CR **175**, 1025 (1922). "Raies ultimes" and spectral series.
4. Uhler and Tanch: AJ **55**, 291 (1922). Wave-lengths. Series formulae.
5. Grotrian: ZP **18**, 169 (1923). Absorption spectrum.
6. Mohler and Ruark: JOSA **7**, 819 (1923). Stages in excitation.
7. Landé: ZP **25**, 46 (1924). The absolute intervals of optical doublets. Doublet laws.
8. Sugiura: JJP **3**, 155 (1924). Calculation of doublet frequency differences.
9. Turner: PM **48**, 384 (1924). Quantum defect.
10. King: AJ **62**, 238 (1925). Spectrum of the high current arc.
11. Russell: AJ **61**, 223 (1925). Ultimate and penultimate lines.
12. Sugiura: IPCR **3**, 1 (1925). Calculation of doublet separations.
13. von Wisniewski: PZ **26**, 255 (1925). Calculation of $s$ terms.

## GALLIUM 31; GERMANIUM 32

14. Frayne and Smith: PR **27**, 23 (1926). Absorption spectrum.
15. Hartree: PCPS **23**, 304 (1926). Quantum defect.
16. Jarvis: PR **29**, 442 (1927). Ionization and resonance potentials.
17. Smith and Muskat: PR **29**, 663 (1927). Absorption spectrum.
18. Lansing: PR **34**, 597 (1929). New terms.
19. Sawyer and Lang: PR **34**, 712 (1929). Series.
20. Campbell and Bacher: PR **38**, 1906 (1931). Hyperfine structure and nuclear moment.

**Ga II**

1. Klein: AJ **56**, 373 (1922). Wave-lengths.
2. Weinberg: PRS **107**, 138 (1925). Wave-lengths.
3. Lang: PR **30**, 762 (1927). Series.
4. Rao: PPS **39**, 161 (1927). Series.
5. Rao, Narrayan and Rao: IJP **2**, 467 (1928). Series.
6. Sawyer and Lang: PR **34**, 712 (1929). Series.

**Ga III**

1. Fues: AP **76**, 299 (1925). Calculation of terms.
2. Carroll: PTRS **225**, 357 (1926). Series.
3. Hartree: PCPS **23**, 304 (1926). Quantum defect.
4. Lang: PR **30**, 762 (1927). Series.
5. Rao: PRS **39**, 150 (1927). Series.

**Ga IV**

1. Mack, Laporte and Lang: PR **31**, 748 (1928). Series. Application of doublet laws.
2. Mack: PR **34**, 17 (1929). Vector coupling in Ni like spectra.
3. Laporte and Inglis: PR **35**, 1337 (1930). Resonance separations for $d^9s$ configurations.

## GERMANIUM 32

**Ge I**

1. de Gramont: CR **171**, 1106 (1920). Ultimate lines.
2. de Gramont: CN **122**, 58 (1921). Ultimate lines.
3. Ireton: TRSC **18**, 103 (1924). Extreme ultraviolet wave-lengths.
4. Lunt: RAS **85**, 38 (1924). Wave-lengths.
5. Lunt: RAS **85**, 148 (1924). Temperature displacements.
6. McLennan and McLay: TRSC **20**, 355 (1926). Series.
7. Richter: Nw **15**, 266 (1927). Series.
8. Gartlein: PR **31**, 782 (1928). Series.
9. Mack, Laporte and Lang: PR **31**, 748 (1928). New lines and levels. Survey of Ni-like spectra.
10. Richter: ZwP **25**, 380 (1928). Series.
11. Houston: PR **33**, 297 (1929). Calculation of energy levels by Schrödinger equation.
12. Rao: PRS **124**, 465 (1929). Series.
13. Schuler and Keyston: ZP **68**, 174 (1931). Isotope abundance ratio and nuclear moment.

**Ge II**

1. Ireton: TRSC **18**, 103 (1924). Series.
2. Green and Loring: PR **30**, 574 (1927). Certain separations predicted by irregular doublet law.
3. Lang: PR **30**, 762 (1927). Series.
4. Lang: PNAS **14**, 32 (1928). Series.
5. Rao and Narayan: PRS **119**, 607 (1928). Series.
6. Lang: PR **34**, 697 (1929). Extension of series.
7. Gartlein: PR **37**, 1704 (1931) (A). Series.
8. Gartlein and Gibbs: PR **38**, 1907 (1931) (A). Excitation in hollow cathode lamp.

## Germanium 32; Arsenic 33

**Ge III**

1. Lang: PR **30**, 762 (1927). Series.
2. Smith: N **120**, 728 (1927). New lines and series members.
3. Lang: PNAS **14**, 32 (1928). Series.
4. Rao and Narayan: PRS **119**, 607 (1928). Series.
5. Lang: PR **34**, 697 (1929). Series.
6. Gartlein and Gibbs: PR **38**, 1907 (1931) (A). Excitation in a hollow cathode lamp.

**Ge IV**

1. Fues: AP **76**, 299 (1925). Calculation of terms.
2. Carroll: PTRS **225**, 357 (1926). Series.
3. Hartree: PCPS **23**, 304 (1926). Relations in Cu I like spectra.
4. Lang: PR **30**, 762 (1927). Series.
5. Rao and Narayan: PRS **119**, 607 (1928). Series.
6. Lang: PR **34**, 697 (1929). Series.

**Ge V**

1. Mack, Laporte and Lang: PR **31**, 748 (1928). New lines and levels. Survey of Ni like spectra.
2. Mack: PR **34**, 17 (1929). Vector coupling in Ni like spectra.
3. Laporte and Inglis: PR **35**, 1337 (1930). Resonance separations for $d^9s$ configuration.

## Arsenic 33

**As I**

1. Bloch and Bloch: CR **171**, 709 (1920). Wave-lengths.
2. Dobbie and Fox: PRS **98**, 147 (1920). Absorption in the vapour state.
3. de Gramont: CR **171**, 1106 (1920). Ultimate lines.
4. Bloch and Bloch: JPR **2**, 229 (1921). Ultraviolet wave-lengths.
5. Dauvillier: CR **173**, 1458 (1921). Electronic structure of the elements.
6. de Gramont: CN **122**, 58 (1921). Ultimate lines.
7. Lang: PTRS **224**, 371 (1924). Ultraviolet wave-lengths.
8. Ruark, Mohler, Foote and Chenault: BSP No. 490, **19**, 463 (1924). Series and critical potentials.
9. McLennan and McLay: TRSC **19**, 89 (1925). Absorption spectrum.
10. Russell: AJ **61**, 223 (1925). Ultimate and penultimate lines.
11. Terenin: ZP **37**, 98 (1926). Excitation of atoms by radiation.
12. Rao: PRS **125**, 238 (1929). Series.
13. Meggers and de Bruin: BSJ **3**, 765 (1930). Series.

**As II**

1. Bloch and Bloch: CR **171**, 709 (1920). Wave-lengths.
2. Bloch and Bloch: JPR **2**, 229 (1921). Wave-lengths.
3. Lang: PTRS **224**, 371 (1924). Wave-lengths.
4. Gartlein: PR **32**, 320 (1928). Series.

**As III**

1. Lang: PR **32**, 737 (1928). Series.
2. Pattabhiramiah and Rao: IJP **3**, 437 (1928). Series.
3. Rao and Narayan: N **124**, 229 (1929); ZP **57**, 865 (1929). Series.
4. Rao: PPS **43**, 68 (1931). Series.

**As IV**

1. Sawyer and Humphreys: PR **32**, 583 (1928). Series.
2. Queney: CR **189**, 158 (1929); JPR **10**, 448 (1929). Series.
3. Rao: N **123**, 244 (1929). Series.
4. Rao and Badami: PRS **131**, 154 (1931). Series.

## Arsenic 33; Selenium 34; Bromine 35

**As V**

1. Sawyer and Humphreys: PR **32,** 583 (1928). Series.
2. Queney: CR **189,** 158 (1929); JPR **10,** 448 (1929). Series.

**As VI**

1. Pattabhiramiah and Rao: ZP **53,** 587 (1929). Series.
2. Borg and Mack: PR **37,** 470 (1931). Series.

## Selenium 34

**Se I**

1. de Gramont: CR **171,** 1106 (1920). Ultimate lines.
2. McLennan, Young and Ireton: PRS **98,** 95 (1920). Wave-lengths.
3. de Gramont: CN **122,** 58 (1921). Series.
4. Udden: PR **18,** 385 (1921). Ionization potential.
5. Catalan: CR **176,** 247 (1923). Note concerning nature of Se I multiplets.
6. Hopfield: N **112,** 437 (1923). New triplets.
7. Hopfield and Birge: N **112,** 790 (1923). Series.
8. Birge: JOSA **8,** 233 (1924). Series of divalent elements.
9. Landé: ZP **25,** 46 (1924). The absolute intervals of optical triplets. Doublet laws.
10. Turner: PM **48,** 384 (1924). Quantum defect.
11. Russell: AJ **61,** 223 (1925). Ultimate and penultimate lines.
12. Kimura: JJP **4,** 81 (1925/27). Absorption spectrum.
13. McLennan, McLay and McLeod: PM **4,** 486 (1927). Series.
14. Lacroute: JPR **9,** 180 (1928). Wave-lengths.
15. Schmidt: BIAS **3a,** 61 (1928). Resonance spectrum.
16. Grünbaum: BIAS **10a,** 611 (1929). Resonance series.
17. McLennan and Crawford: N **124,** 874 (1929). Low terms.
18. Natanson: ZP **65,** 75 (1930). Intensity variations in resonance spectrum due to pressure.
19. Gibbs and Ruedy: PR **37,** 1704 (1931) (A). An extension of series.

**Se II**

1. Bloch and Bloch: CR **185,** 761 (1927). Wave-lengths.
2. Lacroute: JPR **9,** 180 (1928). Wave-lengths.
3. Bloch and Bloch: AsP **13,** 233 (1930). Wave-lengths.

**Se III**

1. Bhattacharjya: N **124,** 229 (1929). Series.
2. Rao: ZP **58,** 251 (1929). Series.
3. Bloch and Bloch: AsP **13,** 233 (1930). Wave-lengths.
4. Badami and Rao: N **128,** 496 (1931). Series.

**Se IV**

1. Bloch and Bloch: CR **187,** 562 (1928). Wave-lengths.
2. Pattabhiramayya and Rao: IJP **3,** 531 (1928). Series.
3. Bloch and Bloch: AsP **13,** 233 (1930). Wave-lengths.
4. Rao: N **126,** 568 (1930). Series.
5. Rao and Badami: PRS **131,** 154 (1931). Series.

**Se V**

1. Sawyer and Humphreys: PR **32,** 583 (1928). Series.
2. Rao and Badami: PRS **131,** 154 (1931). Series.

## Bromine 35

**Br I**

1. de Gramont: CR **171,** 1106 (1920). Ultimate lines.
2. Kimura: MKCS **4,** 127 (1920). Line structures and Zeeman effect.

## Bromine 35; Krypton 36


3. Dobbie and Fox: PRS **99**, 456 (1921). Absorption spectrum.
4. de Gramont: CN **122**, 58 (1921). Ultimate lines.
5. Nagaoka and Sugiura: JJP **2**, 167 (1923). Spectroscopic evidence of isotopy.
6. Narayan and Gunnayya: PM **45**, 827 (1923). Emission and absorption spectra.
7. Bovis: CR **178**, 1964 (1924). Absorption spectrum.
8. Nagaoka and Sugiura: N **113**, 532 (1924). Spectroscopic evidence of isotopes.
9. Ruark and Chenault: PM **50**, 937 (1925). Fine structure.
10. Hori: MKCS **9**, 307 (1926). The structure of certain lines.
11. Turner: PR **27**, 397 (1926). Wave-lengths. Doublet separations.
12. Bloch and Bloch: AsP **7**, 205 (1927). Wave-lengths.
13. Laporte PR **29**, 650 (1927). Screening constants from optical data.
14. Bloch and Bloch AsP **9**, 554 (1928). Arc and spark spectra of Cl and Br. (Corrective note).
15. Siracusano: AAL **7**, 835 (1928). Wave-lengths.
16. Siracusano: NC **5**, 273 (1928). Continuous and arc spectrum of Br.
17. Asagoe: IPCR No. 206, Vol. **11**, 243 (1929). Stark effect.
18. Asagoe: MKCS **12**, 275 (1929). Classification of lines according to degree of ionization.
19. de Bruin and Kiess: S **69**, 360 (1929). Series.
20. de Bruin: N **125**, 414 (1930); Nw **18**, 265 (1930). Nuclear moment.
21. Kiess and de Bruin: BSJ **4**, 667 (1930). Series.
22. Kimura: MKCS **4**, 133 (1930). Fine structure.
23. Kronig and Frisch: PZ **32**, 457 (1931). Nuclear moments. A review. Bibliography
24. Tolansky: N **127**, 855 (1931). Fine structure.


**Br II**


1. Bloch and Bloch: AsP **7**, 205 (1927); CR **184**, 193 (1927). Wave-lengths.
2. Vaudet: CR **185**, 1270 (1927). Wave-lengths.
3. Bloch and Bloch: AsP **9**, 554 (1928). Wave-lengths.
4. Asagoe: MKCS **12**, 275 (1929). Wave-lengths.
5. Deb: PRS **127**, 197 (1930). Series.
6. Bloch, Bloch and Lacroute: CR **193**, 232 (1931). Multiplets of quintet system.


**Br III**


1. Bloch and Bloch: AsP **7**, 205 (1927); CR **184**, 193 (1927). Wave-lengths.
2. Bloch and Bloch: AsP **9**, 554 (1928). Wave-lengths.
3. Asagoe: MKCS **12**, 275 (1929). Wave-lengths.
4. Deb: PRS **127**, 197 (1930). Series.


**Br IV**


1. Bloch and Bloch: AsP **7**, 205 (1927). Wave-lengths.
2. Bloch and Bloch: AsP **9**, 554 (1928). Wave-lengths.
3. Deb: N **123**, 981 (1929). Series.
4. Deb: PRS **127**, 197 (1930). Series.


**Br V**


1. Deb: PRS **127**, 197 (1930). Series.


## Krypton 36

**Kr I**


1. Collie: PRS **97**, 349 (1920). Wave-lengths.
2. de Gramont: CR **171**, 1106 (1920). Ultimate lines.
3. Hicks: PTRS **220**, 335 (1920). Critical study of spectral series.
4. de Gramont: CN **122**, 58 (1921). Ultimate lines.
5. Meggers: BSP No. 414, Vol. **17**, 193 (1921); PR **18**, 160 (1921) (A). Wave-lengths and constant frequency differences.

## KRYPTON 36; RUBIDIUM 37


6. Meggers: JOSA **5,** 308 (1921). Standard wave-lengths. A review.
7. Déjardin: CR **176,** 894 (1923). Radiation and ionization potentials.
8. Déjardin: AsP **2,** 241 (1924); CR **178,** 1069 (1924). Excitation by electron impact.
9. Turner: PM **48,** 1010 (1924). Quantum defect.
10. Hertz and Kloppers: ZP **31,** 463 (1925). Excitation and ionization potentials.
11. Hertzfeld and Wolf: AP **76,** 71 and 567 (1925). A test of the classical disperion formula. The number of dispersion electrons.
12. Gehrcke and Janicki: AP **81,** 314 (1926). Fine structure.
13. Hertz and Abbink: Nw **14,** 648 (1926). Resonance lines.
14. Hicks: AsP **6,** 294 (1926). Structure of rare gas spectra.
15. Otsuka: ZP **36,** 786 (1926). Wave-lengths.
16. Swindler: PR **28,** 1136 (1926). Effect of potential and frequency on spectra.
17. Taylor: PNAS **12,** 658 (1926). Extreme ultraviolet wave-lengths.
18. Abbink and Dorgelo: P **7,** 343 (1927). Extreme ultraviolet wave-lengths.
19. Pérard: CR **184,** 681 (1927). Structure of certain lines.
20. Abbink and Doreglo: ZP **47,** 221 (1928). Extreme ultraviolet wave-lengths.
21. Gremmer: ZP 50, 716 (1928). Series.
22. McLennan and Ruedy: TRSC **22,** 15 (1928). Absorption spectrum.
23. Williams: PPS **40,** 312 (1928); UNLP No. 82, 253 (1928). Structure of the induction spectra of rare gases. Arc spectra of argon, krypton and xenon.
24. Gremmer: ZP **54,** 215 (1929). Series.
25. Bakker: N **126,** 955 (1930); Nw **18,** 1100 (1930). Electron coupling in the rare gases.
26. Humphreys: BSJ **5,** 1041 (1930). Interferometer measurements.
27. Laporte and Inglis: PR **35,** 1337 (1930). Resonance separations for $p^5s$ configuration.
28. Meggers, de Bruin and Humphreys: BSJ **3,** 129 (1930). Series.
29. Beeck and Mouzon: AP **11,** 737 (1931). Ionization by slow alkali ions.
30. Humphreys: BSJ **7,** 453 (1931); PR **37,** 1703 (1931) (A). Hyperfine structure.
31. Meggers, de Bruin and Humphreys: BSJ **7,** 643 (1931). Extension of series.
32. Rasmussen and Swenson: N **128,** 188 (1931). Intensity anomalies.
33. White: PR **38,** 1786 and 2016 (1931). Auto-ionization.


**Kr II**


1. Déjardin: CR **176,** 894 (1923). Critical potentials.
2. Bloch, Bloch and Dejardin: AsP **2,** 461 (1924); CR **178,** 766 (1924). Wave-lengths.
3. Kichlu: PRS **120,** 643 (1928). Series.
4. Acharya: N **123,** 244 (1929). Series.
5. Bakker and Zeeman: PKAA **32,** 565 (1929). Zeeman effect.
6. Bakker: ANSE **13,** 121 (1931). Zeeman effect and anomalous coupling.
7. Bakker and de Bruin: ZP **69,** 36 (1931). Series and Zeeman effect.


**Kr III**


1. Bloch, Bloch and Dejardin: AsP **2,** 461 (1924); CR **178,** 766 (1924). Wave-lengths.
2. Acharya: N **123,** 244 (1929). Series.
3. Deb and Dutt: ZP **67,** 138 (1931). Series.


**Kr IV**


1. Bloch, Bloch and Dejardin: AsP **2,** 461 (1924); CR **178,** 766 (1924). Wave-lengths.
2. Acharya: IJP **5,** 385 (1930); N **125,** 204 (1930). Series.
3. Acharya: IJP **6,** 35 (1931). New lines of quartet system.


## RUBIDIUM 37

**Rb I**


1. Fues: AP **63,** 1 (1920). Selection rules. Displacement law. Calculation of constants in Ritz formula, and of series limits.
2. Gouy: AsP **13,** 188 (1920). Intensity measurements.

## RUBIDIUM 37


3. de Gramont: CR **171,** 1106 (1920). Ultimate lines.
4. Dunoyer: CR **173,** 472 (1921). Induction spectrum.
5. de Gramont: CN **122,** 58 (1921). Ultimate lines.
6. Ladenburg: ZP **4,** 451 (1921). Quantum mechanical interpretation of the number of dispersion electrons.
7. Ramsauer and Wolf: AP **66,** 373 (1921). Duration of emission in quenched arc.
8. Rogestwensky: N **107,** 203 (1921). Doublets in spectral series.
9. Rogestwensky: VOIL **2,** No. 13 (1921). Intensity ratios.
10. Becker: ZP **9,** 332 (1922). Stark effect.
11. Dunoyer: JPR **3,** 261 (1922). Wave-lengths from electrodeless discharge.
12. King: AJ **55,** 380 (1922). Furnace absorption spectra.
13. Rogestwensky: JRPC **50,** 11 (1922). Intensity ratios.
14. Bartels: ZP **20,** 398 (1924). Intensity distribution, term sequence, and excitation functions.
15. Nagaoka and Sugiura: JJP **2,** 167 (1923). Spectroscopic evidence of isotopy.
16. Newman: PM **45,** 181 and 293 (1923). Visibility of spectra.
17. Turner: AJ **58,** 176 (1923). Relation between spectra and sizes of the alkali atoms.
18. van Urk: ZP **13,** 268 (1923). Normal orbits of series electrons of the alkalies.
19. Bleeker and Bongers: ZP **27,** 195 (1924). Intensities in flame spectra.
20. Dorgelo: ZP **22,** 170 (1924). Intensities.
21. Hund: ZP **22,** 405 (1924). Rydberg correction and radius of the atom core.
22. Jones and Boyce: PRS **106,** 773 (1924). Constants of the Rydberg-Ritz equation. Quantum defect.
23. Landé: ZP **25,** 46 (1924). The absolute intervals of optical doublets. Doublet laws.
24. Lindsay: MIT **3,** 191 (1924). Electronic orbits in the alkali metals.
25. Nagaoka and Sugiura: N **113,** 532 (1924). Spectroscopic evidence of isotopes.
26. Rasetti: NC **1,** 115 (1924). Anomalous dispersion.
27. Shaver: TRSC **18,** 23 (1924). Extreme ultraviolet wave-lengths.
28. Sugiura: JJP **3,** 155 (1924). Calculation of doublet frequency differences.
29. Turner: PM **48,** 384 (1924). Quantum defect.
30. de Wisniewski: CR **179,** 1316 (1924). A formula expressing alkali doublet separation.
31. Dannmeyer: ZP **31,** 76 (1925). Intensities in flame spectra.
32. Mohler: BSP No. 505, Vol. **20,** 167 (1925). Critical potentials.
33. Newman: PM **50,** 1276 (1925). Low voltage spectrum.
34. Oudt: ZP **33,** 656 (1925). Intensities.
35. Russell: AJ **61,** 223 (1925). Ultimate and penultimate lines.
36. Schrödinger: AP **77,** 43 (1925). Hydrogen-like spectra and polarizability of the atom core.
37. Sugiura: IPCR Vol. **3,** No. 28, 1 (1925). Calculation of doublet separations.
38. von Wisniewski: PZ **26,** 255 (1925). Calculation of *s* term.
39. Bleeker: TFS **21,** 479 (1926); ZPC **120,** 63 (1926). Intensities.
40. Gibbs and White: PNAS **12,** 551 (1926). Doublets of stripped atoms.
41. Kohn and Jakob: PZ **27,** 819 (1926). Intensity ratios of principal series doublets.
42. Mohler: PR **28,** 46 (1926). Photoionization in gases.
43. Sowerby and Barratt: PRS **110,** 190 (1926). Absorption spectrum.
44. Unsöld: ZP **36,** 92 (1926). Polarizability. Calculation of quantum defect.
45. Brodsky: ZP **42,** 899 (1927). Intensities.
46. Mohler: PR **29,** 419 (1927). Excitation by atomic hydrogen.
47. Shrum, Carter and Fowler: PM **3,** 27 (1927). *1s-md* series of alkali metals.
48. Jakob: AP **86,** 449 (1928). Intensity ratios of the principal series doublets.
49. Kupper: AP **86,** 511 (1928). Application of wave mechanics to derivation of theoretical intensities.
50. Sambursky: ZP **49,** 731 (1928). Intensity ratios for principal series doublets.
51. Filippov and Gross: Nw **17,** 121 (1929). Fine structure of principal series doublets.
52. Gibbs and White: PR **33,** 159 (1929). Doublets of stripped atoms.

## RUBIDIUM 37; STRONTIUM 38


53. Korff: PR **34,** 457 (1929). Dispersion and absorption line width.
54. Prokofjew: ZP **57,** 387 (1929). Probability of forbidden transitions.
55. Deslandres: CR **191,** 169 (1930). Ultimate rays.
56. Fermi: N **125,** 16 (1930); ZP **60,** 320 (1930). Nuclear moment.
57. Fermi: ZP **59,** 680 (1930). Intensity ratios of the alkali doublets. Effect of perturbations.
58. Sambursky: ZP **61,** 660 (1930). Fermi intensity formula for the principal series doublets.
59. Stevenson: PRS **128,** 591 (1930). Intensity of quadrupole radiation.
60. Datta and Maitra: ZP **70,** 548 (1931). Absorption spectrum.
61. Fermi: NC **8,** XIV (1931). Nuclear moment.
62. Jackson: N **127,** 925 (1931); N **128,** 34 (1931). Hyperfine structure.
63. Kronig and Frisch: PZ **32,** 457 (1931). Nuclear moments. A review. Bibliography.
64. Meissner and Masaki: AP **10,** 325 (1931). Structure of the *F* terms.
65. Ramb: AP **10,** 311 (1931). Interferometer measurements of wave-length. Inverted multiplets.
66. Whitelaw and Stevenson: N **127,** 817 (1931). Intensity of forbidden transitions.


**Rb II**


1. Dunoyer: JPR **3,** 261 (1922). Wave-lengths. Electrodeless discharge.
2. Mohler, Foote, Ruark and Kiess: JOSA **7,** 62 (1923) (A). Excitation.
3. Reinheimmer: AP **71,** 162 (1923). Series.
4. Mohler: BSP No. 505, Vol. **20,** 167 (1925). Critical potentials.
5. Otsuka: ZP **36,** 786 (1926). Wave-lengths.
6. Newman: PM **3,** 229 (1927). "Flash" arc spectrum.
7. Hartree: PCPS **24,** 111 (1928). Distribution of charge calculated from wave equation for a central field. Calculation of terms.
8. Majumdar: Nw **17,** 198 (1929). Series.
9. Schüler and Brück: ZP **58,** 735 (1929). Hyperfine structure.
10. Datta and Maitra: ZP **70,** 548 (1931). Absorption spectrum.
11. Laporte and Miller: PR **37,** 1703 (1931) (A). Series.
12. Laporte, Miller and Sawyer: PR **37,** 219 (1931); PR **38,** 843 (1931). Series, resonance lines, and hyperfine structure.


**Rb IX**


1. Mack: PR **38,** 193 (1931). Principal doublet of Rb IX.


## STRONTIUM 38

**Sr I**


1. Fues: AP **63,** 1 (1920). Selection rules. Displacement law. Calculation of constants in Ritz formula, and of series limits.
2. Gouy: AsP **13,** 188 (1920). Intensity measurements.
3. de Gramont: CR **171,** 1106 (1920). Ultimate lines.
4. King: AJ **51,** 179 (1920). Furnace spectrum.
5. Mohler, Foote and Meggers: BSP No. 403, Vol. **16,** 725 (1920); JOSA **4,** 364 (1920). Resonance potentials and low voltage arcs.
6. Götze: AP **66,** 285 (1921). Line groups and inner quanta.
7. de Gramont: CN **122,** 58 (1921). Ultimate lines.
8. Moore: AJ **54,** 191 (1921). Excitation stages in the open arc.
9. Ramsauer and Wolf: AP **66,** 373 (1921). Duration of emission in quenched arc.
10. King: AJ **55,** 380 (1922). Furnace absorption spectra.
11. Saunders: AJ **56,** 73 (1922). Series.
12. Saunders and Russell: PR **22,** 201 (1923) (A). Series.
13. Sawyer and Becker: AJ **57,** 98 (1923). Explosion spectra.
14. Wentzel: PZ **24,** 104 (1923). Two-electron transitions.
15. Birge: JOSA **8,** 233 (1924). Series of divalent elements.
16. Dorgelo: ZP **22,** 170 (1924). Intensities.

## STRONTIUM 38

17. Green and Petersen: AJ **60,** 301 (1924). Double excitation spectra. Primed terms.
18. Kimura and Nakamura: JJP **3,** 29 (1924). Cathode spectra of metals.
19. Landé: ZP **25,** 46 (1924). The absolute intervals of optical triplets. Doublet laws.
20. Sugiura: JJP **3,** 155 (1924). Calculation of triplet separations.
21. Turner: PM **48,** 384 (1924). Quantum defect.
22. Kronig: ZP **31,** 885 (1925). Intensity of multiplet lines and their Zeeman components. Part I.
23. Royds: PRS **107,** 360 (1925). Apparent tripling of certain lines in the arc spectra.
24. Russell: AJ **61,** 223 (1925). Ultimate and penultimate lines.
25. Russell and Saunders: AJ **61,** 38 (1925). Series.
26. Schrödinger: AP **77,** 43 (1925). Hydrogen-like spectra and polarizability of the atom core.
27. Kapitza and Skinner: PRS **109,** 224 (1925). Zeeman effect.
28. Sugiura: IPCR Vol. **3,** No. 28, 1 (1925). Calculation of triplet separations.
29. Wentzel: ZP **34,** 730 (1925). Interpretation of alkaline earth spectra.
30. von Wisniewski: PZ **26,** 255 (1925). Calculation of *s*-terms.
31. Hori: IPCR No. 48, Vol. **4,** 59 (1926). Explosion spectra.
32. Laporte: JOSA **13,** 1 (1926). Interpretation of spectra. Vector model. Zeeman effect.
33. Laporte: ZP **39,** 123 (1926). Ground terms of spectra of first and second long periods.
34. Unsöld: ZP **36,** 92 (1926). Polarizability. Calculation of quantum defect.
35. Kerschbaum: AP **83,** 287 (1927). Measurements of duration of luminosity.
36. Kichlu and Saha: PM **4,** 193 (1927). Spectra of group II metals.
37. Ornstein and Burger: ZP **40,** 403 (1927). Intensities.
38. Saha: PM **3,** 1265 (1927). Spectra of group II metals.
39. Walters and Barratt: PM **3,** 991 (1927). Absorption spectrum.
40. Locher: JOSA **17,** 91 (1928). Time intervals between the appearance of spectral lines.
41. Prokofjew: ZP **50,** 701 (1928). Transition probabilities. Anomalous dispersion.
42. Deslandres: CR **191,** 169 (1930). Ultimate rays.
43. Querbach: ZP **60,** 109 (1930). New wave-lengths.
44. White: PR **38,** 1786 and 2016 (1931). Auto-ionization.

**Sr II**

1. Fues: AP **63,** 1 (1920). Selection rules. Displacement law. Calculation of constants in Ritz formula, and of series limits.
2. Sawyer and Becker: AJ **57,** 98 (1923). Explosion spectra.
3. Turner: AJ **58,** 176 (1923). Relation between spectra and sizes of atoms.
4. Hund: ZP **22,** 405 (1924). Rydberg correction and radius of the atom core.
5. Jones and Boyce: PRS **106,** 773 (1924). Constants of the Rydberg-Ritz equation. Quantum defect.
6. Kimura and Nakamura: JJP **3,** 197 (1924). Wave-lengths.
7. Landé: ZP **25,** 46 (1924). The absolute intervals of optical doublets. Doublet laws.
8. Turner: PM **48,** 384 (1924). Quantum defect.
9. Kapitza and Skinner: PRS **109,** 224 (1925). Zeeman effect in strong fields.
10. Russell: AJ **61,** 223 (1925). Ultimate and penultimate lines.
11. von Wisniewski: PZ **26,** 255 (1925). Calculation of *s*-terms.
12. Gibbs and White: PNAS **12,** 551 (1926). Doublets of stripped atoms.
13. Grotrian: Nw **14,** 144 (1926). Zeeman effect in strong fields.
14. Laporte: ZP **39,** 123 (1926). Ground terms of spectra of first and second long periods.
15. Kerschbaum: AP **83,** 287 (1927). Measurements on duration of emission.
16. Gibbs and White: PR **33,** 157 (1929). Doublets of stripped atoms.
17. Frisch: ZP **71,** 89 (1931). Hyperfine structure.
18. Kronig and Frisch: PZ **32,** 457 (1931). Nuclear moments. A review. Bibliography.

**Sr III**

1. Kimura and Nakamura: JJP **3,** 197 (1924). Wave-lengths.

## YTTRIUM 39; ZIRCONIUM 40

**Y I**

1. de Gramont: CR **171,** 1106 (1920). Ultimate lines.
2. de Gramont: CN **122,** 58 (1921). Ultimate lines.
3. Kiess, Hopkins and Kremers: BSP No. 421, Vol. **17,** 318 (1921). Wave-lengths.
4. Yntema and Hopkins: JOSA **6,** 121 (1922). Wave-lengths.
5. Meggers: JWAS **14,** 419 (1924). Series and Zeeman effect.
6. Meggers and Moore: JWAS **15,** 207 (1925). Quartet system.
7. Russell: AJ **61,** 223 (1925). Ultimate and penultimate lines.
8. Laporte: JOSA **13,** 1 (1926). Interpretation of spectra. Vector model. Zeeman effect.
9. Laporte: ZP **39,** 123 (1926). Ground terms of spectra of first and second long periods.
10. McDonald, Sutton and McLay: TRSC **20,** 313 (1926). Wave-lengths.
11. McLennan and Liggett: TRSC **20,** 377 (1926). Wave-lengths.
12. Meggers and Kiess: JOSA **12,** 417 (1926). Series.
13. King and Carter: AJ **65,** 86 (1927). Furnace spectrum.
14. Meggers: BSJ **1,** 319 (1928). Wave-lengths and Zeeman effects.
15. Meggers and Russell: BSJ **2,** 733 (1929). Series and Zeeman effect.

**Y II**

1. Meggers: JWAS **14,** 419 (1924). Series.
2. Russell: AJ **61,** 223 (1925). Ultimate and penultimate lines.
3. Wentzel: ZP **34,** 730 (1925). Interpretation of alkaline earth spectra.
4. Laporte: JOSA **13,** 1 (1926). Interpretation of spectra. Vector model. Zeeman effect.
5. Laporte: ZP **39,** 123 (1926). Ground terms of spectra of first and second long periods.
6. Meggers and Kiess: JOSA **12,** 417 (1926). Series.
7. Meggers: BSJ **1,** 319 (1928). Wave-lengths and Zeeman effect.
8. Meggers and Russell: BSJ **2,** 733 (1929). Series.

**Y III**

1. Jones and Boyce: PRS **106,** 773 (1924). Constants of the Rydberg-Ritz equation. Quantum defect.
2. Bowen and Millikan: PR **28,** 923 (1926). Series.
3. Gibbs and White: PNAS **12,** 551 (1926). Rubidium like doublets of Y III.
4. Meggers: BSJ **1,** 319 (1928). Wave-lengths and Zeeman effects.
5. Gibbs and White: PR **33,** 157 (1929). Doublets of stripped atoms.
6. Meggers and Russell: BSJ **2,** 733 (1929). Series.

## ZIRCONIUM 40

**Zr I**

1. de Gramont: CR **171,** 1106 (1920). Ultimate lines.
2. McLennan and Lewis: PRS **98,** 109 (1920). Wave-lengths.
3. de Gramont: CN **122,** 58 (1921). Ultimate lines.
4. Kiess and Kiess: PA **33,** 255 (1925). Series.
5. Russell: AJ **61,** 223 (1925). Ultimate and penultimate lines.
6. Laporte: JOSA **13,** 1 (1926). Interpretation of spectra. Vector model. Zeeman effect.
7. Laporte: ZP **39,** 123 (1926). Ground terms of spectra of first and second long periods.
8. McDonald, Sutton and McLay: TRSC **20,** 313 (1926). Wave-lengths.
9. Meggers and Kiess: JOSA **12,** 417 (1926). Series and Zeeman effect.
10. King and Carter: AJ **65,** 86 (1927). Furnace spectrum.
11. Kiess and Kiess: BSJ **6,** 621 (1931). Series spectrum and Zeeman effect.

**Zr II**

1. Russell: AJ **61,** 223 (1925). Ultimate and penultimate lines.
2. Laporte: JOSA **13,** 1 (1926). Interpretation of spectra. Vector model. Zeeman effect.
3. Laporte: ZP **39,** 123 (1926). Ground terms of spectra of first and second long periods.

## Zirconium 40; Columbium 41; Molybdenum 42

4. Meggers and Kiess: JOSA **12,** 417 (1926) (A). Series.
5. Kiess and Kiess: JOSA **14,** 140 (1927). Series.
6. Kiess and Kiess: BSJ **5,** 1205 (1930). Zeeman effect.

**Zr III**

1. Kiess and Kiess: JOSA **14,** 140 (1927) (A). Series.
2. Kiess and Lang: BSJ **5,** 305 (1930). Series.

**Zr IV**

1. Jones and Boyce: PRS **106,** 773 (1924). Constants of the Rydberg-Ritz equation. Quantum defect.
2. Bowen and Millikan: PR **28,** 923 (1926). Series.
3. Gibbs and White: PNAS **12,** 551 (1926). Rubidium like doublets.
4. Gibbs and White: PR **33,** 157 (1929). Doublets of stripped atoms.
5. Kiess and Lang: BSJ **5,** 305 (1930). Series.

## Columbium 41

**Cb I**

1. de Gramont: CR **171,** 1106 (1920). Ultimate lines.
2. de Gramont: CN **122,** 58 (1921). Ultimate lines.
3. Meggers: JWAS **14,** 442 (1924). Series and Zeeman effect.
4. Laporte: JOSA **13,** 1 (1926). Interpretation of spectra. Vector model. Zeeman effect.
5. Laporte: ZP **39,** 123 (1926). Ground terms of spectra of first and second long periods.
6. McLennan and Liggett: TRSC **20,** 377 (1926). Wave-lengths.
7. Meggers and Kiess: JOSA **12,** 417 (1926). Series.
8. McDonald: TRSC **21,** 223 (1927). Wave-lengths.
9. King: AJ **73,** 13 (1931). Furnace spectrum, with notes on hyperfine structure.
10. King and Meggers: PR **37,** 226 (1931) (A). Furnace spectrum.

**Cb II**

1. Laporte: JOSA **13,** 1 (1926). Interpretation of spectra. Vector model. Zeeman effect.
2. Laporte: ZP **39,** 123 (1926). Ground terms of spectra of first and second long periods.
3. Meggers and Kiess: JOSA **12,** 417 (1926). Multiplets, interval ratios, and Zeeman effects

**Cb III**

1. Gibbs and White: PR **31,** 520 (1928). Multiplets.

**Cb IV**

1. Gibbs and White: PR **31,** 520 (1928). Multiplets.

## Molybdenum 42

**Mo I**

1. de Gramont: CR **171,** 1106 (1920). Ultimate lines.
2. Kiess and Meggers: BSP **372,** Vol. **16,** 51 (1920). Wave-lengths.
3. McLennan and Lewis: PRS **98,** 109 (1920). Wave-lengths.
4. de Gramont: CN **122,** 58 (1921). Ultimate lines.
5. Catalan: AFQ **21,** 213 (1923); CR **176,** 247 and 1063 (1923). Series.
6. Catalan: AFQ **21,** 527 (1923). Zeeman effect.
7. Kiess: BSP **474,** Vol. **19,** 113 (1923). Series.
8. Hulburt: PR **24,** 129 (1924). Absorption in under-water spark.
9. Lang: PTRS **224,** 371 (1924). Ultraviolet wave-lengths.
10. Nagaoka and Sugiura: JJP **3,** 45 (1924). Stark effect.
11. Russell: AJ **61,** 223 (1925). Ultimate and penultimate lines.
12. Wilhelmy: VDPG **6,** 56 (1925). Zeeman effect.
13. Laporte: JOSA **13,** 1 (1926). Interpretation of spectra. Vector model. Zeeman effect.
14. Laporte: ZP **39,** 123 (1926). Ground terms of spectra of first and second long periods.

## MOLYBDENUM 42; MASURIUM 43; RUTHENIUM 44; RHODIUM 45

15. Meggers and Kiess: JOSA **12,** 417 (1926). Multiplets.
16. Wilhelmy: AP **80,** 305 (1926); Nw **14,** 49 (1926). Zeeman effect.
17. Allin and Ireton: TRSC **21,** 127 (1927). Wave-lengths.
18. Rolla and Piccardi: AAL **5,** 546 (1927). Ionization potential.
19. Frisch: ZP **71,** 89 (1931). Hyperfine structure.
20. Schuler and Keyston: ZP **68,** 174 (1931). Isotope abundance ratio and nuclear moment.
21. Setna: IJP **6,** 29 (1931). Infrared spectrum of under-water spark.

**Mo II**

1. Lang: PTRS **224,** 371 (1924). Wave-lengths.
2. Wilhelmy: VDPG **6,** 56 (1925). Zeeman effect.
3. Laporte: JOSA **13,** 1 (1926). Interpretation of spectra. Vector model. Zeeman effect.
4. Meggers and Kiess: JOSA **12,** 417 (1926). Multiplets.
5. Wilhelmy: AP **80,** 305 (1926). Zeeman effect.

## MASURIUM 43

**Ma I**

1. Laporte: ZP **39,** 123 (1926). Ground terms of spectra of first and second long periods.

## RUTHENIUM 44

**Ru I**

1. de Gramont: CR **171,** 1106 (1920). Ultimate lines.
2. de Gramont: CN **122,** 58 (1921). Ultimate lines.
3. Meggers: BSP No. 499, Vol. **20,** 19 (1925). Wave-lengths.
4. Meggers and Laporte: S **61,** 635 (1925). Series.
5. Sommer: Nw **13,** 840 (1925). Zeeman effect.
6. Clark and Cohen: TRSC **20,** 55 (1926). Wave-lengths.
7. Laporte: JOSA **13,** 1 (1926). Interpretation of spectra. Vector model. Zeeman effect.
8. Laporte: ZP **39,** 123 (1926). Ground terms of spectra of first and second long periods.
9. Meggers and Kiess: JOSA **12,** 417 (1926). Certain multiplets.
10. Meggers and Laporte: JWAS **16,** 143 (1926). Series.
11. Meggers and Laporte: PR **28,** 642 (1926). Absorption spectrum.
12. Sommer: ZP **37,** 1 (1926). Series and Zeeman effect.
13. Ireton and Keast: TRSC **23,** 13 (1929). Wave-lengths.

**Ru II**

1. Laporte: JOSA **13,** 1 (1926). Interpretation of spectra. Vector model. Zeeman effect.
2. Meggers and Shenstone: PR **35,** 868 (1930). Low levels of Ru II.

## RHODIUM 45

**Rh I**

1. de Gramont: CR **171,** 1106 (1920). Ultimate lines.
2. de Gramont: CN **122,** 58 (1921). Ultimate lines.
3. Hulburt: PR **24,** 129 (1924). Absorption in under-water spark.
4. Meggers: BSP No. 499, Vol. **20,** 19 (1925). Wave-lengths.
5. Sommer: Nw **13,** 392 (1925). Series.
6. Clark and Cohen: TRSC **20,** 55 (1926). Wave-lengths.
7. Laporte: JOSA **13,** 1 (1926). Interpretation of spectra. Vector model. Zeeman effect.
8. Laporte: ZP **39,** 123 (1926). Ground terms of spectra of first and second long periods.
9. Meggers and Kiess: JOSA **12,** 417 (1926). Certain multiplets.
10. Meggers and Laporte: PR **28,** 642 (1926). Absorption spectrum.
11. Laporte: PR **29,** 650 (1927). Screening constants from optical data.
12. Sommer: ZP **45,** 147 (1927). Series and Zeeman effect.
13. Ireton and Keast: TRSC **23,** 13 (1929). Wave-lengths.
14. Meggers, King and Bacher: PR **38,** 1258 (1931). Hyperfine structure and nuclear moment.

**Rh II**

1. Laporte: JOSA **13,** 1 (1926). Interpretation of spectra. Vector model. Zeeman effect.
2. Shenstone and Livingood: PR **36,** 380 (1930). (A). Series and Zeeman effect.

# Palladium 46; Silver 47


**Pd I**

1. de Gramont: CR **171,** 1106 (1920). Ultimate lines.
2. de Gramont: CN **122,** 58 (1921). Ultimate lines.
3. Catalan: PTRS **223,** 127 (1923). Series.
4. Beals: PRS **109,** 369 (1925). Series and Zeeman effect.
5. Meggers: BSP No. 499, Vol. **20,** 19 (1925). Wave-lengths.
6. Bechert and Catalan: ZP **35,** 449 (1926). Series.
7. Clark and Cohen: TRSC **20,** 55 (1926). Wave-lengths.
8. Laporte: JOSA **13,** 1 (1926). Interpretation of spectra. Vector model. Zeeman effect.
9. Laporte: ZP **39,** 123 (1926). Ground terms of spectra of first and second long periods.
10. Lewitsky: AP **80,** 397 (1926). Zeeman effect.
11. McLennan, Cohen and Liggett: TRSC **20,** 365 (1926). Absorption spectrum.
12. McLennan and Smith: PRS **112,** 110 (1926); TRSC **20,** 157 (1926). Series.
13. Meggers and Kiess: JOSA **12,** 417 (1926). Certain multiplets.
14. Meggers and Laporte: PR **28,** 642 (1926). Absorption spectrum.
15. Laporte: PR **29,** 650 (1927). Screening constants from optical data.
16. Ireton and Keast: TRSC **23,** 13 (1929). Wave-lengths.
17. Mack: PR **34,** 17 (1929). Vector coupling in Pd like spectra.
18. Laporte and Inglis: PR **35,** 1337 (1930). Resonance separations for $d^9s$ configurations.
19. Shenstone: PR **36,** 669 (1930). Series.
20. Guthrie and Copley: PR **38,** 360 (1931). Magnetic moment.

**Pd II**

1. Laporte: JOSA **13,** 1 (1926). Interpretation of spectra. Vector model. Zeeman effect.
2. McLennan and Smith: PRS **112,** 110 (1926). Series.
3. Shenstone: PR **32,** 30 (1928). Series.
4. Blair: PR **36,** 173 (1930). Extension of series.


## Silver 47


**Ag I**

1. Bloch and Bloch: CR **170,** 320 (1920). Wave-lengths.
2. Fues: AP **63,** 1 (1920). Selection rules. Displacement law. Calculation of constants in Ritz formula, and of series limits.
3. de Gramont: CR **171,** 1106 (1920). Ultimate lines.
4. Hicks: PM **39,** 457 (1920). Series.
5. McLennan, Young and Ireton: PRS **98,** 95 (1920). Wave-lengths.
6. Bloch and Bloch: JPR **2,** 229 (1921). Ultraviolet wave-lengths.
7. Gerlach and Stern: ZP **8,** 110 (1921). Magnetic moment.
8. de Gramont: CN **122,** 58 (1921). Ultimate lines.
9. Moore: AJ **54,** 246 (1921). Excitation stages in the open arc.
10. Walters, Jr.: BSP No. 411, Vol. **17,** 161 (1921). Wave-lengths.
11. Bloch and Bloch: CR **174,** 1456 (1922); JPR **3,** 309 (1922). Wave-lengths from under-water spark.
12. Campetti and Corsi: NC **24,** 117 (1922). Spectra of sparks in the middle of a flame.
13. Gerlach and Stern: ZP **9,** 349 and 353, (1922). Magnetic moment.
14. de Gramont: CR **175,** 1025 (1922). "Raies Ultimes" and spectral series.
15. van der Lingen: ZP **8,** 145 (1922). Electrodeless discharge.
16. Grotrian: ZP **18,** 169 (1923). Absorption spectrum.
17. Kimura and Nakamura: JJP **2,** 61 (1923). Line broadening and the Stark effect.
18. Royds: KB **73,** 53 (1923). Effect on wave-length in arc spectra of introducing foreign substances into the arc.
19. Shenstone: N **112,** 100 (1923). Ionization potential.
20. Wentzel: ZP **19,** 53 (1923). Rydberg's formula and deviating types of series.
21. Gerlach and Cilliers: ZP **26,** 106 (1924). Magnetic moment.
22. Hulburt: PR **24,** 129 (1924). Absorption in under-water spark.

## SILVER 47


23. Hund: ZP **22,** 405 (1924). Rydberg correction and radius of the atom core.
24. Landé: ZP **25,** 46 (1924). The absolute intervals of optical doublets. Doublet laws.
25. Lowery: PM **48,** 1122 (1924). Pole lines in interrupted arc.
26. Nagaoka and Sugiura: JJP **3,** 45 (1924). Distribution of electric field in metal arcs.
27. Sugiura: JJP **3,** 155 (1924). Calculation of doublet separations.
28. Turner: PM **48,** 384 (1924). Quantum defect.
29. Bloch and Bloch: JPR **6,** 105 and 154 (1925). Wave-lengths in Schumann region.
30. Buffan and Ireton: TRSC **19,** 113 (1925). Under-water spark spectra.
30a. Gerlach: AP **76,** 163 (1925). Magnetic moment.
31. Holtsmark and Trumpy: ZP **31,** 803 (1925). Broadening of lines and the Stark effect.
32. Lowery: PM **49,** 1176 (1925). Broadening of lines and the Stark effect.
33. McLennan and McLay: TRSC **19,** 89 (1925). Absorption spectrum.
34. Ruark and Chenault: PM **50,** 937 (1925). Fine structure.
35. Russell: AJ **61,** 223 (1925). Ultimate and penultimate lines.
36. Shenstone: PM **49,** 951 (1925). Series.
37. Sugiura: IPCR No. 28, Vol. **3,** 1 (1925). Calculation of doublet separations.
38. Zumstein: PR **25,** 523 (1925). Absorption spectrum.
39. Hori: IPCR No. 48, Vol. **4,** 59 (1926). Explosion spectra.
40. Laporte: ZP **39,** 123 (1926). Ground terms of spectra of first and second long periods.
41. Piccardi: AAL **3,** 489 (1926). Ionization potential.
42. Shenstone: PR **28,** 449 (1926). Series and Zeeman effect.
43. Taylor: PR **28,** 576 (1926). Magnetic moment.
44. Fujioka and Nakamura: AJ **65,** 201 (1927). Stark effect.
45. Fukuda: IPCR No. 85, Vol. **6,** 1 (1927). Explosion spectra. Broadening and reversal of lines.
46. Nagaoka, Nukiyama and Futagami: PIAT **3,** 319 (1927). Explosion spectra.
47. Kapuscinski: BIAS **6,** 284 (1929). Resonance radiation.
48. Loyarte and Williams: PZ **30,** 68 (1929). Absorption spectrum.
49. Prokofjew: ZP **57,** 387 (1929). Intensities of forbidden transitions.
50. Blair: PR **36,** 1531 (1930). Correction and extension of series.
51. Sambursky: PKAA **33,** 1025 (1930). Anomalous intensities.
52. Badami: PPS **43,** 538 (1931). Doublet regularities. Screening constants.
53. Frisch: ZP **71,** 89 (1931). Hyperfine structure.
54. Loyarte and Williams: UNLP **5,** 392 (1931). Absorption spectrum.
55. Mohammad and Sharma: IJP **6,** 75 (1931). Hyperfine structure.
56. Sambursky: ZP **68,** 774 (1931). Intensity ratios for multipole lines.
57. Schuler and Keyston: Nw **19,** 676 (1931). Hyperfine structure and nuclear moment.
58. Williams: CR **193,** 358 (1931). Ultimate rays and absorption lines.


**Ag II**


1. Bloch and Bloch: JPR **2,** 229 (1921). Wave-lengths.
2. Kimura and Nakamura: JJP **3,** 197 (1924). Wave-lengths.
3. Bloch and Bloch: JPR **6,** 154 (1925). Wave-lengths.
4. Beals: PM **2,** 770 (1926). Series.
5. Laporte: JOSA **13,** 1 (1926). Interpretation of spectra. Vector model. Zeeman effect.
6. McLennan and McLay: TRSC **22,** 1 (1928). Series.
7. Majumdar: IJP **2,** 257 (1928). Series.
8. Shenstone: PR **31,** 317 and 707 (1928) (A); PR **32,** 30 (1928). Series.
9. Mack: PR **34,** 17 (1929). Vector coupling in Pd like spectra.
10. Shenstone and Blair: PM **8,** 765 (1929). Analysis of a spectrum by means of unresolved Zeeman patterns.
11. Blair: PR **36,** 173 (1930). Series.
12. Laporte and Inglis: PR **35,** 1337 (1930). Resonance separations for $d^9s$ configurations.
13. Kato: IPCR No. 294, Vol. **15,** 161 (1931). Absorption spectrum.

## Silver 47; Cadmium 48

**Ag III**


1. Kimura and Nakamura: JJP **3,** 197 (1924). Wave-lengths.
2. Gibbs and White: PR **32,** 318 (1928). (A). Certain doublets and quartets.


## Cadmium 48

**Cd I**


1. Bates: PM **39,** 353 (1920). A new Cd vapour arc lamp.
2. Dobbie and Fox: PRS **98,** 147 (1920). Absorption spectrum.
3. Fues: AP **63,** 1 (1920). Selection rules. Displacement law. Calculation of constants in Ritz formula, and of series limits.
4. de Gramont: CR **170,** 31 (1920). Variability of arc spectrum; presence of spark lines.
5. de Gramont: CR **171,** 1106 (1920). Ultimate lines.
6. King: AJ **51,** 179 (1920). Furnace spectrum.
7. McLennan, Young and Ireton: PRS **98,** 95 (1920). Wave-lengths.
8. Mohler, Foote and Meggers: BSP No. 403, Vol. **16,** 725 (1920); JOSA **4,** 364 (1920). Resonance potentials and low voltage arcs.
9. Polvani: NC **20,** 119 (1920). Time variations in the spectrum of an electric discharge.
10. Sand: PM **39,** 678 (1920). On the new Cd vapour arc lamp.
11. Sommerfeld: AP **63,** 221 (1920). Interpretation of spectra.
12. Bloch and Bloch: CR **172,** 803 (1921); JPR **2,** 229 (1921). Ultraviolet wave-lengths.
13. Franck: PZ **22,** 409 (1921). Excitation by electron impact.
14. de Gramont: CN **122,** 58 (1921). Ultimate lines.
15. Moore: AJ **54,** 246 (1921). Excitation stages in the open arc.
16. Paschen and Back: P **1,** 261 (1921). Zeeman effect.
17. Walters, Jr.: BSP No. 411, Vol. **17,** 161 (1921). Wave-lengths.
18. Annual report director Mount Wilson Observatory. Year book of Carnegie Institution for 1921, page 215.
19. Bloch and Bloch: JPR **3,** 309 (1922). Wave-lengths from under-water spark.
20. Brown: AJ **56,** 53 (1922). Wave-lengths.
21. Campetti and Corsi: NC **24,** 117 (1922). On the spectra of sparks in the middle of a flame.
22. Carter: AJ **55,** 162 (1922). Vacuum spark spectra of metals.
23. de Gramont: CR **175,** 1025 (1922). "Raies Ultimes" and spectral series.
24. Hemsalech and de Gramont: PM **43,** 834 (1922). Occurrence of enhanced lines in the arc.
25. van der Lingen: ZP **8,** 145 (1922). Electrodeless discharge.
26. Meggers: JOSA **6,** 135 (1922). Standard wave-lengths.
27. Meggers and Burns: BSP No. 441, Vol. **18,** 185 (1922). Notes on standard wave-lengths.
28. Back: AP **70,** 333 (1923). Zeeman effect.
29. Cario and Franck: ZP **17,** 202 (1923). Sensitized fluorescence of gases.
30. Minkowski: ZP **18,** 258 (1923). Free path of electrons in Cd vapour.
31. St. Procopiu: CR **176,** 385 and 504 (1923). Flame, arc, and spark lines from arcs in vacuo.
32. Takamine and Fukuda: JJP **2,** 111 (1923). Spectrum of constricted arc.
33. Wentzel: ZP **19,** 53 (1923). Rydberg's formula and deviating types of series.
34. Birge: JOSA **8,** 233 (1924). Series of divalent elements.
35. Dorgelo: ZP **22,** 170 (1924). Multiplet intensities.
36. Hulburt: PR **24,** 129 (1924). Absorption in under-water spark.
37. Kimura and Nakamura: JJP **3,** 29 and 43 (1924). Cathode spectra of metals.
38. Landé: ZP **25,** 46 (1924). Absolute intervals of optical doublets and triplets. Doublet laws.
39. Lang: PTRS **224,** 371 (1924). Ultraviolet wave-lengths.
40. Nagaoka and Sugiura: JJP **3,** 45 (1924). Stark effect.
41. Randall and St. Peter: PR **23,** 766 (1924). (A). Infrared spectrum.
42. St. Procopiu: AsP **1,** 89 (1924). Spectra from arcs on immersion in various media.
43. St. Procopiu: CR **178,** 1368 (1924). Ultimate lines from the electric arc.
44. St. Procopiu: JPR **5,** 220 (1924). Line width at various pressures.
45. Stücklen: ZP **30,** 24 (1924). Absorption spectrum.

## Cadmium 48

46. Sugiura: JJP **3,** 155 (1924). Calculation of doublet and triplet separations.
47. Turner: PM **48,** 384 (1924). Quantum defect.
48. Wallerath: AP **75,** 37 (1924). Secondary wave-length standards.
49. Brown and Beams: JOSA **11,** 11 (1925). Order of appearance of spectral lines.
50. Foote, Takamine and Chenault: PR **26,** 165 (1925). Excitation of forbidden lines.
51. Fukuda: IPCR No. 37, Vol. **3,** 183 (1925). Change of wave-length in a condensed discharge.
52. Hertzfeld and Wolf: AP **76,** 71 and 567 (1925). A test of the classsical dispersion formula. The number of dispersion electrons.
53. Joos: PZ **26,** 357 and 380 (1925). Regularities in hyperfine structure.
54. Ruark: JOSA **11,** 199 (1925). Extension of subordinate series. *PP'* groups.
55. Ruark and Chenault: JOSA **10,** 653 (1925). Stages in excitation.
56. Ruark and Chenault: PM **50,** 937 (1925). Fine structure.
57. Russell: AJ **61,** 223 (1925). Ultimate and penultimate lines.
58. Smith: AJ **61,** 186 (1925). Spectra of exploded wires.
59. Sugiura: IPCR No. 28, Vol. **3,** 1 (1925). Calculation of doublet and triplet separations.
60. Terenin: ZP **31,** 26 (1925). Optical excitation.
61. von Wisniewski: PZ **26,** 255 (1925). Calculation of *s*-terms.
62. Beams: PR **28,** 475 (1926). Time interval for excitation of spectra.
63. Brown: JOSA **13,** 183 (1926). Wave-length of red line in arc and discharge tube.
64. Deppermann: AJ **63,** 33 (1926). Stark effect.
65. Esclangon: JPR **7,** 52 (1926). Wave-lengths.
66. Frayne and Smith: PM **1,** 732 (1926). Absorption spectrum.
67. Fujioka: IPCR No. 68, **5,** 45 (1926). Stark effect.
68. Fukuda: IPCR No. 54, **4,** 167 (1926). Change in wave-length of red line due to self-inductance.
69. Fukuda: IPCR No. 55, **4,** 171 (1926). New lines, ($1s-2p_{1,3}$).
70. Fukuda, Kuyama and Uchida: IPCR No. **56,** 177 (1926). Spectra of metals under heavy current excitation. Forbidden lines.
71. Hori: IPCR No. 53, **4,** 59 (1926). Explosion spectra.
72. Kuhn: MK **7,** No. 12, 1 (1926). Anomalous dispersion in nonluminous vapours. Intensity data.
73. Kuhn: Nw **14,** 48 (1926). Intensity of absorption lines.
74. MacNair: PM **2,** 613 (1926); PNAS **12,** 555 (1926). Fine structure.
75. Nagaoka and Mishima: PIAT **2,** 201 (1926). Fine structure.
76. Rayleigh: PRS **112,** 14 (1926). Studies on luminous vapour distilled from metallic arcs.
77. Ruark: PM **1,** 977 (1926). Zeeman effect.
78. Sawyer: JOSA **13,** 431 (1926). Deep-lying terms in 2 and 3 electron spectra. *PP'* groups.
79. Snoek and Bouma: ZP **38,** 368 (1926). Intensity distribution in fine structure.
80. Unsöld: ZP **36,** 92 (1926). Polarizability. Calculation of quantum defect.
81. Wood: PM **2,** 611 (1926). Structure of resonance lines.
82. Burger and van Cittert: ZP **44,** 58 (1927). True and apparent breadth of $\lambda$6439.
83. Fukuda: IPCR No. 85, Vol. **6,** 1 (1927). Explosion spectra. Broadening and reversal of lines.
84. Kichlu and Saha: PM **4,** 193 (1927). Spectra of metals of group II.
85. Leu: ZP **41,** 551 (1927). Magnetic moment.
86. MacNair: PR **29,** 677 (1927). Polarization of resonance radiation.
87. Mohammad and Mathur: PM **4,** 112 (1927). Fine structure.
88. Mohler: PR **29,** 419 (1927). Excitation by atomic hydrogen.
89. Mohler and Moore: JOSA **15,** 74 (1927). Absorption spectrum.
90. Nagaoka, Nukiyama and Futagami: PIAT **3,** 324 (1927). Explosion spectra.
91. Ornstein and Burger: Nw **15,** 670 (1927). Intensities in forbidden multiplets.
92. Paschen: SAWB **29,** 207 (1927). Excitation through the metastable condition of rare gas atoms.

## Cadmium 48

93. Schrammen: AP **83,** 1161 (1927). Hyperfine structure.
94. Soleillet: CR **185,** 198 (1927). Influence of magnetic field on resonance radiation.
95. Unsöld: AP **82,** 355 (1927). Calculation of terms.
96. Locher: JOSA **17,** 91 (1928). Time intervals between the appearance of spectral lines.
97. Okubo and Hamada: PM **5,** 372 (1928). Excitation by active nitrogen.
98. Schrammen: AP **87,** 638 (1928). Hyperfine structure.
99. Soleillet: CR **187,** 212 (1928). Polarization of resonance radiation.
100. Taylor: PM **5,** 166 (1928). Intensities of forbidden multiplets.
101. Crew: PM **7,** 312 (1929). Influence of a hydrogen atmosphere upon the arc spectrum.
102. Ellett: PR **33,** 124 (1929). (A) Polarization of resonance radiation.
103. Goudsmit: Nw **17,** 805 (1929). Hyperfine structure.
104. Goudsmit and Bacher: PR **34,** 1501 (1929). Hyperfine structure separations.
105. Houston: PR **33,** 297 (1929). Calculation of energy levels and Zeeman effect from Schrödinger equation.
106. Schüler and Brück: ZP **56,** 291 (1929); ZP **58,** 735 (1929). Hyperfine structure.
107. Takahashi: AP **3,** 49 (1929). Excitation in the negative glow of a Helium discharge.
108. White: PR **34,** 1288 and 1404 (1929). Interpretation of hyperfine structure.
109. Albright: PR **36,** 847 (1930). Hyperfine structure.
110. Bender: PR **36,** 1535 (1930). Effect of gases on the optically excited spectrum of Cd I.
111. Colson: PR **35,** 294 (1930). (A). Voltage intensity relations.
112. Hofmann: ZP **60,** 457 (1930). Absorption of electrically excited vapours.
113. Stark: PZ **31,** 374 (1930). Zeeman effect of hyperfine structure.
114. White: PR **35,** 441 (1930). Nuclear spin and hyperfine structure.
115. Badami: PPS **43,** 538 (1931). Doublet regularities. Screening constants.
116. Bartlett, Jr.: PR **37,** 327 (1931). Nuclear spin.
117. Campbell and Houston: PR **38,** 581 (1931). Zeeman effect.
118. Jackson: PRS **133,** 553 (1931). Interferometer measurement of red line.
119. Knorr: PR **37,** 1611 (1931). Time interval for the appearance of lines in a condensed spark.
120. Kronig and Frisch: PZ **32,** 457 (1931). Nuclear moments. A review. Bibliography.
121. Larche: PZ **32,** 180 (1931). Excitation functions.
122. Larche: ZP **67,** 440 (1931). Voltage intensity relations.
123. Majorana: NC **8,** 107 (1931). Theory of anomalous $P'$ triplet.
124. Mitchell: PR **38,** 473 (1931). Effect of hyperfine structure on the polarization of Cd resonance radiation.
125. Okubo and Matuyama: N **128,** 224 (1931). Forbidden lines in the high frequency discharge.
126. Okubo and Matuyama: PR **38,** 1651 (1931). Appearance of forbidden lines, and intensity modifications under high frequency excitation.
127. Schüler and Keyston: ZP **67,** 433 (1931). Intensity measurements in hyperfine structure.
128. Schüler and Keyston: ZP **68,** 174 (1931). Isotope abundance ratio and nuclear moment.
129. Schüler and Keyston: ZP **71,** 413 (1931). Intensity variations in hyperfine structure components.
130. Setna: IJP **6,** 29 (1931). Infrared spectrum of under-water spark.
131. Zemansky: ZP **72,** 587 (1931). Absorption of resonance radiation. Life of $2'P_1$ state.

**Cd II**

1. Bloch and Bloch: CR **170,** 320 (1920). Wave-lengths.
2. Fues: AP **63,** 1 (1920). Selection rules. Displacement law. Calculation of constants in Ritz formula, and of series limits.
3. Bloch and Bloch: CR **172,** 803 (1921); JPR **2,** 229 (1921). Ultraviolet wave-lengths.
4. Hemsalech and de Gramont: PM **43,** 834 (1922). Occurrence of enhanced lines in the arc.
5. Hund: ZP **22,** 405 (1924). Rydberg correction and radius of the atom core.
6. Kimura: JJP **3,** 217 (1924). Wave-lengths.

## Cadmium 48; Indium 49


7. Kimura and Nakamura: JJP **3**, 197 (1924). Wave-lengths.
8. Landé: ZP **25**, 46 (1924). The absolute intervals of optical doublets and triplets. Doublet laws.
9. Lang: PTRS **224**, 371 (1924). Wave-lengths.
10. Stücklen: ZP **30**, 24 (1924). Absorption spectrum.
11. Turner: PM **48**, 384 (1924). Quantum defect.
12. Brown and Beams: JOSA **11**, 11 (1925). Order of appearance of spectral lines.
13. Russell: AJ **61**, 223 (1925). Ultimate and penultimate lines.
14. Salis: AP **76**, 145 (1925). Series.
15. Beams: PR **28**, 475 (1926). Time interval for excitation of spectra.
16. Esclangan: JPR **7**, 52 (1926). Wave-lengths.
17. Rayleigh: PRS **112**, 14 (1926). Studies on the luminous vapour distilled from metallic arcs.
18. Paschen: SAWB **29**, 207 (1927). Excitation through the metastable condition of the rare gas atom.
19. McLennan, McLay and Crawford: TRSC **22**, 45 (1928). Series.
20. Goudsmit and Bacher: PR **34**, 1501 (1929). Hyperfine structure separations.
21. Lang: PNAS **15**, 414 (1929). Series.
22. McLennan and Allin: PM **8**, 515 (1929). Fine structure.
23. Takahashi: AP **3**, 27 (1929). Series.
24. Takahashi: AP **3**, 49 (1929). Excitation in the negative glow of a helium discharge.
25. Dunnington and Lawrence: PR **35**, 134 (1930). (A) Stark effect in spark discharge.
26. Badami: PPS **43**, 538 (1931). Doublet regularities. Screening constants.
27. Larche: ZP **67**, 440 (1931). Voltage intensity relations.

**Cd III**

1. Kimura and Nakamura: JJP **3**, 197 (1924). Wave-lengths.
2. Esclangan: JPR **7**, 52 (1926). Wave-lengths.
3. Gibbs and White: PR **31**, 776 (1928). Certain multiplets.
4. McLennan, McLay and Crawford: TRSC **22**, 45 (1928). Series.
5. Mack: PR **34**, 17 (1929). Vector coupling in Pd like spectra.
6. Laporte and Inglis: PR **35**, 1337 (1930). Resonance separations for $d^9s$ configurations.
7. Larche: ZP **67**, 440 (1931). Voltage intensity relations.

**Cd IV**

1. Esclangan: JPR **7**, 52 (1926). Wave-lengths.


## Indium 49


**In I**

1. de Gramont: CR **171**, 1106 (1920). Ultimate lines.
2. Dauvillier: CR **173**, 1458 (1921). Contribution to study of spectra of elements of medium atomic number.
3. de Gramont: CN **122**, 58 (1921). Ultimate lines.
4. de Gramont: CR **175**, 1025 (1922). "Raies Ultimes" and spectral series.
5. Uhler and Tanch: AJ **55**, 291 (1922). Wave-lengths. Series formulae.
6. Carroll: PRS **103**, 334 (1923). Series of aluminum sub-group.
7. Grotrian: ZP **12**, 218 (1922). Absorption spectrum.
8. Mohler and Ruark: JOSA **7**, 819 (1923). Stages in excitation.
9. Landé: ZP **25**, 46 (1924). The absolute intervals of optical doublets and triplets. Doublet laws.
10. Ruark, Mohler, Foote and Chenault: BSP No. 490, Vol. **19**, 463 (1924). Series and critical potentials.
11. Sugiura: JJP **3**, 155 (1924). Calculation of doublet and triplet separations.
12. Turner: PM **48**, 384 (1924). Quantum defect.
13. Rao: PPS **37**, 259 (1925). Series. Absorption spectrum.

## Indium 49; Tin 50

14. Ruark: JOSA **11,** 199 (1925). Classification of $PP'$ transitions.
15. Ruark and Chenault: PM **50,** 937 (1925). Fine structure.
16. Russell: AJ **61,** 223 (1925). Ultimate and penultimate lines.
17. Sugiura: IPCR Vol. 3, No. **28,** 1 (1925). Calculation of doublet and triplet separations.
18. von Wisniewski: PZ **26,** 255 (1925). Calculation of $s$-terms.
19. Frayne and Smith: PR **27,** 23 (1926). Absorption spectrum.
20. Hartree: PCPS **23,** 304 (1926). Quantum defect.
21. Frayne and Jarvis: PR **29,** 673 (1927). Stages in excitation.
22. Jarvis: PR **29,** 442 (1927). Ionization and resonance potentials.
23. Smith and Muskat: PR **29,** 663 (1927). Absorption in under-water spark.
24. Frayne: PR **31,** 152 (1928). (A) Unclassified lines.
25. Lansing: PR **34,** 597 (1929). New terms.
26. Sawyer and Lang: PR **34,** 712 (1929). Series.
27. Jackson: PRS **128,** 508 (1930). Hyperfine structure.
28. McLennan and Allin: PRS **129,** 208 (1930). Hyperfine structure.
29. Campbell and Bacher: PR **38,** 1906 (1931). Hyperfine structure and nuclear moment.
30. Goudsmit: PR **37,** 663 and 1014 (1931). (A) Theory of hyperfine structure separations.
31. Jackson: N **127,** 924 (1931). Nuclear moment.
32. Kronig and Frisch: PZ **32,** 457 (1931). Nuclear moments. A review. Bibliography.
33. McLennan, Allin and Hall: PRS **133,** 333 (1931). Nuclear moment.
34. Narayan: N **128,** 675 (1931). Hyperfine structure.

**In II**

1. Weinberg: PRS **107,** 138 (1925). Wave-lengths.
2. Green and Loring: PR **30,** 574 (1927). Certain separations predicted by irregular doublet law.
3. Lang: PR **30,** 762 (1927). Series.
4. Rao: PPS **39,** 161 (1927). Series.
5. Green and Lang: PNAS **14,** 706 (1928). Series.
6. Rao, Narayan and Rao: IJP **2,** 467 (1928). Series.
7. Lang: PNAS **15,** 414 (1929). Series.
8. Lang: PR **35,** 126 (1930). (A). Ground term of In II.
9. McLennan and Allin: PRS **129,** 208 (1930). Hyperfine structure.
10. Badami: PPS **43,** 538 (1931). Doublet regularities. Screening constants.
11. Lang and Sawyer: ZP **71,** 453 (1931). Series.

**In III**

1. Fues: AP **76,** 299 (1925). Calculation of terms.
2. Carroll: PTRS **225,** 357 (1926). Series.
3. Hartree: PCPS **23,** 304 (1926). Quantum defect.
4. Lang: PNAS **13,** 341 (1927). Series.
5. Rao: PPS **39,** 150 (1927). Series.
6. Rao, Narayan and Rao: IJP **2,** 477 (1928). Series.
7. Lang: PNAS **15,** 414 (1929). Series.
8. Badami: PPS **43,** 538 (1931). Doublet regularities. Screening constants.

**In IV**

1. Gibbs and White: PR **31,** 776 (1928). Certain multiplets.
2. Mack: PR **34,** 17 (1929). Vector coupling in Pd like spectra.
3. Laporte and Inglis: PR **35,** 1337 (1930). Resonance separations for $d^9s$ configurations.

## Tin 50

**Sn I**

1. de Gramont: CR **170,** 31 (1920). Variability of arc spectrum. Presence of spark lines.
2. de Gramont: CR **171,** 1106 (1920). Ultimate lines.
3. van der Harst: PKAA **22,** 300 (1920). Zeeman effect.

## Tin 50

4. McLennan, Young and Ireton: PRS **98,** 95 (1920). Wave-lengths.
5. Bloch and Bloch: JPR **2,** 229 (1921). Ultraviolet wave-lengths.
6. de Gramont: CN **122,** 58 (1921). Ultimate lines.
7. Walters, Jr.: BSP No. 411, Vol. **17,** 161 (1921). Wave-lengths.
8. Bloch and Bloch: JPR **3,** 309 (1922). Wave-lengths from under-water spark.
9. Hemsalech and de Gramont: PM **43,** 287 (1922). Occurrence of spark lines in the arc.
10. Grotrian: ZP **18,** 169 (1923). Absorption spectrum.
11. Loyarte: UNLP No. **86,** 409 (1923). Ionization potential.
12. Mitra: AsP **19,** 315 (1923). Ultraviolet standards.
13. Gerlach and Cilliers: ZP **26,** 106 (1924). Magnetic moment.
14. Hulburt: PR **24,** 129 (1924). Absorption in under-water spark.
15. Kimura and Nakamura: JJP **3,** 29 (1924). Cathode spectra of metals.
16. Lang: PTRS **224,** 371 (1924). Ultraviolet wave-lengths.
17. McLennan, Young and McLay: TRSC **18,** 57 (1924). Absorption and series spectra.
18. Nagaoka and Sugiura: JJP **3,** 45 (1924). Stark effect.
19. Sur and Sharma: JMC **1,** No. 4, 121 (1924). Absorption spectrum.
20. Gerlach: AP **76,** 163 (1925). Magnetic moment.
21. van der Harst: ANSE **9,** 1 (1925). Zeeman effect.
22. Narayan and Rao: PM **50,** 645 (1925). Absorption spectrum.
23. Ruark and Chenault: PM **50,** 937 (1925). Fine structure.
24. Smith: AJ **61,** 186 (1925). Spectra of exploded wires.
25. Sponer: ZP **32,** 19 (1925). Series.
26. Frayne and Smith: PM **1,** 732 (1926). Absorption spectrum.
27. Zumstein: PR **27,** 150 (1926). Absorption spectrum.
28. Back: ZP **43,** 309 (1927). Series spectrum and Zeeman effect.
29. Fukuda: IPCR No. 85, Vol. **6,** 1 (1927). Explosion spectra. Broadening and reversal of lines.
30. Green and Loring: PNAS **13,** 347 (1927); PR **30,** 574 (1927). Series spectrum and Zeeman effects.
31. Nagaoka, Nukiyama and Futagami: PIAT **3,** 392 (1927). Explosion spectra.
32. Sur: ZP **41,** 791 (1927). Series.
33. Williams and Charola: JPR **9,** 377 (1928). Series.
34. Houston: PR **33,** 297 (1929). Calculation of energy levels and Zeeman effect from Schrödinger equation.
35. Loyarte and Williams: PZ **30,** 68 (1929). Absorption spectrum.
36. Green: PR **37,** 469 (1931). (A). Multiplet separations and Zeeman effects.
37. Murakawa: ZP **72,** 793 (1931). Hyperfine structure.
38. Randall and Wright: PR **38,** 457 (1931). Wave-lengths in infrared.
39. Schüler and Keyston: ZP **68,** 174 (1931). Isotope abundance ratio and nuclear moment.
40. Williams: CR **193,** 358 (1931). Ultimate rays and absorption lines.

**Sn II**

1. Bloch and Bloch: CR **171,** 709 (1920). Wave-lengths.
2. Bloch and Bloch: JPR **2,** 229 (1921). Wave-lengths.
3. Hemsalech and de Gramont: PM **43,** 287 (1922). Occurrence of spark lines in the arc.
4. Bloch and Bloch: CR **177,** 1025 (1923). Wave-lengths.
5. Mitra: AsP **19,** 315 (1923). Ultraviolet standards.
6. Kimura: JJP **3,** 217 (1924). Wave-lengths.
7. Kimura and Nakamura: JJP **3,** 197 (1924). Wave-lengths.
8. Lang: PTRS **224,** 371 (1924). Wave-lengths.
9. Green and Loring: PNAS **13,** 492 (1927). Zeeman effect.
10. Green and Loring: PR **30,** 574 (1927). Series spectrum and Zeeman effect.
11. Narayan and Rao: ZP **45,** 350 (1927). Series.
12. Rao: PPS **39,** 161 (1927). Series.

## Tin 50; Antimony 51


13. Lang: PNAS **15**, 414 (1929). Series.
14. Lang: PR **35**, 445 (1930). Series.
15. Zumstein and Marston: PR **38**, 305 (1931). Wave-length standards in the Schumann region.

**Sn III**

1. Kimura: JJP **3**, 217 (1924). Wave-lengths.
2. Kimura and Nakamura: JJP **3**, 197 (1924). Wave-lengths.
3. Green and Loring: PNAS **13**, 492 (1927). Zeeman effect.
4. Green and Loring: PR **30**, 574 (1927). Series spectrum and Zeeman effect.
5. Rao: PPS **39**, 161 (1927). Series.
6. Gibbs and Vieweg: PR **34**, 400 (1929). Cd like isoelectronic sequence. Series.
7. Badami: PPS **43**, 538 (1931). Doublet regularities. Screening constants.
8. Green: PR **37**, 469 (1931). (A). Multiplet separations and Zeeman effect.
9. Green and Loring: PR **38**, 1289 (1931). Multiplet structure and Zeeman effect.

**Sn IV**

1. Kimura and Nakamura: JJP **3**, 197 (1924). Wave-lengths.
2. Fues: AP **76**, 299 (1925). Calculation of terms.
3. Carroll: PTRS **225**, 357 (1926). Series.
4. Lang: PNAS **13**, 341 (1927). Series.
5. Rao: PPS **39**, 408 (1927). Series.
6. Rao, Narayan and Rao: IJP **2**, 477 (1928). Series.
7. Lang: PNAS **15**, 414 (1929). Series.
8. Badami: PPS **43**, 538 (1931). Doublet regularities. Screening constants.

**Sn V**

1. Gibbs and White: PNAS **14**, 345 (1928); PR **31**, 1124 (1928). (A). Series.
2. Gibbs, Vieweg and Gartlein: PR **34**, 406 (1929). Use of series inductance in vacuum spark spectra.
4. Laporte and Inglis: PR **35**, 1337 (1930). Resonance separations for $d^9s$ configurations.


## Antimony 51


**Sb I**

1. Bloch and Bloch: CR **171**, 709 (1920). Wave-lengths.
2. de Gramont: CR **170**, 31 (1920). Variability of arc spectrum. Presence of spark lines.
3. de Gramont: CR **171**, 1106 (1920). Ultimate lines.
4. van der Harst: PKAA **22**, 300 (1920). Spectra of Sb in a magnetic field.
5. McLennan, Young and Ireton: PRS **98**, 95 (1920). Wave-lengths.
6. Bloch and Bloch: JPR **2**, 229 (1921). Ultraviolet wave-lengths.
7. de Gramont: CN **122**, 58 (1921). Ultimate lines.
8. Walters, Jr.: BSP No. 411, Vol. **17**, 161 (1921). Wave-lengths.
9. Bloch and Bloch: JPR **3**, 309 (1922). Wave-lengths from under-water spark.
10. Grotrian: ZP **18**, 169 (1923). Absorption spectrum.
11. Hulburt: PR **24**, 129 (1924). Absorption in under-water spark.
12. Lang: PTRS **224**, 371 (1924). Ultraviolet wave-lengths.
13. Ruark, Mohler, Foote and Chenault: BSP No. 490, Vol. **19**, 463 (1924). Series. Critical potentials.
14. Buffam and Ireton: TRSC **19**, 113 (1925). Under-water spark spectrum.
15. Gerlach: AP **76**, 163 (1925). Magnetic moment.
16. van der Harst: ANSE **9**, 1 (1925). Zeeman effect.
17. McLennan and McLay: TRSC **19**, 89 (1925). Absorption spectrum.
18. Narayan and Rao: PM **50**, 645 (1925). Absorption spectrum.
19. Russell: AJ **61**, 223 (1925). Ultimate and penultimate lines.
20. Frayne and Smith: PM **1**, 732 (1926). Absorption spectrum.

## Antimony 51; Tellurium 52


21. Terenin: ZP **37**, 98 (1926). Optical excitation.
22. McLennan and McLay: TRSC **21**, 63 (1927). Series.
23. Green and Loring: PR **31**, 707 (1928). (A). Series.
24. Malurkar: PCPS **24**, 85 (1928). Wave-lengths.
25. Charola: UNLP No. **89**, 205 (1929). Absorption spectrum and new terms.
26. Green and Loring: PR **33**, 286 (1929). (A). Exception to Pauli's *g*-sum rule.
27. Löwenthal: ZP **57**, 822 (1929). Zeeman effects and hyperfine structure.
28. Charola: PZ **31**, 457 (1930). Absorption spectrum and new terms.
29. Green: PR **37**, 469 (1931). (A). Multiplet separations and Zeeman effects.
30. Green and Loring: PR **38**, 1289 (1931). Multiplet structure and Zeeman effect.
31. Kronig and Frisch: PZ **32**, 457 (1931). Nuclear moments. A review. Bibliography.
32. Williams: CR **193**, 358 (1931). Ultimate rays and absorption series.

**Sb II**

1. Bloch and Bloch: CR **171**, 709 (1920). Wave-lengths.
2. Bloch and Bloch: JPR **2**, 229 (1921). Wave-lengths.
3. Bloch and Bloch: CR **178**, 472 (1924). Wave-lengths.
4. Kimura: JJP **3**, 217 (1924). Wave-lengths.
5. Kimura and Nakamura: JJP **3**, 197 (1924). Wave-lengths.
6. Lang: PTRS **224**, 371 (1924). Wave-lengths.
7. Soulillou: CR **188**, 1103 (1929). Wave-lengths.
8. Dhavale: N **126**, 97 (1930). Series.
9. Dhavale: PRS **131**, 109 (1931). Series.

**Sb III**

1. Kimura: JJP **3**, 217 (1924). Wave-lengths.
2. Kimura and Nakamura: JJP **3**, 197 (1924). Wave-lengths.
3. Lang: PR **32**, 737 (1928). Series.
4. Pattabhiramiah and Rao: IJP **3**, 437 (1929). Series.
5. Soulillou: CR **188**, 1103 (1929). Wave-lengths.
6. Lang: PR **35**, 445 and 664 (A) (1930). Series.
7. Rao: PRS **133**, 220 (1931). Term values.

**Sb IV**

1. Kimura and Nakamura: JJP **3**, 197 (1924). Wave-lengths.
2. Green and Lang: N **122**, 242 (1928); PNAS **14**, 706 (1928). Series.
3. Gibbs and Vieweg: PR **34**, 400 (1929). Cd like isoelectronic sequence. Series.
4. Gibbs. Vieweg and Gartlein: PR **34**, 406 (1929). Use of series inductance in vacuum spark spectra.
5. Lang: PNAS **15**, 414 (1929). Series.
6. Soulillou: CR **188**, 1103 (1929). Wave-lengths.
7. Badami: PPS **43**, 538 (1931). Series.

**Sb V**

1. Lang: PNAS **13**, 341 (1927). Series.
2. Badami: PPS **43**, 538 (1931). Series.


## Tellurium 52


**Te I**

1. McLennan and Lewis: PRS **98**, 109 (1920). Wave-lengths.
2. Hopfield: N **112**, 437 (1923). New triplets.
3. Hopfield and Birge: N **112**, 790 (1923). Series.
4. Lang: PTRS **224**, 371 (1924). Ultraviolet wave-lengths.
5. McLennan, Smith and Peters: TRSC **19**, 39 (1925). Infrared wave-lengths.
6. McLennan and Cooley: TRSC **20**, 349 (1926). Absorption spectrum.

## Tellurium 52; Iodine 53

7. Zumstein: PR **27**, 562 (1926). Absorption spectrum.
8. Allin: TRSC **21**, 231 (1927). Under-water spark spectrum.
9. McLennan, McLay and McLeod: PM **4**, 486 (1927). Spectra of the oxygen group.
10. Lacroute: JPR **9**, 180 (1928). Wave-lengths.
11. McLennan and Crawford: N **124**, 874 (1929). Low levels for oxygen group.
12. Bloch and Bloch: AsP **13**, 233 (1930). Wave-lengths.
13. Natanson: ZP **65**, 75 (1931). Intensity variations in resonance spectrum due to pressure.

**Te II**

1. Lang: PTRS **224**, 371 (1924). Wave-lengths.
2. Bloch and Bloch: CR **187**, 562 (1928). Wave-lengths.
3. Lacroute: JPR **9**, 180 (1928). Wave-lengths.
4. Bloch and Bloch: AsP **13**, 233 (1930). Wave-lengths.

**Te III**

1. Bloch and Bloch: CR **187**, 562 (1928). Wave-lengths.
2. Bloch and Bloch: AsP **13**, 233 (1930). Wave-lengths.

**Te IV**

1. Bloch and Bloch: CR **187**, 562 (1928). Wave-lengths.
2. Bloch and Bloch: AsP **13**, 233 (1930). Wave-lengths.
3. Rao: N **127**, 236 (1931); PRS **133**, 220 (1931). Series.

**Te V**

1. Gibbs and Vieweg: PR **34**, 400 (1929). Cd like isoelectronic sequence. Series.

**Te VI**

1. Lang: PNAS **13**, 341 (1927). Series.
2. Rao: N **127**, 236 (1931); PRS **133**, 220 (1931). Series.

## Iodine 53

**I I**

1. Compton and Smythe: PR **16**, 501 (1920); 51, 571 (1920). Ionizing potential.
2. Found: PR **16**, 41 (1920). Ionization potentials.
3. de Gramont: CR **171**, 1106 (1920). Ultimate lines.
4. Mohler and Foote: BSP **400**, Vol. **16**, 669 (1920); PR **15**, 321 (1920). Ionization and resonance potentials.
5. de Gramont: CN **122**, 58 (1921). Ultimate lines.
6. Duffendack: PR **20**, 665 (1922). Low voltage arc.
7. Landau-Ziemecki: PM **44**, 651 (1922). Wave-lengths.
8. Robertson: PR **19**, 470 (1922); TRSC **16**, 151 (1922). Spectrum of electrodeless discharge.
9. Steubing: PZ **23**, 427 (1922). Stark effect.
10. Füchtbauer, Waibel and Holm: ZP **29**, 367 (1924). An absorption line.
11. Gerlach and Gromann: Nw **12**, 578 (1924). An absorption line.
12. West and Ludlam: PRSE **45**, 34 (1924/25). Ionization of iodine vapour by ultraviolet light.
13. Cario and Oldenburg: ZP **31**, 914 (1925). Wave-lengths. Excitation by electron impact.
14. Dymond: ZP **34**, 553 (1925). Dissociation and fluorescence of iodine vapor.
15. Füchtbauer, Waibel and Holm: ZP **31**, 523 (1925). An absorption line.
16. Ruark and Chenault: PM **50**, 937 (1925). Fine structure.
17. Steubing: ZP **33**, 113 (1925). Intensity variations in the line spectrum.
18. Turner and Compton: PR **25**, 791 (1925). Nature of line λ2062A.
19. Turner: PR **27**, 397 (1926). Wave-lengths and frequency differences.
20. Easson and Armour: PRSE **48**, 1 (1927/28). Excitation by active nitrogen.
21. Kondratjew and Leipunsky: ZP **44**, 708 (1927). Critical potentials.

## Iodine 53; Xenon 54


22. Laporte: PR **29,** 650 (1927). Screening constants from optical data.
23. Robertson and Findlay: TRSC **21,** 89 (1927). Spectrum of electrodeless discharge.
24. Taylor and Phipps: PR **29,** 904 (1927). (A). Magnetic moment.
25. Fruth: PR **31,** 614 (1928). Critical potentials. Low voltage arc.
26. Turner: PR **31,** 983 (1928). Resonance line 1830.5A.
27. Warfield: PR **31,** 39 (1928). Iodine resonance spectra excited by the yellow mercury lines.
28. Asagoe: IPCR No. 206, **11,** 243 (1929). Stark effect.
29. Asagoe: MKCS **12,** 275 (1929). Classification of lines according to stage of ionization.
30. Bloch and Bloch: AsP **11,** 141 (1929). Wave-lengths.
31. Kerris: ZP **60,** 20 (1930). Wave-lengths; fine structure.
32. Evans: PRS **133,** 417 (1931). Series.
33. Iwama: IPCR **15,** No. 295, 163 (1931). Infrared wave-lengths. Ionization potential.
34. Tolansky: N **127,** 855 (1931). Fine structure.
35. Turner and Samson: PR **37,** 1023 (1931). (A). Absorption of iodine lines by atoms from optically dissociated molecules.

**I II**

1. Asagoe: MKCS **12,** 275 (1929). Wave-lengths.
2. Bloch and Bloch: AsP **11,** 141 (1929). Wave-lengths.
3. Kerris: ZP **60,** 20 (1930); ZP **61,** 874 (1930). Wave-lengths.
4. Bloch and Bloch: AsP **16,** 503 (1931). Wave-lengths (a correction).
5. Kronig and Frisch: PZ **32,** 457 (1931). Nuclear moments. A review. Bibliography.

**I III**

1. Asagoe: MKCS **12,** 275 (1929). Wave-lengths.
2. Bloch and Bloch: AsP **11,** 141 (1929). Wave-lengths.
3. Bloch and Bloch: AsP **16,** 503 (1931). Wave-lengths (a correction).
4. Seth: N **127,** 165 (1931). Term separations.

**I IV**

1. Asagoe: MKCS **12,** 275 (1929). Wave-lengths.
2. Bloch and Bloch: AsP **11,** 141 (1929). Wave-lengths.
3. Bloch and Bloch: AsP **16,** 503 (1931). Wave-lengths (a correction).


## Xenon 54


**Xe I**

1. Collie: PRS **97,** 349 (1920). Wave-lengths.
2. de Gramont: CR **171,** 1106 (1920). Ultimate lines.
3. Hicks: PTRS **220,** 335 (1920). Series.
4. de Gramont: CN **122,** 58 (1921). Ultimate lines.
5. Meggers: BSP Vol. **17,** 193 (1921). Interferometer measurements of wave-lengths.
6. Meggers: JOSA **5,** 308 (1921). Standard wave-lengths. A review.
7. Sommer: ZP **13,** 85 (1923). Wave-lengths and line groups
8. Dejardin: AsP **2,** 241 (1924). Excitation by electron impact.
9. Dejardin: CR **178,** 1069 (1924). Resonance and ionization potentials.
10. Turner: PM **48,** 1010 (1924). Quantum defect.
11. Hertz and Kloppers: ZP **31,** 463 (1925). Excitation and ionization potentials.
12. Herzfeld and Wolf: AP **76,** 71 and 567 (1925). A test of the classical dispersion formula. The number of dispersion electrons.
13. Gehrcke and Janicki: AP **81,** 314 (1926). Fine structure.
14. Hertz and Abbink: Nw **14,** 648 (1926). Resonance lines of the rare gases.
15. Hicks: AsP **6,** 294 (1926). Structure of rare gas spectra.
16. Swindler: PR **28,** 1136 (1926). Effect of potential and frequency on spectra.
17. Abbink and Dorgelo: P **7,** 343 (1927). Wave-lengths.
18. Perard: CR **184,** 681 (1927). A study of certain lines.

## Xenon 54; Caesium 55

19. Abbink and Dorgelo: ZP **47,** 221 (1928). Wave-lengths.
20. McLennan and Ruedy: TRSC **22,** 15 (1928). Absorption spectrum.
21. Williams: PPS **40,** 312 (1928); UNLP No. 82, 253 (1928). Structure of the induction spectra of rare gases.
22. Bakker: N **126,** 955 (1930); Nw **18,** 1100 (1930). Electron coupling in the rare gases.
23. Gremmer: ZP **59,** 154 (1930). Series.
24. Humphreys: BSJ **5,** 1041 (1930). Interference measurements.
25. Kichlu: ZP **64,** 697 (1930). Series.
26. Laporte and Inglis: PR **35,** 1337 (1930). Resonance separations for $p^9s$ configuration.
27. McLennan and Quintan: TRSC **24,** 47 (1930). Interferometer measurements of wave-length.
28. Meggers, de Bruin and Humphreys: BSJ **3,** 731 (1930). Series.
29. Beeck and Mouzon: AP **11,** 737 (1931). Ionization by slow alkali ions.
30. Deb and Dutt: ZP **67,** 138 (1931). Series.
31. Harkness and Heard: PR **37,** 1687 (1931). (A). Stark effect.
32. Humphreys: BSJ **7,** 453 (1931); PR **37,** 1703 (1931). (A). Hyperfine structure.
33. Rasmussen and Swenson: N **128,** 188 (1931). Intensity anomalies.
34. White: PR **38,** 1786 (A) and 2016 (1931). Auto-ionization.

**Xe II**

1. Bloch, Bloch and Dejardin: AsP **2,** 461 (1924); CR **178,** 766 (1924). Wave-lengths.
2. Humphreys and de Bruin: S **68,** 573 (1928). Series.
3. Dejardin: AsP **14,** 82 (1930); CR **190,** 580 (1930). Wave-lengths.
4. Kichlu: ZP **64,** 697 (1930). Series.
5. Bakker: ANSE **13,** 121 (1931). Zeeman effect and anomalous coupling.
6. Humphreys, de Bruin and Meggers: BSJ **6,** 287 (1931). Series.

**Xe III**

1. Bloch, Bloch and Dejardin: AsP **2,** 461 (1924); CR **178,** 766 (1924). Wave-lengths.
2. Dejardin: AsP **14,** 82 (1930). Wave-lengths.

**Xe IV**

1. Bloch, Bloch and Dejardin: AsP **2,** 461 (1924); CR **178,** 766 (1924). Wave-lengths.
2. Dejardin: AsP **14,** 82 (1930). Wave-lengths.

**Xe V**

1. Dejardin: AsP **14,** 82 (1930). Wave-lengths.

## Caesium 55

**Cs I**

1. Foote and Meggers: BSP No. 386, Vol. **16,** 309 (1920); PR **15,** 322 (1920). (A). Atomic theory and low voltage arcs in Cs vapour.
2. Foote and Meggers: PM **40,** 80 (1920). Relative intensities and exciting voltage.
3. Füchtbauer: PZ **21,** 322 (1920). Absorption from the standpoint of the quantum theory.
4. Fues: AP **63,** 1 (1920). Selection rules. Displacement law. Calculation of constants in Ritz formula, and of series limits.
5. de Gramont: CR **171,** 1106 (1920). Ultimate lines.
6. Bartels: AP **65,** 143 (1921). Intensities.
7. Dunoyer: CR **173,** 350 (1921). Wave-lengths from electrodeless discharge.
8. Füchtbauer and Bartels: ZP **4,** 337 (1921). Absorption laws. Determination of vapor pressure.
9. de Gramont: CN **122,** 58 (1921). Ultimate lines.
10. King: PR **18,** 335 (1921). (A). Absorption spectrum.
11. Ladenburg: ZP **4,** 451 (1921). Quantum mechanical interpretation of the number of dispersion electrons.

## Caesium 55


12. Meissner: AP **65**, 378 (1921). Bergmann and combination series.
13. Ramsauer and Wolf: AP **66**, 373 (1921). Duration of emission in quenched arc.
14. Rogestwensky: N **107**, 203 (1921). Doublets in spectral series.
15. Rogestwensky: VOIL **2**, Nr. 13 (1921). Intensity ratios.
16. Annual report of director Mt. Wilson Observatory, year book No. 20 of the Carnegie Institution of Washington, 1921.
17. Becker: ZP **9**, 332 (1922). Stark effect.
18. Dunoyer: JPR **3**, 261 (1922). Wave-lengths from electrodeless discharge.
19. Füchtbauer and Joos: PZ **23**, 73 (1922). Intensities and broadening of spectral lines.
20. de Gramont: CR **175**, 1025 (1922). "Raies ultimes" and spectral series.
21. Greinacher: PZ **23**, 65 (1922). Radiation from spark in air.
22. King: AJ **55**, 380 (1922). Furnace absorption spectrum.
23. King: PNAS **8**, 123 (1922). Electric furnace spectrum.
24. Rogestwensky: JRPC **50**, 11 (1922). Intensity ratios.
25. Bartels: ZP **20**, 398 (1923). Intensity distribution, term sequence and excitation functions for alkali spectra.
26. Dorgelo: ZP **13**, 206 (1923). Intensity ratios.
27. Newman: PM **45**, 181 and 293 (1923). Visibility of spectra.
28. Turner: AJ **58**, 176 (1923). Relation between spectra and sizes of alkali metal atoms.
29. van Urk: ZP **13**, 268 (1923). Normal orbits of series electrons of the alkalies.
30. de Wisniewski: PZ **24**, 294 (1923). Caesium doublets.
31. Bartels: ZP **20**, 398 (1924). Intensity distribution, term sequence, and excitation functions for alkali spectra.
32. Bleeker and Bongers: ZP **27**, 195 (1924). Intensities in flame spectra.
33. Dorgelo: ZP **22**, 170 (1924). Intensities.
34. Ellett: N **114**, 931 (1924). Polarization of resonance radiation in magnetic fields.
35. Fues: ZP **21**, 265 (1924). Motion of electron in central field. Calculation of terms.
36. Hughes and Hagenow: PR **24**, 229 (1924). Low voltage excitation.
37. Hund: ZP **22**, 405 (1924). Rydberg correction and radius of the atom core.
38. Jones and Boyce: PRS **106**, 773 (1924). Constants of the Rydberg-Ritz equation. Quantum defect.
39. Landé: ZP **25**, 46 (1924). Absolute intervals of optical doublets. Doublet laws.
40. Lindsay: MIT **3**, 191 (1924). Electronic orbits in the alkali metals.
41. Rasetti: NC **1**, 115 (1924). Anomalous dispersion.
42. Shaver: TRSC **18**, 23 (1924). Extreme ultraviolet wave-lengths.
43. Sugiura: JJP **3**, 155 (1924). Calculation of doublet separations.
44. Turner: PM **48**, 384 (1924). Quantum defect.
45. de Wisniewski: CR **179**, 1316 (1924). A formula expressing alkali doublet separation.
46. Dannmeyer: ZP **31**, 76 (1925). Intensities in flame spectra.
47. Mensing: ZP **34**, 611 (1925). Theory of line broadening.
48. Mohler: BSP No. 505, Vol. **20**, 167 (1925). Critical potentials.
49. Oudt: ZP **33**, 656 (1925). Intensities.
50. Russell: AJ **61**, 223 (1925). Ultimate and penultimate lines.
51. Schrödinger: AP **77**, 43 (1925). Hydrogen like spectra and polarizability of the atom core.
52. Sugiura: IPCR Vol. **3**, No. 28, 1 (1925). Calculation of doublet separations.
53. Tartakowsky: ZP **34**, 216 (1925). Diamagnetism and anomalous Zeeman effect.
54. de Wisniewski: PZ **26**, 255 (1925). Calculation of *s* terms.
55. Bleeker: TFS **21**, 479 (1926); ZPC **120**, 63 (1926). Intensity measurements.
56. Filippov: ZP **36**, 477 (1926). Intensity rule of Burger and Dorgelo.
57. Füchtbauer and Muir: PZ **27**, 853 (1926). Intensity ratios.
58. Gibbs and White: PNAS **12**, 551 (1926). Doublets of stripped atoms.
59. Kohn and Jakob: PZ **27**, 819 (1926). Intensity ratio of the principal series doublets.
60. Mohler: PR **28**, 46 (1926). Photoionization in gases.
61. Newman: PM **1**, 705 (1926). Low voltage arc.

## Caesium 55

62. Sowerby and Barratt: PRS **110,** 190 (1926). Absorption spectrum.
63. Unsöld: ZP **36,** 92 (1926). Polarizability. Calculation of quantum defect.
64. Brodsky: ZP **42,** 899 (1927). Intensities.
65. Filippov: ZP **42,** 495 (1927). Intensities.
66. Hagenow and Hughes: PR **30,** 284 (1927). Intensity ratio of the blue doublet.
67. Mohler: PR **29,** 419 (1927). Excitation by atomic hydrogen.
68. Shrum, Carter and Fowler: PM **3,** 27 (1927). 1*s-md* series.
69. Gentile and Majorana: AAL **8,** 229 (1928). Calculation of intensities.
70. Jackson: PRS **121,** 432 (1928). Hyperfine structure.
71. Jacob: AP **86,** 449 (1928). Intensity ratios of the principal series doublets.
72. Kupper: AP **86,** 511 (1928). Comparison of experimental and theoretical intensities.
73. Mathews: PRS **120,** 650 (1928). Absorption spectrum.
74. Mohler: PR **31,** 187 (1928). Recombination spectra.
75. Sambursky: ZP **49,** 731 (1928). Intensity ratios for principle series doublets.
76. Filippov and Gross: Nw **17,** 121 (1929). Hyperfine structure.
77. Füchtbauer and Wolff: AP **3,** 359 (1929). Intensity ratios in the principal series.
78. Gibbs and White: PR **33,** 157 (1929). Doublets of stripped atoms.
79. Hargreaves: PRS **124,** 568 (1929). Hyperfine structure.
80. Jackson, Filippov and Gross: Nw **17,** 364 (1929). Hyperfine structure.
81. Okubo and Hamada: PM **7,** 729 (1929). Excitation by active nitrogen.
82. Prokofjew: ZP **57,** 387 (1929). Probability of forbidden transitions.
83. Waibel: ZP **53,** 459 (1929). Absorption measurements in the principal series; broadening due to pressure.
84. Boeckner: BSJ **5,** 13 (1930). Resonance and quenching of the third principal series line.
85. Boeckner and Mohler: BSJ **5,** 831 (1930). Photoionization of Cs vapour by absorption between the series lines.
86. Deslandres: CR **191,** 169 (1930). Ultimate rays.
87. Fermi: N **125,** 16 (1930); ZP **60,** 320 (1930). Nuclear moment.
88. Fermi: ZP **59,** 680 (1930). Intensity ratios of the alkali doublets. Effect of perturbations.
89. Goudsmit: PR **35,** 436 (1930). Hyperfine structure. Magnetic field at nucleus due to spinning orbital electron. Remarks on an error in the literature.
90. Minkowski and Mühlenbruch: ZP **63,** 198 (1930). Transition probabilities for the principal series doublets.
91. Sambursky: ZP **61,** 660 (1930). Fermi intensity formula for the principal series doublets.
92. Schütz: ZP **64,** 682 (1930). Intensity and natural breadth of the blue doublet.
93. Stevenson: PRS **128,** 591 (1930). Intensity of quadrupole radiation.
94. White: PR **35,** 441 (1930). Nuclear spin and hyperfine structure.
95. Barth and Schütz: Nw **19,** 774 (1931). Nuclear moment.
96. Boeckner: BSJ **6,** 277 (1931). Probabilities of recombination into the $1^2S$ state.
97. Cooke: PR **38,** 1351 (1931). Photoionization of Cs vapour.
98. Fermi: NC **8,** XIV (1931). Magnetic moments of atomic nuclei.
99. Jackson: N **127,** 925 (1931). Nuclear moment.
100. Kopfermann: Nw **19,** 675 (1931). Nuclear moments.
101. Kronig and Frisch: PZ **32,** 457 (1931). Nuclear moments. A review. Bibliography.
102. Nile: PR **38,** 375 (1931). Effective nuclear moments from hyperfine structure.
103. Schütz: Nw **19,** 1007 (1931). Nuclear moment.
104. Whitelaw and Stevenson: N **127,** 817 (1931). Intensity of forbidden transitions.

**Cs II**

1. Dunoyer: JPR **3,** 261 (1922). Wave-lengths. Electrodeless discharge.
2. Mohler, Foote, Ruark and Kiess: JOSA **7,** 62 (1923) (A). Excitation.
3. Dunoyer: JPR **3,** 261 (1924). Wave-lengths.
4. Sommer: AP **75,** 163 (1924). Series.
5. Mohler: BSP No. 505, Vol. **20,** 167 (1925). Critical potentials.

## Caesium 55; Barium 56

6. Mohler: PR **28,** 46 (1926). Photoionization in gases. Critical potentials.
7. Balasse: JPR **8,** 311 (1927). Series.
8. Filippov and Gross: ZP **42,** 77 (1927). Fine structure.
9. Newman: PM **3,** 843 (1927). Flash arc spectrum.
10. Schüler and Brück: ZP **58,** 735 (1929). Hyperfine structure.
11. Kronig and Frisch: PZ **32,** 457 (1931). Nuclear moments. A review. Bibliography.
12. Laporte, Miller and Sawyer: PR **37,** 845 and 1703 (A) (1931). Hollow cathode excitation. Revision of Sommer's classifications.

## Barium 56

**Ba I**

1. Fues: AP **63,** 1 (1920). Selection rules. Displacement law. Calculation of constants in Ritz formula, and of series limits.
2. Gouy: AsP **13,** 188 (1920). Intensity measurements.
3. de Gramont: CR **171,** 1106 (1920). Ultimate lines.
4. King: AJ **51,** 179 (1920). Furnace spectra.
5. Mohler, Foote and Meggers: BSP No. 403, Vol. **16,** 725 (1920); JOSA **4,** 364 (1920). Resonance potentials and low voltage arcs.
6. Saunders: AJ **51,** 23 (1920); AJ **52,** 265 (1920). Series.
7. Chrisler: AJ **54,** 273 (1921). The low current arc.
8. Franck: PZ **22,** 409 (1921). Excitation by electron impact.
9. Götze: AP **66,** 285 (1921). Line groups and inner quanta. Zeeman effect.
10. de Gramont: CN **122,** 58 (1921). Ultimate lines.
11. Moore: AJ **54,** 191 (1921). Excitation stages in the open arc.
12. Paschen and Back: P **1,** 261 (1921). Zeeman effect.
13. Ramsauer and Wolf: AP **66,** 373 (1921). Duration of emission in quenched arc.
14. Saunders: JOSA **5,** 1 (1921). A review of series.
15. Campetti and Corsi: NC **24,** 117 (1922). Spectra of sparks in the middle of a flame.
16. King: AJ **55,** 380 (1922). Furnace absorption spectra.
17. Back: AP **70,** 333 (1923). Zeeman effect.
18. Nagaoka and Sugiura: JJP **2,** 167 (1923). Spectroscopic evidence of isotopy.
19. Saunders and Russell: PR **22,** 201 (1923) (A). Series.
20. Sawyer and Becker: AJ **57,** 98 (1923). Explosion spectra.
21. Wentzel: PZ **24,** 104 (1923). Two electron transitions.
22. Birge: JOSA **8,** 233 (1924). Series of divalent elements.
23. Green and Petersen: AJ **60,** 301 (1924). Double excitation spectra. Primed terms.
24. Kimura and Nakamura: JJP **3,** 29 (1924). Cathode spectra of metals.
25. Landé: ZP **25,** 46 (1924). The absolute intervals of optical triplets. Doublet laws.
26. Nagaoka and Sugiura: N **113,** 532 (1924). Spectroscopic evidence of isotopes.
27. Sugiura: JJP **3,** 155 (1924). Calculation of triplet separations.
28. Turner: PM **48,** 384 (1924). Quantum defect.
29. Russell: AJ **61,** 223 (1925). Ultimate and penultimate lines.
30. Russell and Saunders: AJ **61,** 38 (1925). Regularities in alkaline earth spectra.
31. Schrödinger: AP **77,** 43 (1925). Hydrogen-like spectra and polarizability of the atom core.
32. Sugiura: IPCR Vol. **3,** No. 28, 1 (1925). Calculation of triplet separations.
33. Wentzel: ZP **34,** 730 (1925). Interpretation of alkaline earth spectra.
34. von Wisniewski: PZ **26,** 255 (1925). Calculation of *s* terms.
35. Unsöld: ZP **36,** 92 (1926). Polarizability. Calculation of quantum defect.
36. Kerschbaum: AP **83,** 287 (1927). Measurements of duration of luminosity.
37. Kichlu and Saha: PM **4,** 193 (1927). Spectra of metals of group II.
38. Pokrowski: ZP **45,** 140 (1927). Intensities of arc and spark lines with relation to the concentration of the emittor.
39. Saha: PM **3,** 1265 (1927). Spectra of group II metals. Theoretical.

## Barium 56; Lanthanum 57

40. Walters and Barratt: PM **3,** 991 (1927). Absorption spectrum.
41. Kiess: BSJ **1,** 75 (1928). Interferometer measurements of wave-lengths.
42. Locher: JOSA **17,** 91 (1928). Time intervals between the appearance of spectral lines.
43. Prokofjew: ZP **50,** 701 (1928). Transition probabilities. Anomalous dispersion.
44. McLennan and Allin: PM **8,** 515 (1929). Hyperfine structure.
45. White: PR **34,** 1288 and 1404 (1929). Interpretation of hyperfine structure.
46. Deslandres: CR **191,** 169 (1930). Ultimate rays.
47. Querbach: ZP **60,** 109 (1930). Measurements and analysis in infrared.
48. White: PR **38,** 1786 and 2016 (1931). Autoionization.

**Ba II**

1. Fues: AP **63,** 1 (1920). Selection rules. Displacement law. Calculation of constants in Ritz formula, and of series limits.
2. Sawyer and Becker: AJ **57,** 98 (1923). Explosion spectra.
3. Turner: AJ **58,** 176 (1923). Relation between spectra and sizes of atoms.
4. Hund: ZP **22,** 405 (1924). Rydberg correction and radius of the atom core.
5. Jones and Boyce: PRS **106,** 773 (1924). Constants of the Rydberg-Ritz equation. Quantum defect.
6. Kimura and Nakamura: JJP **3,** 197 (1924). Wave-lengths.
7. Landé: ZP **25,** 46 (1924). The absolute intervals of optical doublets. Doublet laws.
8. Turner: PM **48,** 384 (1924). Quantum defect.
9. Russell: AJ **61,** 223 (1925). Ultimate and penultimate lines.
10. Von Wisniewski: PZ **26,** 255 (1925). Calculation of *s* terms.
11. Gibbs and White: PNAS **12,** 551 (1926). Caesium like doublets.
12. Kerschbaum: AP **83,** 287 (1927). Measurements on duration of emission.
13. Ornstein, Coelingh and Eymers: ZP **44,** 653 (1927). Intensity variations of doublets with very large frequency difference.
14. Sambursky: ZP **49,** 731 (1928). Intensity ratios for principal series doublets.
15. Gibbs and White: PR **33,** 157 (1929). Doublets of stripped atoms.
16. White: PR **34,** 1288 and 1404 (1929). Interpretation of hyperfine structure.
17. Frisch: ZP **68,** 758 (1931). Hyperfine structure.
18. Gibbs and Kruger: PR **38,** 1921 (1931) (A). Hyperfine structure.
19. Kronig and Frisch: PZ **32,** 457 (1931). Nuclear moments. A review. Bibliography.
20. Ritschl and Sawyer: ZP **72,** 36 (1931). Hyperfine structure and Zeeman effect of resonance lines.

**Ba III**

1. Kimura and Nakamura: JJP **3,** 197 (1924). Wave-lengths.

## Lanthanum 57

**La I**

1. de Gramont: CR **171,** 1106 (1920). Ultimate lines.
2. de Gramont: CN **122,** 58 (1921). Ultimate lines.
3. Kiess, Hopkins and Kremers: BSP No. 421, Vol. **17,** 318 (1921). Wave-lengths.
4. Goudsmit: Nw **12,** 851 (1924). Series.
5. Goudsmit: PKAA **28,** 23 (1925). Series and Zeeman effect.
6. Hund: ZP **33,** 855 (1925). Interpretation of the paramagnetism of the rare earths.
7. de Rubies: CR **180,** 1478 (1925). Wave-lengths.
8. McDonald, Sutton and McLay: TRSC **20,** 313 (1926). Wave-lengths.
9. McLennan, Cohen and Liggett: TRSC **20,** 365 (1926). Absorption spectrum.
10. McLennan & Liggett: TRSC **20,** 377 (1926). Wave-lengths.
11. King and Carter: AJ **65,** 86 (1927). Furnace spectrum.
12. Meggers: JWAS **17,** 25 (1927). Series and Zeeman effect.

## LANTHANUM 57; CERIUM 58

13. Meggers and Burns: JOSA **14,** 449 (1927). Hyperfine structure.
14. Goudsmit and Bacher: PR **34,** 1501 (1929). Separations in hyperfine structure.
15. Rolla and Piccardi: PM **7,** 286 (1929). Ionizing potential.
16. White: PR **34,** 1288 and 1404 (1929). Interpretation of hyperfine structure.
17. Querbach: ZP **60,** 109 (1930). Infrared wave-lengths.
18. Freed: PR **38,** 2122 (1931). Electronic transitions between an inner shell and the virtual outer shells of the ions of the rare earth crystals.

**La II**

1. Goudsmit: PKAA **28,** 23 (1925). Series and Zeeman effect.
2. Russell: AJ **61,** 223 (1925). Ultimate and penultimate lines.
3. Wentzel: ZP **34,** 730 (1925). Interpretation of alkaline earth spectra.
4. Meggers: JOSA **14,** 140 (A) and 191 (1927). Series and Zeeman effect.
5. Meggers and Burns: JOSA **14,** 449 (1927). Fine structure.
6. Goudsmit and Bacher: PR **34,** 1501 (1929). Hyperfine structure separations.
7. McLennan and Allin: PM **8,** 515 (1929). Hyperfine structure.
8. White: PR **34,** 1288 and 1404 (1929). Interpretation of hyperfine structure.
9. Condon and Shortley: PR **37,** 1025 (1931). Assignment of levels.
10. Kronig and Frisch: PZ **32,** 457 (1931). Nuclear moments. A review. Bibliography.

**La III**

1. Jones and Boyce: PRS **106,** 773 (1924). Constants of the Rydberg-Ritz equation. Quantum defect.
2. Gibbs and White: PNAS **12,** 551 (1926). Caesium-like doublets.
3. Gibbs and White: PR **33,** 157 (1929). Doublets of stripped atoms. New wave-lengths.
4. Badami: PPS **43,** 53 (1931). New lines and ionization potential.

## CERIUM 58

**Ce I**

1. de Gramont: CR **171,** 1106 (1920). Ultimate lines.
2. de Gramont: CN **122,** 58 (1921). Ultimate lines.
3. Kiess, Hopkins and Kremers: BSP No. 421, Vol. **17,** 318 (1921). Wave-lengths.
4. Lang: PTRS **224,** 371 (1924). Ultraviolet wave-lengths.
5. Back: ZP **33,** 579 (1925). Zeeman effect.
6. Hund: ZP **33,** 855 (1925). Interpretation of the paramagnetism of the rare earths.
7. McDonald, Sutton and McLay: TRSC **20,** 313 (1926). Wave-lengths.
8. McLennan and Liggett: TRSC **20,** 377 (1926). Wave-lengths.
9. Margenau: PR **30,** 458 (1927). Zeeman effect.
10. King: AJ **68,** 194 (1928). Temperature classifications.
11. Rolla and Piccardi: PM **7,** 286 (1929). Ionizing potential.
12. Freed: PR **38,** 2122 (1931). Electronic transitions between an inner shell and the virtual outer shells of the ions of the rare earth crystals.

**Ce IV**

1. Jones and Boyce: PRS **106,** 773 (1924). Constants of the Rydberg-Ritz equation. Quantum defect.
2. Gibbs and White: PNAS **12,** 551 (1926). Caesium like doublets.
3. Gibbs and White: PR **33,** 157 (1929). Doublets of stripped atoms. New wave-lengths.
4. Badami: PPS **43,** 53 (1931). Series.
5. Bose and Datta: N **128,** 270 (1931). Absorption spectrum of the Ce IV ion in solution.
6. Brunetti and Ollano: NC **8,** 281 (1931). Separation of $4^2F$ terms.

## PRAESODYMIUM 59; NEODYMIUM 60; SAMARIUM 62; EUROPIUM 63

**Pr I**

1. de Gramont: CR **171,** 1106 (1920). Ultimate lines.
2. de Gramont: CN **122,** 58 (1921). Ultimate lines.
3. Hund: ZP **33,** 855 (1925). Interpretation of the paramagnetism of the rare earths.
4. McLennan, Cohen and Liggett: TRSC **20,** 365 (1926). Absorption spectrum.
5. McLennan and Liggett: TRSC **20,** 377 (1926). Wave-lengths.
6. McDonald: TRSC **21,** 223 (1927). Wave-lengths.
7. Brunnetti: NC **5,** 391 (1928). Absorption spectrum.
8. King: AJ **68,** 194 (1928). Temperature classifications.
9. Ireton and Keast: TRSC **23,** 13 (1929). Infrared wave-lengths.
10. Rolla and Piccardi: PM **7,** 286 (1929). Ionizing potential.

**Pr II**

1. King: AJ **68,** 194 (1928). Temperature classifications.
2. Gibbs, White and Ruedy: PNAS **15,** 642 (1929). Hyperfine structure.
3. White: PR **34,** 1397 (1929). Hyperfine structure.
4. Freed: PR **38,** 2122 (1931). Electronic transitions between an inner shell and the virtual outer shells of the ions of the rare earth crystals.
5. Kronig and Frisch: PZ **32,** 457 (1931). Nuclear moments. A review. Bibliography.

**Pr V**

1. Gibbs and White: PNAS **12,** 551 (1926). Caesium-like doublets of stripped atoms.
2. Gibbs and White: PR **33,** 157 (1929). Doublets of stripped atoms.

## NEODYMIUM 60

**Nd I**

1. de Gramont: CR **171,** 1106 (1920). Ultimate lines.
2. de Gramont: CN **122,** 58 (1921). Ultimate lines.
3. Kiess: BSP No. 472, Vol. **18,** 201 (1922). Wave-lengths.
4. Hund: ZP **33,** 855 (1925). Interpretation of the paramagnetism of the rare earths.
5. McDonald, Sutton and McLay: TRSC **20,** 313 (1926). Wave-lengths.
6. McLennan, Cohen and Liggett: TRSC **20,** 365 (1926). Absorption spectrum.
7. McLennan and Liggett: TRSC **20,** 377 (1926). Wave-lengths.
8. Rolla and Piccardi: PM **7,** 286 (1929). Ionizing potential.
9. Freed: PR **38,** 2122 (1931). Electronic transitions between an inner shell and the virtual outer shells of the ions of the rare earth crystals.

## SAMARIUM 62

**Sa I**

1. de Gramont: CR **171,** 1106 (1920). Ultimate lines.
2. de Gramont: CN **122,** 58 (1921). Ultimate lines.
3. Prandtl: ZAC **116,** 96 (1921). Absorption spectrum.
4. Kiess: BSP No. 442, Vol. **18,** 201 (1922). Wave-lengths.
5. Hund: ZP **33,** 855 (1925). Interpretation of the paramagnetism of the rare earths.
6. Freed and Spedding: N **123,** 525 (1929). Line absorption spectra in solids.
7. Rolla and Piccardi: PM **7,** 286 (1929). Ionizing potential.
8. de Rubies: CR **188,** 780 and 1101 (1929). Wave-lengths.
9. Selwood: JACS **52,** 1937 (1930). Absorption spectrum.

## EUROPIUM 63

**Eu I**

1. de Gramont: CR **171,** 1106 (1920). Ultimate lines.
2. de Gramont: CN **122,** 58 (1921). Ultimate lines.
3. Prandtl: ZAC **116,** 96 (1921). Absorption spectrum.

## EUROPIUM 63; GADOLINIUM 64; TERBIUM 65; DYSPROSIUM 66; HOLMIUM 67

4. Hund: ZP **33,** 855 (1925). Interpretation of the paramagnetism of the rare earths.
5. de Rubies: CR **183,** 385 (1926). Wave-lengths.
6. McDonald: TRSC **21,** 223 (1927). Wave-lengths.
7. de Rubies: CR **184,** 87 (1927). Wave-lengths.
8. King: PR **34,** 540 (1929) (A). Furnace spectrum.
9. King: AJ **72,** 221 (1930). Furnace spectrum. Hyperfine structure.

## GADOLINIUM 64

**Gd I**

1. de Gramont: CR **171,** 1106 (1920). Ultimate lines.
2. de Gramont: CN **122,** 58 (1921). Ultimate lines.
3. Kiess: BSP No. 466, Vol. **18,** 695 (1923). Wave-lengths.
4. Hund: ZP **33,** 855 (1925). Interpretation of the paramagnetism of the rare earths.
5. de Rubies: CR **184,** 593 (1927). Wave-lengths.
6. Freed and Spedding: N **123,** 525 (1929); PR **34,** 945 (1929). Line absorption spectra in solids.
7. King: PR **34,** 540 (1929) (A). Furnace spectrum.
8. Rolla and Piccardi: PM **7,** 286 (1929). Ionizing potential.
9. King: AJ **72,** 221 (1930). Furnace spectrum.
10. Laporte: PR **35,** 130 (1930) (A). Origin of the line absorption spectra of the rare earths.
11. Freed and Spedding: PR **38,** 670 (1931). Energy levels in crystals.
12. Spedding: PR **37,** 777 (1931). Interpretation of the spectra of rare earth crystals.
13. Spedding: PR **38,** 2080 (1931). Zeeman effect in solids.

## TERBIUM 65

**Tb I**

1. Eder: SAWW **129,** 421 (1920). Wave-lengths.
2. de Gramont: CR **171,** 1106 (1920). Ultimate lines.
3. de Gramont: CN **122,** 58 (1921). Ultimate lines.
4. Eder: SAWW **131,** 199 (1922). Wave-lengths.
5. Hund: ZP **33,** 855 (1925). Interpretation of the paramagnetism of the rare earths.
6. King: PR **34,** 540 (1929) (A). Furnace spectrum.
7. Rolla and Piccardi: PM **7,** 286 (1929). Ionizing potential.
8. King: AJ **72,** 221 (1930). Temperature classifications. Notes on hyperfine structure.

## DYSPROSIUM 66

**Dy I**

1. de Gramont: CR **171,** 1106 (1920). Ultimate lines.
2. de Gramont: CN **128,** 58 (1921). Ultimate lines.
3. Kiess: BSP No. 466, Vol. **18,** 695 (1923). Wave-lengths.
4. Hund: ZP **33,** 855 (1925). Interpretation of the paramagnetism of the rare earths.
5. McDonald: TRSC **21,** 223 (1927). Wave-lengths.
6. King: PR **34,** 540 (1929) (A). Furnace spectrum.
7. Rolla and Piccardi: PM **7,** 286 (1929). Ionizing potential.
8. King: AJ **72,** 221 (1930). Temperature classification. Notes on hyperfine structure.

## HOLMIUM 67

**Ho I**

1. de Gramont: CR **171,** 1106 (1920). Ultimate lines.
2. de Gramont: CN **122,** 58 (1921). Ultimate lines.
3. Yntema: JACS **45,** 907 (1923). Absorption spectrum.
4. Hund: ZP **33,** 855 (1925). Interpretation of the magnetism of the rare earths.
5. King: PR **34,** 540 (1929) (A). Furnace spectrum.
6. King: AJ **72,** 221 (1930). Temperature classification, with notes on hyperfine structure.

## Erbium 68; Thulium 69; Ytterbium 70; Lutecium 71; Hafnium 72

**Er I**

1. de Gramont: CR **171,** 1106 (1920). Ultimate lines.
2. de Gramont: CN **122,** 58 (1921). Ultimate lines.
3. Hund: ZP **33,** 855 (1925). Interpretation of the paramagnetism of the rare earths.
4. Freed and Spedding: N **123,** 525 (1929). Line absorption spectra in solids at low temperatures.

## Thulium 69

**Tm I**

1. de Gramont: CR **171,** 1106 (1920). Ultimate lines.
2. de Gramont: CN **122,** 58 (1921). Ultimate lines.
3. Hund: ZP **33,** 855 (1925). Interpretation of the paramagnetism of the rare earths.
4. McDonald: TRSC **21,** 223 (1927). Wave-lengths.
5. King: PR **38,** 583 (1931) (A). Temperature classification, with notes on hyperfine structure.

## Ytterbium 70

**Yb I**

1. de Gramont: CR **171,** 1106 (1920). Ultimate lines.
2. de Gramont: CN **122,** 58 (1921). Ultimate lines.
3. Hund: ZP **33,** 855 (1925). Interpretation of the paramagnetism of the rare earths.
4. McDonald: TRSC **21,** 223 (1927). Wave-lengths.
5. Ireton and Keast: TRSC **23,** 13 (1929). Infrared wave-lengths.
6. Rolla and Piccardi: PM **7,** 286 (1929). Ionizing potential.
7. King: AJ **74,** 328 (1931). Temperature classification of lines.

**Yb II**

1. King: AJ **74,** 328 (1931). Temperature classification of lines.

## Lutecium 71

**Lu I**

1. de Gramont: CR **171,** 1106 (1920). Ultimate lines.
2. de Gramont: CN **122,** 58 (1921). Ultimate lines.
3. Hund: ZP **33,** 855 (1925). Interpretation of the paramagnetism of the rare earths.
4. Laporte: PR **29,** 650 (1927). Screening constants from optical data.
5. McDonald: TRSC **21,** 223 (1927). Wave-lengths.
6. Meggers and Scribner: BSJ **5,** 73 (1930). Series.
7. King: AJ **74,** 328 (1931). Temperature classification, with notes on hyperfine structure.

**Lu II**

1. Meggers and Scribner: BSJ **5,** 73 (1930). Series.
2. King: AJ **74,** 328 (1931). Temperature classification, with notes on hyperfine structure.

**Lu III**

1. Meggers and Scribner: BSJ **5,** 73 (1930). Series.

## Hafnium 72

**Hf I**

1. de Gramont: CR **171,** 1106 (1920). Ultimate lines.
2. de Gramont: CN **122,** 58 (1921). Ultimate lines.
3. Bardet: CR **176,** 1711 (1923). Wave-lengths.
4. Hansen and Werner: FT **21,** 185 (1923); MK **5,** 18 pages (1923); N **111,** 322 and 461 (1923); N **112,** 618 and 900 (1923). Wave-lengths.
5. Hansen and Werner: Nw **12,** 528 (1924). Wave-lengths.

## Hafnium 72; Tantalum 73; Tungsten 74; Rhenium 75

6. Bardet and Toussaint: CR **180,** 1936 (1925). Arc spectrum.
7. McDonald: TRSC **21,** 223 (1927). Wave-lengths.
8. Petersen: N **119,** 352 (1927). Persistent lines.
9. Meggers: BSJ **1,** 151 (1928). Wave-lengths.
10. King: AJ **70,** 105 (1929). Furnace spectrum.
11. Meggers and Scribner: BSJ **4,** 169 (1930). Series.

**Hf II**

1. Meggers: BSJ **1,** 151 (1928). Wave-lengths.
2. Meggers and Scribner: JOSA **17,** 83 (1928). Series.

**Hf III**

1. Meggers: BSJ **1,** 151 (1928). Wave-lengths.

## Tantalum 73

**Ta I**

1. de Gramont: CR **171,** 1106 (1920). Ultimate lines.
2. de Gramont: CN **122,** 58 (1921). Ultimate lines.
3. Allin and Ireton: TRSC **21,** 127 (1927). Under-water spark spectrum.
4. McLennan and Durnford: PRS **120,** 502 (1928). Zeeman effect.
5. Ireton and Keast: TRSC **23,** 13 (1929). Infrared wave-lengths.

## Tungsten 74

**W I**

1. de Gramont: CR **171,** 1106 (1920). Ultimate lines.
2. Kiess and Meggers: BSP No. 372, Vol. **16,** 51 (1920). Wave-lengths in red and infrared.
3. de Gramont: CN **122,** 58 (1921). Ultimate lines.
4. Hulburt: PR **24,** 129 (1924). Absorption in under-water spark.
5. Bayen: CR **180,** 57 (1925). Extreme ultraviolet wave-lengths.
6. Bloch and Bloch: JPR **6,** 105 and 154 (1925). Wave-lengths in the Schumann region.
7. Laporte: Nw **13,** 627 (1925); PR **25,** 886 (1925) (A). Regularities in WI.
8. Allin: TRSC **21,** 231 (1927). Wave-lengths from under-water spark.
9. Allin and Ireton: TRSC **21,** 127 (1927). Under-water spark spectrum.
10. Beining: ZP **42,** 146 (1927). Zeeman effect.
11. Schüler and Keyston: ZP **68,** 174 (1931). Isotope abundance ratio and nuclear moment.
12. Setna: IJP **6,** 29 (1931). Infrared spectrum of under-water spark.

**W II**

1. Bloch and Bloch: JPR **6,** 105 (1925). Ultraviolet wave-lengths.
2. Beining: ZP **42,** 146 (1927). Zeeman effect.

## Rhenium 75

**Re I**

1. Meggers: BSJ **6,** 1027 (1931). Series.
2. Meggers: JFI **211,** 373 (1931); PR **37,** 219 and 1702 (A) (1931). Wave-lengths.
3. Meidinger: ZP **68,** 331 (1931). Wave-lengths.
4. Schober: SAWW **140,** 79 (1931). Wave-lengths.
5. Schober and Birke: Nw **19,** 211 (1931). Ultimate rays.
6. Sommer and Karlson: Nw **19,** 1021 (1931). Nuclear moment.
7. Zeeman, Gisolf and de Bruin: N **128,** 637 (1931). Zeeman effect and nuclear moment.

## Osmium 76; Iridium 77; Platinum 78; Gold 79

**Os I**

1. de Gramont: CR **171,** 1106 (1920). Ultimate lines.
2. de Gramont: CN **122,** 58 (1921). Ultimate lines.
3. Beals: PRS **109,** 369 (1925). Zeeman effect.
4. Meggers: BSP No. 499, Vol. **20,** 19 (1925). Wave-lengths.
5. Clark and Cohen: TRSC **20,** 55 (1926). Wave-lengths from under-water spark.
6. Meggers and Laporte: PR **28,** 642 (1926). Absorption spectrum.
7. Ireton and Keast: TRSC **23,** 13 (1929). Wave-lengths in infrared.

## Iridium 77

**Ir I**

1. de Gramont: CR **171,** 1106 (1920). Ultimate lines.
2. de Gramont: CN **122,** 58 (1921). Ultimate lines.
3. Hulburt: PR **24,** 129 (1924). Absorption in under-water spark.
4. Meggers: BSP No. 499, Vol. **20,** 19 (1925). Wave-lengths.
5. Clark and Cohen: TRSC **20,** 55 (1926). Wave-lengths from under-water spark.
6. Meggers and Laporte: PR **28,** 642 (1926). Absorption spectrum.
7. Ireton and Keast: TRSC **23,** 13 (1929). Infrared wave-lengths.

## Platinum 78

**Pt I**

1. de Gramont: CR **171,** 1106 (1920) . Ultimate lines.
2. Bloch and Bloch: JPR **2,** 229 (1921). Ultraviolet wave-lengths.
3. de Gramont: CN **122,** 58 (1921). Ultimate lines.
4. Hulburt: PR **24,** 129 (1924). Absorption in under-water spark.
5. Lang: PTRS **224,** 371 (1924). Ultraviolet wave-lengths.
6. Bloch and Bloch: JPR **6,** 105 and 154 (1925). Wave-lengths in the Schumann region.
7. Meggers: BSP No. 499, Vol. **20,** 19 (1925). Wave-lengths.
8. Clark and Cohen: TRSC **20,** 55 (1926). Wave-lengths from under-water spark.
9. McLennan, Cohen and Liggett: TRSC **20,** 365 (1926). Absorption spectrum.
10. McLennan and McLay: TRSC **20,** 201 (1926). Series.
11. Meggers and Laporte: PR **28,** 642 (1926). Absorption spectrum.
12. Haussman: AJ **66,** 333 (1927). Zeeman effect, and term values.
13. Haussmann: PR **31,** 152 (1928). Zeeman effect and terms.
14. Ovrebo: PR **31,** 1123 (1928). (A). Series.
15. Ireton and Keast: TRSC **23,** 13 (1929). Infrared wave-lengths.
16. Livingood: PR **34,** 185 (1929). Series.
17. Mack: PR **34,** 17 (1929). Vector coupling in Pt like spectra.
18. Ovrebo: PR **33,** 1098 (1929). (A). New terms.
19. Laporte and Inglis: PR **35,** 1337 (1930). Resonance separations for $d^9s$ configurations.

**Pt II**

1. Bloch and Bloch: CR **172,** 962 (1921); JPR **2,** 229 (1921). Wave-lengths.
2. Bloch and Bloch: JPR **6,** 154 (1925). Ultraviolet wave-lengths.

## Gold 79

**Au I**

1. de Gramont: CR **171,** 1106 (1920). Ultimate lines.
2. Bloch and Bloch: CR **172,** 962 (1921); JPR **2,** 229 (1921). Ultraviolet spark spectra.
3. de Gramont: CN **122,** 58 (1921). Ultimate lines.
4. Walters, Jr.: BSP No. 411, Vol. **17,** 161 (1921). Visible and infrared wave-lengths.
5. de Gramont: CR **175,** 1025 (1922). "Raies ultimes" and spectral series.

## Gold 79; Mercury 80

6. Kimura and Nakamura: JJP **2,** 61 (1923). Line broadening and the Stark effect.
7. St. Procopiu: CR **176,** 385 (1923). Spectra from arcs on immersion in various media.
8. Thorsen: FT **21,** 187 (1923); Nw **11,** 500 (1923). Series.
9. Gerlach and Cilliers: ZP **26,** 106 (1924). Magnetic moment.
10. Hulburt: PR **24,** 129 (1924). Absorption in under-water spark.
11. Lang: PTRS **224,** 371 (1924). Ultraviolet wave-lengths.
12. Lowery: PM **48,** 1122 (1924). Pole lines in the interrupted arc.
13. St. Procopiu: AsP **1,** 89 (1924). Study of arc spectrum in various media and in vacuo.
14. Bloch and Bloch: JPR **6,** 105 and 154 (1925). Wave-lengths in Schumann region.
15. Buffam and Ireton: TRSC **19,** 113 (1925). Wave-lengths from under-water spark.
16. Gerlach: AP **76,** 163 (1925). Magnetic moment.
17. Lowery: PM **49,** 1176 (1925). Line broadening and the Stark effect.
18. McLennan and McLay: PRS **108,** 571 (1925). Series.
19. McLennan and McLay: TRSC **19,** 89 (1925). Ultraviolet absorption spectrum.
20. McLennan, Smith and Peters: TRSC **19,** 39 (1925). Infrared wave-lengths.
21. Russell: AJ **61,** 223 (1925). Ultimate and penultimate lines.
22. Zumstein: PR **25,** 523 (1925). Ultraviolet absorption spectrum.
23. McLennan and Liggett: TRSC **20,** 377 (1926). Wave-lengths.
24. MeLennan and McLay: PRS **112,** 95 (1926). Series.
25. Nagaoka and Futagami: PIAT **2,** 252 (1926). Coincidence of some special lines of Au and Tl.
26. Smith and Westman: TRSC **20,** 323 (1926). Infrared spectrum.
27. Allin and Ireton: TRSC **21,** 127 (1927). Wave-lengths from under-water spark.
28. Fujioka and Nakamura: AJ **65,** 201 (1927); IPCR **7,** No. 127, 263 (1927). Stark effect.
29. Fukuda: IPCR Vol. **6,** No. 58, 1 (1927). Explosion spectra. Broadening and reversal of lines.
30. Laporte: PR **29,** 650 (1927). Screening constants from optical data.
31. Nagaoka, Nukiyama and Futagami: PIAT **3,** 319 (1927). Explosion spectra.
32. Symons and Daley: PPS **41,** 431 (1928). Zeeman effect.
33. Sambursky: PKAA **33,** 1025 (1930). Anomalous intensities.
34. Frisch: ZP **71,** 89 (1931). Hyperfine structure.
35. Loyarte and Williams: UNLP **5,** 392 (1931). Absorption spectrum.
36. McLennan and McLay: PRS **134,** 35 (1931). Series.
37. Ornstein: PZ **32,** 517 (1931). Temperature in the arc light. Intensities.
38. Ornstein and Sambursky: PKAA **34,** 339 (1931). Multiplet intensity and arc temperature.
39. Ritschl: Nw **19,** 690 (1931). Hyperfine structure.
40. Williams: CR **193,** 358 (1931). Ultimate rays and absorption lines.

**Au II**

1. Bloch and Bloch: JPR **2,** 229 (1921). Wave-lengths.
2. Lang: PTRS **224,** 371 (1924). Wave-lengths.
3. Bloch and Bloch: JPR **6,** 154 (1925). Wave-lengths.
4. McLennan and McLay: TRSC **22,** 103 (1928). Series.
5. Mack: PR **34,** 17 (1929). Vector coupling in Pt like spectra.
6. Laporte and Inglis: PR **35,** 1337 (1930). Resonance separations for $d^9s$ configurations.
7. Sawyer and Thomson: PR **38,** 2293 (1931). Ground term.

## Mercury 80

**Hg I**

1. Burger and van Cittert: PKAA **23,** 790 (1920). Intensities.
2. Dobbie and Fox: PRS **98,** 147 (1920). Absorption spectrum.
3. Found: PR **15,** 132 (1920); (A). PR **16,** 41 (1920). Ionization potential.
4. Franck: ZE **26,** 305 (1920). Excitation potentials.

## MERCURY 80

5. Franck and Einsporn: ZP **2,** 18 (1920). Excitation potentials.
6. Füchtbauer: PZ **21,** 635 (1920). Excitation of Hg lines.
7. Füchtbauer and Joos: PZ **21,** 694 (1920). Broadening of λ2537.
8. Fues: AP **63,** 1 (1920). Selection rules. Displacement law. Calculation of constants in Ritz formula, and of series limits.
9. de Gramont: CR **171,** 1106 (1920). Ultimate lines.
10. Mohler, Foote and Meggers: BSP No. **403,** Vol. **16,** 725 (1920); JOSA **4,** 364 (1920). Resonance potentials and low voltage arcs.
11. Polvani: NC **20,** 119 (1920). Time variations in the spectrum of an electric discharge.
12. Seeliger: ZP **2,** 405 (1920). Excitation in glow discharge.
13. Seeliger and Mierdel: ZP **1,** 355 (1920). Excitation by electron impact.
14. Stead and Gossling: PM **40,** 413 (1920). Relative ionization potentials as observed in thermionic valves.
15. Waran: PCPS **20,** 45 (1920). Effect of magnetic field on line intensity.
16. Dingle: PRS **100,** 167 (1921). Revision of series.
17. Einsporn: ZP **5,** 208 (1921). Excitation and ionization potentials.
18. Franck: PZ **22,** 388, 409 and 441 (1921). Excitation by electron impact.
19. Franck and Grotrian: ZP **4,** 89 (1921). Remarks on excited atoms.
20. de Gramont: CN **122,** 58 (1921). Ultimate lines.
21. Lande: PZ **22,** 417 (1921). Anomalous Zeeman effect.
22. McLennan and Shaver: PRS **100,** 200 (1921). Emission and absorption spectra.
23. Meggers: JOSA **5,** 308 (1921). Standard wave-lengths.
24. Metcalfe and Venkatesachar: PRS **100,** 149 (1921). Absorption spectrum.
25. Paschen and Back: P **1,** 261 (1921). Zeeman effect.
26. Ramsauer and Wolf: AP **66,** 373 (1921). Duration of emission in quenched arc.
27. Seeliger: PZ **22,** 610 (1921). Excitation by electron impacts.
28. Seeliger and Mierdel: ZP **5,** 182 (1921). Excitation by electron impact.
29. Seeliger and Thaer: AP **65,** 423 (1921). Displacement law. Study of excitation potentials.
30. Sponer: ZP **7,** 185 (1921). Excitation by electron impact.
31. Terenin: N **107,** 203 (1921). Measurements in absorption. Normal electron orbits in the Hg atom.
32. Walters, Jr.: BSP No. **411,** Vol. 17, 161 (1921). Wave-lengths in red and infrared.
33. Bloch and Bloch: JPR **3,** 309 (1922). Wave-lengths from under-water spark.
34. Campetti and Corsi: NC **24,** 117 (1922). Spectra of sparks in the middle of a flame.
35. Cario: ZP **10,** 185 (1922). On the origin of true absorption and apparent coupling of quantum jumps.
36. Compton: PR **20,** 283 (1922). Theory of ionization by culminative action and the low voltage arc.
37. Croze: CR **175,** 1143 (1922). Place of the ultimate rays of the elements in the spectral series and their relations to the resonance rays.
38. Dejardin: CR **175,** 952 (1922). Excitation; influence of helium.
39. Dejardin: CR **175,** 1203 (1922). Ionization of Hg vapour in presence of argon.
40. Eldridge: PNAS **8,** 268 (1922); PR **20,** 456 (1922). Energy losses accompanying ionization and resonance.
41. Füchtbauer and Joos: PZ **23,** 73 (1922). Intensities and broadening of lines.
42. Gunther-Schulze: ZP **11,** 74 (1922). Phenomena at the cathode of the vacuum arc.
43. Haber and Zisch: ZP **9,** 302 (1922). Excitation of gas spectra by chemical reaction.
44. van der Lingen: ZP **8,** 145 (1922). Electrodeless discharge.
45. Lubovich and Pearen: TRSC **16,** 195 (1922). Infrared spectrum.
46. McLennan, Ainslie and Cale: PRS **102,** 33 (1922). Absorption of λ5460.97.
47. Rayleigh: PRS **102,** 190 (1922). Polarization of resonance radiation.
48. Robertson: PR **19,** 470 (1922). Spectrum of electrodeless discharge.
49. St. Procopiu: CR **175,** 217 (1922). Variation of arc spectrum with conditions of emission.

## MERCURY 80

50. Seeliger: AP **67,** 352 (1922). Radiation from the glow-discharge.
51. Seeliger: ZP **11,** 197 (1922). Excitation by electron impact.
52. Sellerio: NC **24,** 165 (1922). Spectrum of constricted arc.
53. Terenin: JRPC **50,** 51 (1922). Normal orbit of electron in Hg atom.
54. Wien: AP **69,** 325 (1922). Method of distinguishing between arc and spark lines.
55. Wood: PM **44,** 1107 (1922). Polarized resonance radiation.
56. Brunetti: AAL **32,** 496 (1923). Structure of 5461.
57. Cario and Franck: ZP **17,** 202 (1923). Sensitized flourescence of gases.
58. Compton: JOSA **7,** 955 (1923); PM **45,** 750 (1923). Properties of excited atoms.
59. Dejardin: JPR **4,** 121 (1923). Excitation by slow electrons.
60. Dorgelo: ZP **13,** 206 (1923). Intensities.
61. Füchtbauer, Joos and Dinkelacker: AP **71,** 204 (1923). Intensity, broadening, and pressure displacement of λ2537 in absorption.
62. Hanle: Nw **11,** 690 (1923). Zeeman effect of resonance fluorescence.
63. Hansen, Takamine and Werner: MK **5,** 3 (1923). Effect of magnetic and electric fields on the Hg spectrum.
64. Hertz: Nw **11,** 778 (1923). Excitation by electron collision.
65. Kimura and Nakamura: JJP **2,** 61 (1923). Line broadening and the Stark effect.
66. Kurth: PR **22,** 202 (1923) (A). Test of Bohr-Sommerfeld theory of spectrum lines.
67. Minkowski: ZP **18,** 258 (1923). Free path of slow electrons in Hg vapour.
68. Moore: AJ **58,** 86 (1923). Excitation stages in the open arc.
69. Nagaoka and Mishima: AJ **57,** 92 (1923). Fine structure.
70. Nagaoka and Sugiura: AJ **57,** 86 (1923). Vacuum arc for obtaining spectra extending from visible to soft x-rays.
71. Nagaoka, Sugiura and Mishima: JJP **2,** 121 (1923). Fine structure.
72. Nakamura: JJP **2,** 77 (1923). Study of glow discharge.
73. Newman: PM **45,** 181 (1923). Visibility of spectra.
74. Noyes: S **57,** 314 (1923). Ionization and resonance potentials. General survey.
75. St. Procopiu: CR **176,** 504 (1923). Flame, arc, and spark lines from arcs in vacuo.
76. Takamine and Fukuda: JJP **2,** 111 (1923). Spectrum of constricted arc.
77. Webb: PR **21,** 479 (A), and 719 (A) (1923). Duration of resonance radiation.
78. Wentzel: ZP **19,** 53 (1923). Rydberg's formula and deviating types of series.
79. Wood and Ellett: N **111,** 255 (1923); PRS **103,** 396 (1923); S **57,** 267 (1923). Influence of magnetic fields on the polarization of resonance radiation.
80. Yao: PR **21,** 1 (1923). Low voltage arc.
81. Athanasiu: CR **178,** 2071 (1924). Distribution of energy in the arc spectrum.
82. Breit: PM **47,** 832 (1924). Polarization of resonance radiation.
83. Brunetti: NC **1,** 185 (1924). Structure of the green line, and Hg isotopes.
84. Brunetti: NC **1,** 277 (1924). Structure of λ4358.
85. Buisson: CR **178,** 1270 (1924). Triplet series:
86. Compton and Mohler: BNC **9,** part 1, No. 48 (1924). Critical potentials. Methods and interpretation.
87. Croze: CR **178,** 200 (1924). Ultimate rays.
88. Dejardin: AsP **2,** 241 (1924). Excitation by electron impact.
89. Eckart and Compton: PR **24,** 97 (1924). Low voltage arc.
90. Eldridge: PR **23,** 109 (1924) (A). Low voltage spectrum.
91. Eldridge: PR **23,** 294 (A), and 685 (1924). Excitation by electron impact.
92. Eldridge: PR **24,** 234 (1924). Theoretical interpretation of polarization experiment of Wood and Ellett.
93. Ellett: N **114,** 931 (1924). Polarization of resonance radiation in magnetic fields.
94. Fukuda: JJP **3,** 139 (1924). Spectrum under heavy current excitation. Forbidden lines.
95. Grotrian: Nw **12,** 307 (1924). Influence of magnetic and electric fields on the Hg spectrum.
96. Hanle: ZP **30,** 93 (1924). Influence of magnetic fields on the polarization of resonance radiation.

## MERCURY 80

97. Hayner: PR **23,** 294 (1924). (A). Behavior of arc lines after removal of exciting potential.
98. Hertz: ZP **22,** 18 (1924). Excitation by electron impact.
99. Joos: PZ **25,** 130 and 298 (1924). Influence of a magnetic field on the polarization of resonance radiation.
100. Jung: AP **75,** 201 (1924). Electrodeless ring discharge.
101. Kimura and Nakamura: JJP **3**, 197 (1924). A classification of enhanced lines.
102. Krefft: PZ **25,** 352 (1924). Doppler effect in arc and spark lines.
103. Landé: ZP **25,** 46 (1924). The absolute intervals of optical triplets. Doublet laws.
104. Marshall: AJ **60,** 243 (1924). Metastable states in low voltage.
105. Metcalfe and Venkatesachar: PRS **105,** 520 (1924). Selective absorption.
106. Mierdel: PZ **25,** 240 (1924). Electrodeless discharge.
107. Nagaoka, Sugiura and Mishima: N **113,** 459 (1924). Fine structure.
108. Nichols and Tear: JFI **198,** 103 (1924). Long wave radiation.
109. Oldenberg: ZP **29,** 328 (1924). Light filter for Hg $\lambda 2537$.
110. Pauli: Nw **12,** 741 (1924). Theoretical significance of the satellites of some spectral lines and the effect of a magnetic field upon them.
111. Pringsheim: ZP **23,** 324 (1924). On the polarization of resonance radiation.
112. Rasetti: AAL **33,** part 2, 38 (1924). Effect of magnetic fields upon the polarization of resonance radiation.
113. Royds: KB **43,** 109 (1924). Different character of lines belonging to the same series.
114 Ruark, Mohler and Chenault: N **114,** 575 (1924). Hyperfine structure.
115. Runge: N **113,** 781 (1924). Fine structure and isotopes.
116. St. Procopiu: AsP **1,** 89 (1924); JPR **5,** 75 (1924). Study of arc spectrum in various media and in vacuo.
117. Seeliger and Okubo: PZ **25,** 337 (1924). Radiation from striated discharge.
118. Sugiura: JJP **3,** 155 (1924). Calculation of triplet separations.
119. Turner: PM **48,** 384 (1924). Quantum defect.
120. Turner: PR **23,** 464 (1924). Estimation of the average life of excited atoms.
121. Webb: PR **24,** 113 (1924). Metastable state in Hg vapour.
122. Webb and Hayner: PR **23,** 294 (1924). (A). Metastable state in Hg vapour.
123. Weigert: Nw **12,** 38 (1924). Influence of a weak magnetic field on the polarization of resonance radiation.
124. Wien: AP **73,** 483 (1924). Duration of light emission and dampening of spectral lines.
125. Wood: PRS **106,** 679 (1924). Controlled orbital transfers of electrons in Hg vapour.
126. Wood and Ellett: PR **24,** 243 (1924). Polarized resonance radiation in weak magnetic fields.
127. Bouma: ZP **33,** 658 (1925). Intensity relations of some intercombination lines.
128. Breit and Ellett: PR **25,** 888 (1925) (A). Depolarizing influence of a rapidly changing magnetic field on resonance radiation.
129. Brown and Beams: JOSA **11,** 11 (1925). Order of appearance of spectral lines.
130. Dannmeyer: ZP **31,** 76 (1925). Intensities in flame spectra.
131. Dorgelo: P **5,** 429 (1925). Life period of metastable states.
132. Eckart: S **61,** 517 (1925). Life of metastable Hg.
133. Fermi and Rasetti: AAL **1,** 716 (1925); AAL **2,** 117 (1925); ZP **33,** 246 (1925). Influence of an alternating electric field on polarization of resonance radiation.
134. Foote, Takamine and Chenault: PR **26,** 165 (1925). Excitation of forbidden lines. *PP'* multiplet.
135. Franz and Kallmann: ZP **34,** 924 (1925). Excitation of gas spectra by chemical reaction.
136. Fukuda: IPCR Vol. **3,** No. 37, 183 (1925). Change of wave-length for lines in a condensed discharge.
137. Gaviola and Pringsheim: ZP **34,** 1 (1925). An explanation of the apparently too little polarization of resonance radiation in a magnetic field.
138. Gross and Terenin: N **116,** 280 (1925). Fine structure of optically excited lines.

## Mercury 80

139. Harrison and Forbes: JOSA **10**, 1 (1925). Spectral energy characteristics of the Hg vapour lamp.
140. Hayner: PR **26**, 364 (1925). Presistence of radiation excited in Hg vapour.
141. Hertz: PKAA **28**, 767 (1925). Excitation by electron impact.
142. Hönl: ZP **31**, 340 (1925). Intensities of Zeeman components.
143. Kapitza and Skinner: PRS **109**, 224 (1925). Zeeman effect in strong fields.
144. Kwei: PR **26**, 537 (1925). Characteristics and spectra of low voltage arcs.
145. Laffay: CR **180**, 823 (1925). Infrared wave-lengths.
146. Loria: PNAS **11**, 673 (1925). Metastable $2p_3$ state.
147. McLennan and Ireton: TRSC **19**, 77 (1925). Structure of the green line λ5460.74.
148. McLennan, Smith and Peters: TRSC **19**, 39 (1925). Wave-lengths. Infrared spectra.
149. Mitchell: PNAS **11**, 458 (1925). Activation of hydrogen by excited Hg atoms.
150. Orthmann: AP **78**, 601 (1925). Collision broadening of the Hg resonance line.
151. Ramanathan: IACS **9**, 93 (1925). Polarization of resonance radiation and the duration of excited state.
152. Rayleigh: PRS **108**, 262 (1925). Luminous vapour from the mercury arc and the progressive changes in its spectrum.
153. Rouse and Giddings: PNAS **11**, 514 (1925). Ionization of Hg vapour by ultraviolet light.
154. Ruark and Chenault: PM **50**, 937 (1925). Fine structure.
155. Russell: AJ **61**, 223 (1925). Ultimate and penultimate lines.
156. Schütz: ZP **35**, 260 (1925). Region of action of excited atoms.
157. Skinner: PRS **109**, 224 (1925). Zeeman effect.
158. Sugiura: IPCR **3**, No. 28. 1 (1925). Calculation of triplet separations.
159. Takamine: Nagaoka Anniversary Vol. Tokyo, p. 167 (1925). New lines in the Hg spectrum.
160. Takamine and Fukuda: IPCR **2**, No. 26, 293 (1925); PR **25**, 23 (1925). Excitation of λ2270 A°. Shift of certain lines in condensed discharge.
161. Tate: PR **25**, 110 (1925) (A). Absorption of λ2540.
162. Terenin: ZP **31**, 26 (1925). Optical excitation.
163. Turner and Compton: PR **25**, 606 (1925). Absorption and emission spectra of the Geissler discharge.
164. Venkatesachar: PM **49**, 33 (1925). Length of radiating column and width of lines.
165. Wood: N **115**,, 461 (1925). Structure of λ2536.
166. Wood: PM **50**, 761 (1925). Fine structure, absorption and Zeeman effect of λ2536.
167. Wood PM **50**, 774 (1925). Optical excitation of the Hg spectrum with controlled radiating states.
168. Beams and Rhodes: PR **28**, 1147 (1926). Time intervals between appearance of certain lines.
169. Bronstein: ZP **37**, 217 (1926). Theory of fine structure.
170. Cario and Franck: ZP **37**, 619 (1926). Extinguishing of resonance radiation by addition of foreign gases.
171. Ellett, Foote & Mohler: PR **27**, 31 (1926). Polarization of radiation excited by electron impact.
172. Eskeland: AO No. 7, 9 pages (1926); FT **24**, 107 (1926). Intensity measurements.
173. Frerichs: AP **81**, 807 (1926). Intensity measurements.
174. Fukuda: IPCR No. 55, **4**, 171 (1926). New lines.
175. Fukuda, Kuyama & Uchida: IPCR No. 56, **4**, 177 (1926). Spectra of metals under heavy current excitation.
176. Gaviola and Pringsheim: ZP **39**, 75 (1926). An explanation of the apparently too little polarization of resonance radiation in a magnetic field.
177. Goos and Meyer: ZP **35**, 803 (1926). Intensity of resonance radiation.
178. Grotrian: Nw **14**, 144 (1926), Zeeman effect in strong fields.
179. Hales: PR **27**, 809 (1926). (A). Long wave-length limit of Hg.
180. Hanle: ZP **35**, 346 (1926). Resonance fluorescence.

## MERCURY 80

181. Hayner: ZP **35**, 365 (1926). Behaviour of current and radiation in the Hg arc after interruption of potential.
182. Hori: IPCR No. 48, **4**, 59 (1926); MKCS **9**, 379 (1926). Explosion spectra.
183. Jarvis: PR **27**, 808 (1926). (A). Resonance and ionization potentials.
184. Jenkins: N **117**, 893 (1926). Line spectra of isotopes.
185. Keussler: PZ **27**, 313 (1926). Zeeman effect of hyperfine structure.
186. Lawrence: PR **28**, 947 (1926). Ultra-ionization potentials.
187. Loyarte: PZ **27**, 584 (1926). Excitation potentials.
188. Madelung: ZP **37**, 374 (1926). Graphical method for the discovery and demonstration of spectral regularities.
189. Messenger: PR **28**, 962 (1926). Critical potentials and metastable states.
190. Nagaoka and Futagami: PIAT **2**, 153 (1926). Occurrence of harmonics in spectral series.
191. Nagaoka and Futagami: PIAT **2**, 254 (1926). Explosion spectra.
192. Nagaoka and Mishima: PIAT **2**, 383 (1926). Anomalous Zeeman effect of $\lambda$5791 and satellite.
193. Nagaoka and Mishima: PIAT **2**, 479 (1926). Zeeman effect of $\lambda$5770.
194. Nash: S **64**, 190 (1926). Effect of He on intensities in the Hg spectrum.
195. Orthmann and Pringsheim: ZP **35**, 626 (1926). Extinguishing of resonance radiation at high pressures.
196. Quarder: VDPG **7**, 21 (1926). Polarization in Hg radiation.
197. Rayleigh: PRS **112**, 14 (1926). Spectroscopic studies of luminous vapour distilled from metallic arcs.
198. Ruark: PM **1**, 977 (1926). The fine structure and Zeeman effect of complex lines.
199. Sawyer: JOSA **13**, 431 (1926). Deep-lying terms in 2 and 3 electron spectra. *PP′* groups.
200. Sawyer and Beese: S **64**, 44 (1926). New terms.
201. Schütz: ZP **35**, 260 (1926). Experimental contribution to knowledge of the effective cross sections of excited atoms. Zeeman effect.
202. Snoek, Jr.: ZP **35**, 883 (1926). Intensity distribution in fine structure.
203. Swindler: PR **28**, 1136 (1926). Effect of potential and frequency on spectra.
204. Takamine: ZP **37**, 72 (1926). Intensity of the forbidden line $\lambda$2270.
205. Terenin: ZP **37**, 98 (1926). Optical excitation.
206. Terenin: ZP **37**, 676 (1926). Action of an electric field on the optically excited spectrum.
207. Unsöld: ZP **36**, 92 (1926). Polarizability. Calculation of quantum defect.
208. White: PR **28**, 1125 (1926). Voltage intensity relations.
209. White and Webb: PR **27**, 243 (1926). (A). Voltage intensity relations.
210. Clarke: N **120**, 727 (1927). Excitation by high frequency oscillations.
211. Dejardin: AsP **8**, 424 (1927). Ultraviolet wave-lengths.
212. Eskeland and Vegard: PZ **28**, 89 (1927). Intensity variations in an Hg triplet.
213. Foote: PR **30**, 288 (1927). Quenching of resonance radiation.
214. Foote: PR **30**, 300 (1927). Depolarization of resonance radiation.
215. Hansen: N **119**, 237 (1927). Fine structure of $\lambda$4916.
216. Hughes and Thomas: PR **30**, 466 (1927). Absorption of resonance radiation.
217. Jenkins: PR **29**, 50 (1927). Line spectra of isotopes.
218. van Keussler: AP **82**, 793 (1927). Polarization of resonance radiation and its influence by magnetic fields and foreign gases.
219. Loyarte: PZ **28**, 904 (1927). Quantum rotation of the Hg atom.
220. Loyarte and Williams: PZ **28**, 383 (1927). An abnormal series.
221. Lubovich: PR **29**, 355 (1927) (A). Infrared wave-lengths.
222. McCurdy: PR **29**, 915 (1927) (A). Fine structure of $\lambda$3650.
223. MacNair: PNAS **13**, 430 (1927); PR **29**, 915 (1927) (A). Zeeman effect of hyperfine structure of $\lambda$2537.
224. MacNair and Ellett: PNAS **13**, 583 (1927). Incomplete polarization of resonance radiation.
225. Mohler: PR **29**, 419 (1927). Excitation by atomic hydrogen.

## Mercury 80

226. Mohler and Moore: JOSA **15**, 74 (1927). Absorption spectrum at high pressure.
227. Nagaoka, Nukiyama and Futagami: PIAT **3**, 324 (1927). Explosion spectra.
228. Olson: PR **29**, 207 (1927) (A). Polarization of λ2537.
229. Ornstein and Burger: ZP **40**, 403 (1927). Intensities.
230. Ornstein and Minnaert: ZP **43**, 404 (1927). Intensity distribution within spectral lines.
231. Orthmann and Pringsheim: ZP **43**, 9 (1927). Broadening of the resonance line in the presence of other gases.
232. Orthmann and Pringsheim: ZP **46**, 160 (1927). Effect on resonance line of raising the vapour pressure.
233. Ramon, Loyarte and Williams: UNLP **11**, 125 (1927). An anomalous series.
234. Rayleigh: N **120**, 295 (1927); PRS **117**, 294 (1927). Forbidden line λ2270 in absorption.
235. Ruark, Foote, Rudhick and Chenault: JOSA **14**, 17 (1927). Excitation by active nitrogen.
236. Trumpy: ZP **40**, 594 (1927). Intensity and breadth of λ2537.
237. Unsöld: AJ **82**, 355 (1927). Calculation of terms.
238. Valasek: PR **29**, 817 (1927). Relative intensities of certain lines.
239. Venkatesachar: PRS **117**, 11 (1927). Vapour density and relative intensities. Forbidden line λ2770.
240. Williams: UNLP **4**, 35 (1927). An anomalous series.
241. Wood: PM **4**, 466 (1927). Optical excitation with controlled radiating states and forbidden lines.
242. Abbink and Dorgelo: ZP **47**, 221 (1928). Wave-lengths.
243. Asada: PZ **29**, 708 (1928). Life of excited atoms.
244. Asada, Ladenburg and Tietze: PZ **29**, 549 (1928). Duration of metastable states.
245. Bricout: JPR **9**, 88 (1928). Measurement of the intensity of lines excited by electron collision.
246. Carrelli: AAL **7**, 1014 (1928). Width of certain lines.
247. Collins: PR **31**, 152 (1928) (A); PR **32**, 753 (1928). Hyperfine structure of the triplet $2^3P_{0,1,2}-2^3S_1$ when excited optically.
248. Crew and Dawson: JOSA **17**, 261 (1928). Mercury spectrum at atmospheric pressure.
249. Crozier: PR **31**, 800 (1928). Voltage intensity relations.
250. Dawson and Crew: PR **31**, 308 (1928) (A). Self-reversed lines.
251. Ellett and MacNair: PR **31**, 180 (1928). Zeeman effect of hyperfine structure.
252. Fues: ZP **49**, 269 (1928). Line intensities under varying conditions of excitation.
253. Gaviola: N **122**, 772 (1928). Intensities of emission lines. Test of Schroedinger's theory.
254. Gaviola: PM **6**, 1154 (1928). Power relation of intensities in the optical excitation of Hg.
255. Gaviola: PM **6**, 1167 (1928). Influence of foreign gases on optical excitation.
256. van Geel: ZP **47**, 615 (1928). Zeeman effect of intercombination lines.
257. van Geel: ZP **51**, 51 (1928). Intensities of forbidden lines in a magnetic field.
258. de Groot: ZP **50**, 559 (1928). Absorption of λ1941.5 in positive column. Optical concentration of ions.
259. Hori: ZP **49**, 259 (1928). Intensities under different excitations.
260. Hulburt: PR **32**, 593 (1928). Intensities.
261. Jezewski: CRSP **3**, 367 (1928). Extension of the ultraviolet spectrum.
262. Klumb and Pringsheim: ZP **52**, 610 (1928). Transitions from excited $2^3P_1$ states into metastable $2^3P_0$ states due to collision with foreign molecules.
263. Kunze: AP **85**, 1013 (1928). Absolute intensity of λ2537.
264. McCurdy: PM **5**, 386 (1928). Fine structure.
265. MacNair: PR **31**, 986 (1928). Zeeman pattern of the hyperfine structure of the resonance line.
266. Morris, Jr.: PR **32**, 447 (1928). Comparisons of measurements of critical potentials.
267. Okubo and Hamada: PM **5**, 372 (1928). Excitation by active nitrogen.
268. Olson: PR **32**, 443 (1928). Polarization of resonance radiation.
269. Ponte: N **121**, 243 (1928). Excitation by high frequency oscillations.

## MERCURY 80


270. Ponte: CR **187**, 37 (1928). Absorption spectrum. Reversal of the green line and its satellites.
271. Schein: AP **85**, 257 (1928). Fine structure and Zeeman effect of the resonance line.
272. Stark: AP **86**, 541 (1928). Ionization of Hg atoms by He ions.
273. Williams: CR **187**, 761 (1928). Ultimate rays.
274. Wilson: PRS **118**, 362 (1928). Absorption by Hg Vapour.
275. Wood and Gaviola: PM **6**, 271 (1928). Factors governing appearance of λ2656.
276. Wood and Gaviola; PM **6**, 352 (1928). Power relation of intensities in the optically excited spectrum.
277. Zielinski: PR **31**, 559 (1928). Absorption and scattering of Hg vapour for the line λ2536.
278. Ende: ZP **56**, 503 (1929). Intensity measurements on multiplets excited by electron impacts.
279. Frayne and Montgomery: PR **33**, 549 (1929). Variation of intensities with pressure.
280. Gaviola: PR **33**, 309 (1929). Quenching of resonance radiation.
281. Gaviola: PR **34**, 1373 (1929). Life of metastable atoms.
282. Gaviola: UNLP **89**, 67 (1929). Transition probability for λ2656 Å.
283. Hanle: ZP **54**, 852 (1929). Excitation by electron collision. Influence of direction of impact on intensity ratios.
284. Houston: PR **33**, 297 (1929). Calculation of energy levels, Zeeman effect, and intensities from Schrödinger equation.
285. Kopfermann and Tietze: ZP **56**, 604 (1929). Absorption of λ2537.
286. Loyarte: PZ **30**, 678 (1929); UNLP No. **89**, 123 (1929). Quantized rotation of Hg atom.
287. Loyarte: UNLP No. **89**, 111 (1929). New wave-lengths.
288. McAlister: PR **34**, 1142 (1929). New wave-lengths in infrared.
289. Ostensen: PR **34**, 1352 (1929). Voltage intensity relations.
290. Pavlov and Sueva: ZP **54**, 236 (1929). Method of determining critical potentials.
291. Pool: PR **33**, 22 (1929). Life of metastable atoms.
292. Shein: HPA **2** (Supplement) 111 pages (1929). Optical measurements: Doppler effect, resonance radiation, hyperfine structure, Zeeman effect, Stark effect, and other phenomena.
293. Stuhlman and Trawick: PR **33**, 287 (1929) (A). Spectrum of high voltage electrodeless discharge.
294. Takahashi: AP **3**, 49(1929). Excitation in the negative glow of a helium discharge.
295. Takamine and Suga: IPCR **11**, No. 198, 131 (1929). Infrared wave-lengths.
296. Taylor: JFI **207**, 95 (1929). Voltage intensity relations.
297. Venkatesachar and Sibaiya: IJP **4**, 179 (1929). Arc spectrum in foreign gases.
298. Webb and Messenger: PR **33**, 319 (1929). Persistence of λ2537 at low pressures.
299. Williams: N **124**, 985 (1929); UNLP No. **89**, 175 (1929). Persistence of λ1849.57.
300. Wood: PM **8**, 205 (1929). Densitometer curves of the green line.
301. Brazdziunas: AP **6**, 739 (1930). Resonance lines and its behavior in magnetic fields.
302. Hanle and Schaffernicht: AP **6**, 905 (1930). Absolute intensities of lines excited by electron impact.
303. Hart and Stuhlman, Jr.: PR **35**, 1437 (1930) (A). Relative intensities of arc and spark lines of the electrodeless discharge.
304. Huff and Houston: PR **36**, 842 (1930). Nature of the forbidden line λ2270.
305. Latyscheff and Leipunsky: ZP **65**, 111 (1930). Collisions of the second kind. Number of excited atoms.
306. Loedel-Palumbo: PZ **31**, 926 (1930). Quantized rotation of the Hg atom.
307. Lübcke: WVS **9**, 246 (1930). On influencing the intensities of mercury lines.
308. McAlister: PR **35**, 1585 (1930). On the existence of a new term.
309. Masaki: ZP **66**, 229 (1930). Influence of pressure and temperature on absorption in excited vapour in presence of Ne.
310. Mrozowski: BIAS No. 9/10, 464 (1930). Hyperfine structure of λ2537.
311. Mrozowski: CRK No. 10, 3 (1930). Zeeman effect of hyperfine structure of λ2537.

## Mercury 80

312. Mrozowski: N **126,** 684 (1930). Zeeman effect and the absorption coefficients of the hyperfine structure components of the resonance line.
313. Mrozowski: PR **36,** 1591 (1930). Incomplete polarization of resonance radiation.
314. Neumann: ZP **62,** 368 (1930). Absorption of resonance radiation in the presence of foreign gases.
315. Ornstein and Custers: PKAA **33,** 473 (1930). Photometric measurements of intensity.
316. Paschen: AP **6,** 47 (1930). Series.
317. Randall: PR **35,** 1161 (1930). Mean lives of Hg lines.
318. Schaffernicht: ZP **62,** 106 (1930). Optical excitation functions.
319. Schüler: Nw **18,** 895 (1930). Hyperfine structure.
320. Stark: AP **4,** 665 (1930). Intensity asymmetry in the Stark effect.
321. Stauffer: PR **36,** 1352 (1930). Broadening of satellites of $\lambda$5461.
322. Takamine and Suga: IPCR Vol **13,** No. 232, 1 (1930). Infrared wave-lengths.
323. Tolansky: N **126,** 433 (1930). Fine structure in the singlet series.
324. Tolansky: PPS **42,** 556 (1930). Intensity modifications. Fine structure of $\lambda$4916 and $\lambda$5461.
325. Unger: PR **36,** 784 (1930) (A). Near infrared spectrum.
326. Venkatesachar and Sibaiya: JMU **4,** 145 (1930). Hyperfine structure.
327. Zemansky: PR **36,** 219 (1930). Absorption and collision broadening of the resonance line.
328. Ellett: PR **37,** 216 (1931). Hyperfine structure and polarization of resonance radiation.
329. Frisch and Pringsheim: ZP **67,** 169 (1931). Intensity distribution in $2^3S_1-2^3P_{0,1,2}$ and average life of the components.
330. Garrett and Webb: PR **37,** 1686 (1931) (A). Mean life of $\lambda$2537.
331. Golay: PR **37,** 821 (1931). Relative intensities under different conditions of excitation.
332. Haupt: PR **38,** 282 (1931). Probability law governing ionization by electron impact.
333. Kessel: ZP **70,** 614 (1931). Recombination emission.
334. Kondratjew: PZ **32,** 288 (1931). Existence of a 2 volt term.
335. Kronig and Frisch: PZ **32,** 457 (1931). Nuclear moments. A review. Bibliography.
336. Kunze: AP **8,** 500 (1931). Influence of rare gases upon the emission and absorption of $\lambda$2537.
337. McAlister: PR **37,** 1021 (1931) (A). Intensities in ultraviolet.
338. Magliano and Gaviola: UNLP **5,** 478 (1931). Quenching of resonance radiation and concentration of metastable atoms.
339. Majorana: NC 8, 107 (1931). Theory of anomalous $P'$ triplet.
340. Mrozowski: BIAS **464** (1931). Zeeman effect of hyperfine structure.
341. Mrozowski: CRK No. 6, p. 3 (1931). Hyperfine structure.
342. Mrozowski: N **127,** 890 (1931). Isotope effect and hyperfine structure of the resonance line.
343. Mrozowski: PR **37,** 845 (1931). Hyperfine structure and incomplete polarization of resonance radiation.
344. Mrozowski: ZP **68,** 278 (1931). Life of excited atoms and hyperfine structure.
345. Murakawa: ZP **73,** 366 (1931). Hyperfine structure.
346. Nagaoka and Mishima: PIAT **7,** 137 (1931). Hyperfine structure.
347. Neumann: ZP **69,** 701 (1931). Absorption of resonance radiation in the presence of foreign gases.
348. Okubo and Matuyama: N **128,** 224 (1931). Forbidden lines in the high frequency discharge.
349. Okubo and Matuyama: PR **38,** 1651 (1931). Appearance of forbidden lines and intensity modifications under high frequency excitation.
350. Pool: PR **38,** 955 (1931). Life of metastable Hg.
351. Ram and Nauda: IJP **6,** 15 (1931). Experiments on luminous vapours from the arc.
352. Rayleigh: N **128,** 905 (1931). Line spectrum in fluorescence.
353. Reichardt: ZP **70,** 516 (1931). Absorption of $\lambda$2537 by Hg vapour in solution.
354. Ricard: CR **192,** 618 (1931). Wave-lengths.
355. Schüler: Nw **19,** 950 (1931). Hyperfine structure.

## MERCURY 80

356. Schüler and Keyston: Nw **19,** 676 (1931); ZP **72,** 423 (1931). Nuclear moment and hyperfine structure.
357. Schüler and Keyston: ZP **68,** 174 (1931). Isotope abundance ratio and nuclear moment.
358. Schüler and Keyston: ZP **71,** 413 (1931). Intensity variations in hyperfine structure components.
359. Segre and Bakker: N **128,** 1076 (1931). Zeeman effect of a forbidden line.
ponents.
360. Shenstone: PR **38,** 873 (1931). Ultra-ionization potentials.
361. Siebertz: ZP **68,** 505 (1931). Structure of excitation functions.
362. Smith: PR **37,** 808 (1931). Ultra-ionization potentials.
363. Tolansky: N **127,** 595 (1931); PRS **130,** 558 (1931). Fine structure in Hg I singlet terms.
364. Tolansky: PPS **43,** 545 (1931). High frequency spectrum. Fine structure of λ6163.
365. Unger: PR **37,** 844 (1931). New lines in the near infrared.
366. Venkatesachar and Sibaiya: Nw **19,** 1041 (1931). Hyperfine structure of λ4916.
367. Webb and Sinclair: PR **37,** 182 (1931). Recombination in Hg vapour.
368. Zehden and Zemansky: ZP **72,** 442 (1931). Hyperfine structure and absorption of λ2537.

**Hg II**

1. Bloch and Bloch: CR **171,** 909 (1920). Wave-lengths.
2. Bloch and Bloch: JPR **2,** 229 (1921). Wave-lengths.
3. Seeliger and Thaer: AP **65,** 423 (1921). Displacement law. Study of excitation energies.
4. Bloch and Bloch: CR **176,** 833 (1923); JPR **4,** 333 (1923). Wave-lengths.
5. Smyth: PRS **102,** 283 (1923). Method of studying ionizing potentials.
6. Kimura: JJP **3,** 217 (1924). Wave-lengths.
7. Kimura and Nakamura: JJP **3,** 197 (1924). Wave-lengths.
8. Bayen: CR **180,** 57 (1925). Wave-lengths.
9. Laffay: CR **180,** 823 (1925). Infrared spark spectra.
10. Turner and Compton: PR **25,** 238 (1925) (A). Absorption of λ1942.5.
11. Turner and Compton: PR **25,** 613 (1925). Absorption of a principal series line.
12. Carroll: PTRS **225,** 357 (1926). Series.
13. Dejardin: CR **183,** 1340 (1926). Wave-lengths.
14. Rayleigh: PRS **112,** 14 (1926). Studies on the luminous vapour distilled from metal arcs.
15. Sawyer: JOSA **13,** 431 (1926). Deep-lying terms in 2 and 3 electron spectra. *PP'* groups.
16. Dejardin: AsP **8,** 424 (1927). Wave-lengths.
17. Eldridge: PR **29,** 213 (1927) (A). Critical potentials.
18. Robertson and Findlay: TRSC **21,** 89 (1927). Spectrum of electrodeless discharge.
19. Maxwell: PR **32,** 715 (1928). Intensity variations due to motion of positive ions.
20. Paschen: SAWB **32,** 536 (1928). Series.
21. Wood and Gaviola: PM **6,** 271 (1928). Excitation of forbidden line λ2656.
22. Loyarte: UNLP **89,** 123 (1929). Quantized rotation of the Hg atom.
23. Maxwell: PR **34,** 199 (1929). Mean life for the Hg spark spectrum.
24. Naude: AP **3,** 1 (1929). Quartet structure.
25. Rasmussen; Nw **17,** 389 (1929). Infrared spectrum.
26. Takahashi: AP **3,** 49 (1929). Excitation in the negative glow of a helium discharge.
27. Takamine and Suga: IPCR No. 198, **11,** 131 (1929). New infrared spectrum.
28. Bleakney: PR **35,** 139 (1930). Probability and critical potentials for the formation of multiply charged ions by electron impact.
29. Dejardin and Ricard: CR **190,** 427 (1930). Series.
30. Hicks: PM **9,** 673 (1930). Series.
31. Schaffernicht: ZP **62,** 106 (1930). Optical excitation functions.
32. Venkatesachar and Sibaiya: JMU **4,** 145 (1930). Hyperfine structure.
33. Kayto: IPCR **15,** 161 (1931). Absorption spectrum.
34. McLennan, McLay and Crawford: PRS **134,** 41 (1931). Series.

## MERCURY 80; THALLIUM 81

35. Ricard: CR **192,** 618 (1931). Wave-lengths.
36. Tolansky: PPS **43,** 545 (1931). High frequency spectrum. Fine structure of λ4797.
37. Venkatesachar and Subbaraya: ZP **73,** 412 (1931). Extension of series.

**Hg III**

1. Bloch and Bloch: JPR **4,** 333 (1923). Wave-lengths.
2. Smythe: PRS **102,** 283 (1923). Ionizing potential.
3. Kimura and Nakamura: JJP **3,** 197 (1924). Wave-lengths.
4. Laffay: CR **180,** 823 (1925). Infrared wave-lengths.
5. Dejardin: CR **183,** 1340 (1926). Wave-lengths.
6. Dejardin: AsP **8,** 424 (1927). Wave-lengths.
7. Eldridge: PR **29,** 213 (1927) (A). Critical potentials.
8. McLennan, McLay and Crawford: TRSC **22,** 247 (1928). Series.
9. Maxwell: PR **32,** 721 (1928). Mean life of 4797 A.
10. Mack: PR **34,** 17 (1929). Vector coupling in Pt like spectra.
11. Bleakney: PR **35,** 139 (1930). Probability and critical potentials for the formation of multiple charged ions by electron impact.
12. Laporte and Inglis: PR **35,** 1337 (1930). Resonance separations for $d^9s$ configurations.
13. Schaffernicht: ZP **62,** 106 (1930). Optical excitation functions.
14. Ricard: CR **192,** 618 (1931). Wave-lengths.

**Hg IV**

1. Bloch and Bloch: JPR **4,** 333 (1923). Wave-lengths.
2. Dejardin: CR **183,** 1340 (1926). Wave-lengths.
3. Dejardin: AsP **8,** 424 (1927). Wave-lengths.
4. Eldridge: PR **29,** 213 (1927) (A). Critical potentials.
5. Valasek: JOSA **17,** 102 (1928). Spark spectra of Hg vapour.
6. Bleakney: PR **35,** 139 (1930). Probability and critical potentials for the formation of multiply charged ions by electron impact.
7. Schaffernicht: ZP **62,** 106 (1930). Optical excitation functions.
8. Ricard: CR **192,** 618 (1931). Wave-lengths.

**Hg V**

1. Bleakney: PR **35,** 139 (1930). Probability and critical potentials for the formation of multiply charged ions by electron impact.

**Hg VI**

1. Bleakney: PR **35,** 139 (1930). Probability and critical potentials for the formation of multiply charged ions by electron impact.

## THALLIUM 81

**Tl I**

1. de Gramont: CR **171,** 1106 (1920). Ultimate lines.
2. McLennan, Young and Ireton: PRS **98,** 95 (1920). Wave-lengths.
3. Polvani: NC **20,** 119 (1920). Time variations in the spectrum of an electric discharge.
4. Bloch and Bloch: JPR **2,** 229 (1921). Ultraviolet wave-lengths.
5. de Gramont: CN **122,** 58 (1921). Ultimate lines.
6. Paschen and Back: P **1,** 261 (1921). Zeeman effect.
7. Bloch and Bloch: JPR **3,** 309 (1922). Wave-lengths from under-water spark.
8. Back: AP **70,** 333 (1923). Zeeman effect.
9. Cario and Franck: ZP **17,** 202 (1923). Sensitized fluorescence of gases.
10. Carroll: PRS **103,** 334 (1923). Absorption in Tl vapour. Series.
11. Grotrian: ZP **12,** 218 (1923). Absorption spectrum.

## THALLIUM 81


12. Hertz: Nw **11,** 778 (1923). Excitation by electron impact.
13. Mohler, and Ruark: JOSA **7,** 819 (1923); S **57,** 475 (1923). Critical potentials.
14. Moore: AJ **58,** 86 (1923). Excitation stages in the open arc.
15. Takamine and Fukuda: JJP **2,** 111 (1923). Spectrum of constricted arc.
16. Ellett: N **114,** 931 (1924). Polarization of resonance radiation in magnetic fields.
17. Gerlach and Ciliers: ZP **26,** 106 (1924). Magnetic moment.
18. Hertz: ZP **22,** 18 (1924). Excitation by electron impact.
19. Lande: ZP **25,** 46 (1924). Absolute intervals of optical doublets and triplets. Doublet laws.
20. Lang: PTRS **224,** 371 (1924). Ultraviolet wave-lengths.
21. Narayan, Gunnayya and Rao: PRS **106,** 596 (1924). Absorption and dispersion in Tl vapour.
22. St. Procopiu: AsP **1,** 89 (1924). Study of arc spectrum in various media and in vacuo.
23. Sugiura: JJP **3,** 155 (1924). Calculation of doublet separations.
24. Turner: PM **48,** 384 (1924). Quantum defect.
25. Gerlach: AP **76,** 163 (1925). Magnetic moment.
26. Hertz: PKAA **28,** 767 (1925). Excitation by electron impact.
27. Kuhn: Nw **13,** 724 (1925). Intensity of absorption lines.
28. McQuarrie: TRSC **19,** 57 (1925). Spectrum of electrodeless discharge.
29. Narayan and Rao: N **115,** 534 (1925). Resonance radiation.
30. Rao: PPS **37,** 259 (1925). Absorption spectrum.
31. Rao: PRS **107,** 762 (1925). A note on the absorption of the green line.
32. Royds: PRS **107,** 360 (1925). Apparent tripling of certain lines in the arc.
33. Ruark: JOSA **11,** 199 (1925). *PP′* groups.
34. Ruark and Chenault: PM **50,** 937 (1925). Fine structure.
35. Russell: AJ **61,** 223 (1925). Ultimate and penultimate lines.
36. Sugiura: IPCR Vol. **3,** No. 28, 1 (1925). Calculation of doublet separations.
37. Terenin: ZP **31,** 26 (1925). Optical excitation.
38. von Wisniewski: PZ **26,** 255 (1925). Calculation of *s*-terms.
39. Deppermann: AJ **63,** 33 (1926). Stark effect.
40. Frayne and Smith: PR **27,** 23 (1926). Absorption spectrum.
41. Hartree: PCPS **23,** 304 (1926). Quantum defect.
42. Kuhn: MK **7,** No. 12, 1 (1926). Anomalous dispersion in non-luminous vapours. Intensity data.
43. Kuhn: Nw **14,** 48 (1926). Intensity of absorption lines.
44. Nagaoka and Futagami: PIAT **2,** 252 (1926). Coincidence of some spectral lines of gold and thallium.
45. Ruark: PM **1,** 977 (1926). Fine structure and Zeeman effect of complex lines.
46. Terenin: ZP **37,** 98 (1926). Optical excitation.
47. Fukuda: IPCR No. 85, Vol. **6,** 1 (1927). Explosion spectra. Broadening and reversal of lines.
48. Leu: ZP **41,** 551 (1927). Magnetic moment.
49. Mohler: PR **29,** 419 (1927). Excitation by atomic hydrogen.
50. Nagaoka and Futagami: PIAT **3,** 140 (1927). Reversal of series lines.
51. Nagaoka, Nukiyama and Futagami: PIAT **3,** 330 (1927). Explosion spectra.
52. Ornstein: PZ **28,** 688 (1927). Methods and results of intensity measurements. Review.
53. Kimura: IPCR Vol. **9,** No. 154, 51 (1928). Fine structure.
54. Loyarte and Williams: JPR **9,** 121 (1928); UNLP No. 82, 229 (1928). Absorption spectrum.
55. Mohammad and Mathur: PM **5,** 1111 (1928). Fine structure.
56. Okubo and Hamada: PM **5,** 372 (1928). Excitation by active nitrogen.
57. Goudsmit and Bacher: PR **34,** 1501 (1929). Hyperfine structure separations.
58. Loyarte: PZ **30,** 923 (1929); UNLP **89,** 33 (1929). Quantized rotation of the Tl atom.
59. Schüler and Brück: ZP **55,** 575 (1929); ZP **58,** 735 (1929). Hyperfine structure.

## THALLIUM 81

60. White: PR **34**, 1288 (A) and 1404 (1929). Interpretation of hyperfine structure.
61. Back and Wulff: ZP **66**, 31 (1930). Zeeman effect of the hyperfine structure of λ3775.
62. Goudsmit and Bacher: PR **35**, 127 (1930) (A). Relations between hyperfine structure separations.
63. Goudsmit and Bacher: PR **35**, 129 (1930) (A); ZP **66**, 13 (1930). Paschen-Back effect of hyperfine structure.
64. Hoffmann: ZP **60**, 457 (1930). Absorption spectrum.
65. McLennan and Durnford: PRS **129**, 48 (1930). Zeeman effects of fine structure components.
66. Vonwiller: PR **35**, 802 (1930). Intensity measurements.
67. White: PR **35**, 441 (1930). Nuclear spin and hyperfine structure.
68. Breit: PR **37**, 1182 (1931). Anomalies in hyperfine structure.
69. Breit: PR **38**, 463 (1931). Hyperfine structure.
70. Frisch: ZP **68**, 758 (1931). Hyperfine structure.
71. Goudsmit: PR **37**, 663 and 1014 (A) (1931). Theory of hyperfine structure separations.
72. Inglis: PR **37**, 795 (1931). Hyperfine structure as a test of a linear wave equation in the two-body problem.
73. Krefft: Nw **19**, 269 (1931). Effect of ion density on arc spectrum.
74. Kronig and Frisch: PZ **32**, 457 (1931). Nuclear moments. A review. Bibliography.
75. Racah: NC **8**, 178 (1931); ZP **71**, 431 (1931). Hyperfine structure theory.
76. Schüler and Keyston: Nw **19**, 320 (1931); ZP **70**, 1 (1931). Hyperfine structure and isotopes.
77. Schüler and Keyston: ZP **71**, 413 (1931). Intensity variations in hyperfine structure components.
78. Williams: CR **193**, 358 (1931). Ultimate rays and absorption lines.
79. Wulff: ZP **69**, 70 (1931). Attest of hyperfine structure theory.

**Tl II**

1. Bloch and Bloch: CR **171**, 909 (1920). Wave-lengths.
2. Bloch and Bloch: JPR **2**, 229 (1921). Wave-lengths.
3. Bloch and Bloch: CR **178**, 472 (1924). Wave-lengths.
4. Lang: PTRS **224**, 371 (1924). Wave-lengths.
5. McLennan, McLay and Crawford: TRSC **22**, 241 (1928). Series.
6. Rao, Narayan and Rao: IJP **2**, 467 (1928). Series.
7. Smith: PNAS **14**, 951 (1928). Multiplets of Tl II.
8. Goudsmit and Bacher: PR **34**, 1501 (1929). Hyperfine structure separations.
9. McLennan, McLay and Crawford: PRS **125**, 570 (1929). Series. Hyperfine structure.
10. Smith: PR **34**, 393 (1929). New lines.
11. White: PR **34**, 1288 and 1404 (1929). Interpretation of hyperfine structure.
12. Goudsmit and Bacher: PR **35**, 127 (1930) (A). Relations between hyperfine structure separations.
13. Smith: PR **35**, 235 (1930). Extension of series.
14. White: PNAS **16**, 68 (1930). Hyperfine structure.
15. White: PR **35**, 441 (1930). Nuclear spin and hyperfine structure.
16. Bacher: PR **37**, 226 (1931) (A). Zeeman effect of hyperfine structure.
17. Bartlett: N **128**, 408 (1931). Interpretation of hyperfine structure.
18. Goudsmit: PR **37**, 663 and 1014 (A) (1931). Theory of hyperfine separations.
19. Green and Wulff: N **128**, 409 (1931). Zeeman effect of hyperfine structure.
20. Green and Wulff: PR **38**, 2176 (1931); ZP **71**, 593 (1931). Paschen-back effect of hyperfine structure.
21. Kato: IPCR **15**, 161 (1931). Absorption spectrum.
22. Kronig and Frisch: PZ **32**, 457 (1931). Nuclear moments. A review. Bibliography.
23. McLennan, McLay and Crawford: PRS **133**, 652 (1931). Interpretation of hyperfine structure.

## Thallium 81; Lead 82

24. McLennan, Crawford and Leppard: N **128,** 301 (1931). Interpretation of hyperfine structure.
25. Racah: NC **8,** 178 (1931); ZP **71,** 431 (1931). Hyperfine structure theory.
26. Schüler and Keyston: N **128,** 409 (1931). Isotope displacement in Tl II.
27. Schüler and Keyston: ZP **70,** 1 (1931). Hyperfine structure and isotopes.

**Tl III**

1. Carroll: PTRS **225,** 357 (1926). Series.
2. Hartree: PCPS **23,** 304 (1926). Quantum defect.
3. Goudsmit and Bacher: PR **34,** 1501 (1929). Hyperfine structure separations.
4. McLennan, McLay and Crawford: PRS **125,** 50 (1929). Series.
5. Arvidsson: N **126,** 565 (1930). Hyperfine structure.
6. Goudsmit and Bacher: PR **35,** 127 (1930) (A). Relations between hyperfine structure separations.
7. McLennan and Allin: PRS **129,** 43 (1930). Hyperfine structure.
8. Narayan, Pattabhi and Rao: N **126,** 434 (1930). Series.
9. Pattabhiramayya and Rao: IJP **5,** 407 (1930). Series.
10. Bacher: PR **37,** 226 (1931) (A). Zeeman effect of hyperfine structure.
11. Green and Wulff: PR **38,** 2176 (1931). Paschen-Back effect of hyperfine structure.
12. Kronig and Frisch: PZ **32,** 457 (1931). Nuclear moments. A review. Bibliography.
13. Racah: ZP **71,** 431 (1931). Hyperfine structure theory.

**Tl IV**

1. Pattabhiramayya: IJP **3,** 523 (1928), Series.
2. Mack: PR **34,** 17 (1929). Vector coupling in Pt like spectra. New lines and levels.
3. Rao: PPS **41,** 361 (1929). Series.
4. Arvidsson: N **126,** 565 (1930). Hyperfine structure.
5. Laporte and Inglis: PR **35,** 1337 (1930). Resonance separations for $d^9s$ configurations.
6. Narayan, Pattabhiramayya and Rao: N **126,** 434 (1930). Series.

## Lead 82

**Pb I**

1. de Gramont: CR **170,** 31 (1920). Variability of arc spectrum. Presence of spark lines.
2. de Gramont: CR **171,** 1106 (1920). Ultimate lines.
3. Harkins and Aronberg: JACS **42,** 1328 (1920). Spectra of isotopes.
4. van der Harst: PKAA **22,** 300 (1920). Zeeman effect.
5. McLennan, Young and Ireton: PRS **98,** 95 (1920). Wave-lengths.
6. McLennan and Zumstein: TRSC **14,** 9 (1920). Absorption and series spectrum.
7. Merton: PRS **96,** 388 (1920). Spectra of isotopes.
8. Mohler, Foote and Stimson: BSP No. 368, Vol. **15,** 723 (1920); PM **40,** 73 (1920). Ionization and resonance potentials.
9. Polvani: NC **20,** 119 (1920). Time variations in the spectrum of an electric discharge.
10. Bloch and Bloch: JPR **2,** 229 (1921). Ultraviolet wave-lengths.
11. de Gramont: CN **122,** 58 (1921). Ultimate lines.
12. Merton: PRS **100,** 84 (1921). Spectra of isotopes.
13. Walters, Jr.: BSP No. 411, Vol. **17,** 161 (1921). Wave-lengths.
14. Bloch and Bloch: JPR **3,** 309 (1922). Wave-lengths from under-water spark.
15. Hemsalech and de Gramont: PM **43,** 287 (1922). Occurrence of enhanced lines in the arc.
16. Grotrian: Nw **11,** 255 (1923). Series.
17. Grotrian: ZP **18,** 169 (1923). Absorption spectrum.
18. Meissner: AP **71,** 135 (1923). Series.
19. Moore: AJ **58,** 86 (1923). Excitation stages in the open arc.
20. Thorsen: FT **21,** 187 (1923); Nw **11,** 78 (1923). Series.

## LEAD 82

21. Gerlach and Cilliers: ZP **26,** 106 (1924). Magnetic moment.
22. Hulburt: PR **24,** 129 (1924). Absorption in under-water spark.
23. Kimura and Nakamura: JJP **3,** 29 and 43 (1924). Cathode spectra of metals.
24. Lang: PTRS **224,** 371 (1924). Ultraviolet wave-lengths.
25. McLennan, Young and McLay: TRSC **18,** 77 (1924). Absorption and series spectra.
26. Nagaoka and Sugiura: JJP **3,** 45 (1924). Stark effect.
27. St. Procopiu: CR **178,** 1368 (1924). Ultimate lines from the electric arc.
28. Sur and Sharma: JMC **1,** No. 4, 121 (1924). Absorption spectrum.
29. Thorsen: Nw **12,** 705 (1924). Series.
30. Gieseler and Grotrian: ZP **34,** 374 (1925). Series.
31. van der Harst: ANSE **9,** 1 (1925). Zeeman effect.
32. Narayan and Rao: PM **50,** 645 (1925). Absorption spectrum.
33. Ruark and Chenault: PM **50,** 937 (1925). Fine structure.
34. Russell: AJ **61,** 223 (1925). Ultimate and penultimate lines.
35. Smith: AJ **61,** 186 (1925). Spectra of exploded wires.
36. Sponer; ZP **32,** 19 (1925). Series.
37. Terenin: ZP **31,** 26 (1925). Optical excitation.
38. Zumstein: PR **26,** 189 (1925). Absorption spectrum.
39. Back : ZP **37,** 193 (1926). Zeeman effect.
40. Frayne and Smith: PM **1,** 732 (1926). Zeeman effect.
41. Gieseler and Grotrian: ZP **39,** 377 (1926). Series.
42. Sur: PM **2,** 633 (1926). Series.
43. Goudsmit and Back: ZP **40,** 530 (1927). Vector coupling.
44. Sur: PM **3,** 736 (1927). Series.
45. Campetti: NC **5,** 291 (1928). Ultraviolet spectra of the spark in liquids.
46. Houston: PR **33,** 297 (1929). Calculation of energy levels and Zeeman effect from Schrödinger equation.
47. Green: PR **37,** 469 (1931) (A). Multiplet separations and Zeeman effects.
48. Kopfermann: Nw **19,** 400 and 675 (1931). Nuclear moment.
49. Kronig and Frisch: PZ **32,** 457 (1931). Nuclear moments. A review. Bibliography.
50. McLennan, McLay and Crawford: PRS **133,** 652 (1931). Interpretation of hyperfine structure.
51. Mohammad and Sharma: PM **12,** 1106 (1931). Hyperfine structure.
52. Murakawa: ZP **72,** 793 (1931). Hyperfine structure.
53. Schüler and Keyston: ZP **68,** 174 (1931). Isotope abundance ratio and nuclear moment.

**Pb II**

1. Bloch and Bloch: CR **172,** 803 (1921); JPR **2,** 229 (1921). Ultraviolet wave-lengths.
2. Hemsalech and de Gramont: PM **43,** 287 (1922). Occurrence of spark lines in the arc.
3. Bloch and Bloch: CR **178,** 472 (1924). Wave-lengths.
4. Kimura: JJP **3,** 217 (1924). Wave-lengths.
5. Kimura and Nakamura: JJP **3,** 197 (1924). Wave-lengths.
6. Lang: PTRS **224,** 371 (1924). Wave-lengths.
7. Back: ZP **37,** 193 (1926). Zeeman effect.
8. Gieseler: ZP **42,** 265 (1927). Series.
9. Rao, Narayan and Rao: IJP **2,** 467 (1928). Series.
10. McLennan and Allin: TRSC **23,** 7 (1929). Hyperfine structure.
11. Mack: PR **34,** 17 (1929). Lines in condensed spark discharge.
12. Murakawa: ZP **72,** 793 (1931). Hyperfine structure.

**Pb III**

1. Kimura: JJP **3,** 217 (1924). Wave-lengths.
2. Kimura and Nakamura: JJP **3,** 197 (1924). Wave-lengths.
3. Rao, Narayan and Rao: IJP **2,** 467 (1928). Series.

# LEAD 82; BISMUTH 83


4. Smith: PNAS **14,** 878 (1928). Series.
5. Smith: TRSC **22,** 331 (1928). Wave-lengths.
6. Mack: PR **34,** 17 (1929). Lines in condensed spark discharge.
7. Rao and Narayan: N **124,** 794 (1929). Series.
8. Smith: N **123,** 566 (1929). Anomalous terms.
9. Smith: PR **34,** 393 (1929). Series.
10. Rao and Narayan: ZP **59,** 687 (1930). Series.
11. Smith: PR **36,** 1 (1930). Series.
12. Kato: IPCR **15,** 161 (1931). Absorption spectrum.
13. McLennan, Crawford and Leppard: N **128,** 301 (1931). Nuclear moment.


**Pb IV**


1. Kimura: JJP **3,** 217 (1924). Wave-lengths.
2. Kimura and Nakamura: JJP **3,** 197 (1924). Wave-lengths.
3. Carroll: PTRS **225,** 357 (1926). Series.
4. Mack: PR **34,** 17 (1929). Lines in condensed spark.
5. Rao and Narayan: ZP **61,** 149 (1930). Series.
6. Smith: PR **36,** 1 (1930). Series.


**Pb V**


1. Mack: PR **34,** 17 (1929). Vector coupling in Pt like spectra. New lines and levels.


# BISMUTH 83

**Bi I**


1. de Gramont: CR **170,** 31 (1920). Variability of arc spectrum. Presence of spark lines.
2. de Gramont: CR **171,** 1106 (1920). Ultimate lines.
3. van der Harst: PKAA **22,** 300 (1920). Zeeman effect.
4. McLennan, Young and Ireton: PRS **98,** 95 (1920).
5. Polvani: NC **20,** 119 (1920). Time variations in the spectrum of an electric discharge.
6. Bloch and Bloch: JPR **2,** 229 (1921). Ultraviolet wave-lengths.
7. de Garmont: CN **122,** 58 (1921). Ultimate lines.
8. de Gramont and Hemsalech: CR **173,** 278 (1921). Conditions of emission of spark lines.
9. Moore: AJ **54,** 246 (1921). Excitation stages in the open arc.
10. Nagaoka and Sugiura: AJ **53,** 339 (1921). Fine structure.
11. Sugiura and Matoba: AJ **53,** 323 (1921). Fine structure.
12. Walters, Jr.: BSP No. 411, Vol. **17,** 161 (1921). Wave-lengths.
13. Bloch and Bloch: JPR **3,** 309 (1922). Wave-lengths from under-water spark.
14. Grotrian: ZP **18,** 169 (1923). Absorption spectrum.
15. Gerlach and Cilliers: ZP **26,** 106 (1924). Magnetic moment.
16. Hulburt: PR **24,** 129 (1924). Absorption in under-water spark.
17. Kimura and Nakamura: JJP **3,** 29 (1924). Cathode spectra of metals.
18. Lang: PTRS **224,** 371 (1924). Ultraviolet wave-lengths.
19. Nagaoka and Sugiura: JJP **3,** 45 (1924). Stark effect.
20. Nagaoka, Sugiura and Mishima: N **113,** 459 (1924). Fine structure.
21. Ruark, Mohler, Foote and Chenault: BSP No. 490, Vol. **19,** 463 (1924). Series and critical potentials.
22. Runge: N **113,** 781 (1924). Isotopes of Bi and satellites of their spectral lines.
23. Buffam and Ireton: TRSC **19,** 113 (1925). Under-water spark spectrum.
24. Gerlach: AP **76,** 163 (1925). Magnetic moment.
25. van der Harst: ANSE **9,** 1 (1925). Zeeman effect.
26. Joos: PZ **26,** 357 and 380 (1925). Regularities in hyperfine structure.
27. McLennan and McLay: TRSC **19,** 89 (1925). Absorption spectrum.
28. Narayan and Rao: PM **50,** 645 (1925). Absorption spectrum.

## Bismuth 83


29. Ruark and Chenault: PM **50,** 937 (1925). Fine structure.
30. Russell: AJ **61,** 223 (1925). Ultimate and penultimate lines.
31. Terenin: ZP **31,** 26 (1925). Optical excitation.
32. Frayne and Smith: PM **1,** 732 (1926). Absorption spectrum.
33. Nagaoka and Mishima: PIAT **2,** 249 (1926). Fine structure.
34. Narayan and Rao: PPS **38,** 321 (1926). Structure of λ4722 and the nature of "raies ultimes".
35. Terenin: ZP **37,** 98 (1926). Optical excitation.
36. Thorsen: ZP **40,** 642 (1926). Series.
37. Zumstein: PR **27,** 562 (1926). Absorption spectrum.
38. Back and Goudsmit: ZP **43,** 321 (1927). Hyperfine structure and term structure.
39. McLennan and McLay: TRSC **21,** 63 (1927). Series.
40. Thorsen: ZP **40,** 642 (1927). Series.
41. Toshniwal: PM **4,** 774 (1927). Series.
42. Back and Goudsmit: ZP **47,** 174 (1928). Nuclear moment and Zeeman effect.
43. Leu: ZP **49,** 498 (1928). Magnetic moment.
44. Charola: UNLP No. **89,** 205 (1929). Absorption and series spectra.
45. Hill: PNAS **15,** 779 (1929). Relative intensities in nuclear spin multiplets.
46. White: PR **34,** 1288 and 1404 (1929). Interpretation of hyperfine structure.
47. Back and Wulff: ZP **66,** 10 (1930). Hyperfine structure.
48. Charola: PZ **31,** 457 (1930). Absorption and series spectra.
49. Goudsmit and Bacher: ZP **66,** 13 (1930). Paschen-Back effect of hyperfine structure.
50. Hargreaves: PRS **127,** 141 and 407 (1930). Hyperfine structure. Theory.
51. Zeeman, Back and Goudsmit: ZP **66,** 1 (1930). Hyperfine structure and Zeeman effect.
52. Breit: PR **38,** 463 (1931). Hyperfine structure.
53. Goudsmit: PR **37,** 663 and 1014 (A) (1931). Theory of hyperfine structure separations.
54. Inglis: PR **37,** 795 (1931). Hyperfine structure as a test of a linear wave equation in the two-body problem.
55. Kronig and Frisch: PZ **32,** 457 (1931). Nuclear moments. A review. Bibliography.
56. McLennan, McLay and Crawford: PRS **133,** 652 (1931). Interpretation of hyperfine structure.
57. Williams: CR **193,** 358 (1931). Ultimate rays and absorption lines.


**Bi II**


1. Bloch and Bloch: CR **170,** 320 (1920); CR **171,** 709 (1920). Wave-lengths.
2. Bloch and Bloch: JPR **2,** 229 (1921). Wave-lengths.
3. Bloch and Bloch: CR **178,** 472 (1924). Wave-lengths.
4. Kimura: JJP **3,** 217 (1924). Wave-lengths.
5. Kimura and Nakamura: JJP **3,** 197 (1924). Wave-lengths.
6. Lang: PTRS **224,** 371 (1924). Wave-lengths.
7. Ruark, Mohler, Foote and Chenault: BSP **490,** Vol. 19, 463 (1924). Series, and critical potentials.
8. McLennan, McLay and Crawford: PRS **129,** 579 (1930). Fine structure and series.
9. Fischer and Goudsmit: PR **37,** 1013 (A), 1057 and 1674 (1931). Hyperfine structure.
10. Goudsmit: PR **37,** 663 and 1014 (A) (1931). Theory of hyperfine structure separations.
11. Goudsmit and Fisher: PR **37,** 107 (1931) (A). Hyperfine structure patterns.
12. Green: PR **37,** 1687 (1931). (A) Paschen-Back effect and hyperfine structure.
13. Green and Wulff: PR **38,** 2186 (1931). Paschen-Back effect of hyperfine structure.
14. Kronig and Frisch: PZ **32,** 457 (1931). Nuclear moments. A review. Bibliography.
15. Zumstein: PR **38,** 2214 (1931). Wave-length standards in the Schumann region.


**Bi III**


1. Kimura: JJP **3,** 217 (1924). Wave-lengths.
2. Kimura and Nakamura: JJP **3,** 197 (1924). Wave-lengths.

3. Nagaoka and Mishima: PIAT **2,** 249 (1926). Fine structure.
4. Lang: PR **32,** 737 (1928). Series.
5. Arvidsson: N **126,** 565 (1930). Hyperfine structure.
6. McLennan, McLay and Crawford: PRS **129,** 579 (1930). Hyperfine structure.
7. Fisher and Goudsmit: PR **37,** 1013 (A), 1057 and 1674 (1931). Hyperfine structure.
8. Goudsmit: PR **37,** 663 and 1014 (A) (1931). Theory of hyperfine structure separations.
9. Green: PR **37,** 1687 (1931) (A). Paschen-Back effect of hyperfine structure.
10. Green and Wulff: PR **38,** 2186 (1931). Paschen-Back effect of hyperfine structure.

**Bi IV**

1. Kimura and Nakamura: JJP **3,** 197 (1924). Wave-lengths.
2. Smith: N **127,** 855 (1931). Resonance potential.

## POLONIUM 84

**Po I**

1. Czapek: SAWW **11,** 25 (1930.) Wave-lengths.

## RADON 86

**Rn I**

1. Hicks: PTRS **220,** 335 (1920). Series.
2. Nyswander, Lind and Moore: AJ **54,** 285 (1921). Wave-lengths.
3. Turner: PM **48,** 1010 (1924). Ionizing potential.
4. Nagaoka and Futagami: PIAT **2,** 390 (1926). Comparison of Rn spectrum with spectra of U and Th.
5. Biswas: PM **5,** 1094 (1928). Predicted ionization potential.
6. Wolf: ZP **48,** 790 (1928). Wave-lengths.
7. Holweck and Wertenstein: N **126,** 433 (1930). Ionization potential.
8. Nielson: Nw **18,** 620 (1930). Determination of ground term.
9. Rasmussen: ZP **62,** 494 (1930). Series.

## ELEMENT NO. 87

1. Loring: CN **140,** 178, 202, 242 (1930). Prediction of spectrum of element No. 87.
2. Yagoda: PR **38,** 2298 (1931) (A). An estimation of the spectrum of element No. 87.

## RADIUM 88

**Ra I**

1. de Gramont: CR **171,** 1106 (1920). Ultimate lines.
2. de Gramont: CN **122,** 58 (1921). Ultimate lines.

**Ra II**

1. Fues: AP **63,** 1 (1920). Selection rules. Displacement law. Calculation of constants in Ritz formula, and of series limits.
2. Landé: ZP **25,** 46 (1924). Absolute intervals of optical doublets. Doublet laws.
3. Turner: PM **48,** 384 (1924). Quantum defect.

## THORIUM 90

**Th I**

1. de Gramont: CR **171,** 1106 (1920). Ultimate lines.
2. de Gramont: CN **122,** 58 (1921). Ultimate lines.
3. Nagaoka and Futagami: PIAT **2,** 318 (1926). Lines of transformation products.
4. Allin: TRSC **21,** 231 (1927). Under-water spark spectrum.
5. Narayan: N **128,** 675 (1931). Hyperfine structure.

## Uranium 92

**U I**


1. de Gramont: CR **171,** 1106 (1920). Ultimate lines.
2. Kiess and Meggers: BSP No. 372, Vol. **16,** 51 (1920). Wave-lengths in red and infrared.
3. de Gramont: CN **122,** 58 (1921). Ultimate lines.
4. Lang: PTRS **224,** 371 (1924). Wave-lengths.
5. Nagaoka and Sugiura: JJP **3,** 45 (1924). Stark effect.
6. McLennan, Cohen and Liggett: TRSC **20,** 365 (1926). Absorption spectrum.
7. Nagaoka and Futagami: PIAT **2,** 318 (1926). Lines of transformation products of U and Th in the spectra of these elements.
8. Nagaoka and Futagami: PIAT **2,** 533 (1926). Ultraviolet spectrum of freshly prepared uranium oxide.


## General References

**1920**

**Qg**


1. Adams: BNC **1,** pt. 5, No. 5, 301 (1920). The quantum theory (including application to spectral lines).
2. Basu: PM **40,** 619 (1920). Deduction of Rydberg formula from the quantum theory.
3. Bell: PM **40,** 489 (1920). Rydberg constants for hydrogen and ionized helium.
4. Bohr: ZP **2,** 423 (1920). Theory of series spectra. Review.
5. Brillouin: CR **171,** 1000 (1920). Actions à hérédité discontinue et raies spectrals.
6. van Cittert and Burger: PZ **21,** 16 (1920). Influence of temperature on position and intensity of echelon grating lines.
7. Darwin: PM **39,** 537 (1920). Dynamical motions of charged particles. Application to Bohr's theory of spectra.
8. Das: BCMS **12,** 151 (1920–1921). Polarization and intensity in the complex Zeeman effect.
9. Duffield: RAS **80,** 262 (1920). Displacement of spectral lines and equivalence hypothesis.
10. Foote and Meggers: PM **40,** 80 (1920). Atomic theory and low voltage arcs.
11. Försterling: ZP **3,** 404 (1920). Bohr's atom model and relativity.
12. Fowler: E **110,** 382 (1920). Origin of spectra. A review.
13. Franck: ZP **1,** 2 (1920). Intensity distribution and the Bohr theory.
14. Füchtbauer: PZ **21,** 322 (1920). Absorption in the light of quantum theory.
15. Fues: AP **63,** 1 (1920). Selection rules. Displacement law. Calculation of constants in Ritz formula, and of series limits.
16. Gehrcke: PZ **21,** 378 (1920). Relation between optical and x-ray spectra.
17. de Gramont: CR **171,** 1106 (1920). Ultimate lines of 83 elements.
18. Harkins and Aronberg: JACS **42,** 1328 (1920). Spectra of isotopes.
19. Hicks: PTRS **220,** 335 (1920). Critical study of spectral series. V. Monatomic gases.
20. King: AJ **51,** 13 (1920). PNAS **6,** 63 (1920). Characteristics of absorption spectra in the electric furnace.
21. King: AJ **52,** 187 (1920). Influence of *PD* on the radiation of the tube resistance furnace.
22. King: PNAS **6,** 65 (1920). Effect of a magnetic field on electric furnace spectra.
23. Kramers: ZP **3,** 199 (1920). Quantum theory of Stark effect.
24. Ladenburg: Nw **8,** 5 (1920). Electronic structure of atoms of the long periods. Paramagnetism.
25. Ladenburg: ZE **26,** 262 (1920). Atomic structure and the periodic system. A review.
26. Landé: ZP **1,** 191 (1920); ZP **2,** 87 (1920). Concerning the size of atoms.
27. Merton: PRS **96,** 388 (1920). Spectra of isotopes.
28. Merton: PRS **98,** 255 (1920). Effect of concentration on the spectra of luminous gases.
29. Millikan: AJ **52,** 47 (1920). Extension of the ultraviolet spectrum.
30. Nicholson and Merton: PRS **98,** 261 (1920). Effect of asymmetry on wave-length determinations.

**Qg**


31. Pauli, Jr. PZ **21,** 615 (1920). Quantum theory and the magneton.
32. Polvani: NC **20,** 119 (1920). Time variations in the spectrum of an electric discharge.
33. Roschdestwensky: VOIL **1,** Kap. IV No. 6 (1920). Doublets and triplets produced by magnetic fields inside the atom.
34. Saha: PM **40,** 472, 809 (1920). Ionization in solar chromosphere.
35. Seeliger: JRE **16,** 415 (1920). Life of excited atoms.
36. Seeliger and Mierdel: ZP **1,** 355 (1920). Excitation by electron impact.
37. Silberstein: PM **39,** 46 (1920). Aspherical nucleus and quantum theory of spectral emission.
38. Sommerfeld: AP **63,** 221 (1920). General laws: permanence of multiplicities. Selection principle. Displacement law. Rydberg alternation law. Law of Zeeman splitting. Runge denominator. Stark effect.
39. Sommerfeld: JRE **17,** 426 (1920). On criticism of Bohr's theory of radiation.
40. Sommerfeld- Nw **8,** 61 (1920). A "zahlenmysterium" in the theory of the Zeeman effect.
41. Sommerfeld: PZ **21,** 619 (1920). Correspondence of H fine structure with gross structure of non-hydrogenic spectra. Spectra and cubical electron arrangement.
42. Sommerfeld: ZE **26,** 258 (1920). Foundations and scope of the Bohr theory of atoms and spectra.
43. Stark: JRE **17,** 161 (1920). A criticism of Bohr's theory of light emission.
44. Tuczek and Heuck: AP **63,** 766 (1920). Methods of observing the Stark effect.
45. Waran: PCPS **20,** 45 (1920). Effect of magnetic field on line intensity.

1921

46. Allin: PRSE **42,** 213 (1921/22). The magnetic character of the quantum.
47. Back: Nw **9,** 199 (1921). A further "zahlenmysterium" in the theory of the Zeeman effect.
48. Bohr: N **107,** 104 (1921); N **108,** 208 (1921). Series spectra and atomic structure.
49. Burger and van Cittert: PKAA **23,** 790 (1921). Intensity measurements with the echelon.
50. Compton: JFI **192,** 145 (1921). The magnetic electron. Hypothesis of spinning electron.
51. Das: BCMS **12,** 67 (1921). Theory of abnormal Zeeman effect.
52. Dunstan and Wooten: AJ **54,** 65 (1921). A study of arc-cathode spectra. Relative intensity of metallic lines at anode and cathode.
53. Franck: PZ **22,** 388, 409, 441 and 466 (1921). Excitation by electron impact.
54. Franck and Grotrian: ZP **4,** 89 (1921). Remarks on excited atoms.
55. Götze: AP **66,** 285 (1921). Line groups and inner quanta. Zeeman effect.
56. Goudsmit: Nw **9,** 995 (1921). Relativistic conception of doublets.
57. de Gramont: CN **122,** 58 (1921). Ultimate lines of 83 elements.
58. de Gramont and Hemsalech: CR **173,** 278 (1921). Conditions of emission of spark lines by the electric arc.
59. Hale: P **1,** 250 (1921). Astrophysical aspects of Zeeman effect.
60. Hughes: BNC Vol. **2,** part 2, No. 10, 83 (1921). Report on photoelectricity, including critical and ionizing potentials.
61. Kallman: Nw **9,** 513 (1921). Spectra of hydrogen-like elements. General discussion.
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63. Ladenburg: ZP **4,** 451 (1921). Quantum mechanical interpretation of the number of dispersion electrons.
64. Landé: Nw **9,** 926 (1921); PZ **22,** 417 (1921); ZP **5,** 231 (1921); ZP **7,** 398 (1921). Theory of anomalous Zeeman effect.
65. Lorentz: P **1,** 228 (1921). Theory of the Zeeman effect.
66. Meggers, JOSA **5,** 308 (1921). Standard wave-lengths. A review.
67. Mie: AP **66,** 237 (1921). Duration of light emission.
68. Millikan: PNAS **7,** 289 (1921). Extension of the ultraviolet spectrum and the progression with atomic number of the spectra of light elements.
69. Mogendorff: P **1,** 310 (1921). Review of series spectra formulae.
70. Moore: AJ **54,** 191 and 246 (1921). Excitation stages in open arclight spectra.

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71. Paschen and Back: P **1,** 261 (1921). Line groups magnetically complete. Anomalous Zeeman effect.
72. Ribaud: JPR **2,** 107 (1921). Dampening of radiation. Broadening of lines.
73. Rogestwensky: N **107,** 203 (1921); VOIL **2,** No. 13 (1921). Intensity ratio of alkali doublets.
74. Roschdestwensky: VOIL **2,** No. 7 (1921); VOIL **2,** No. 8 (1921). Interpretation of spectral series.
75. Rubinowicz: ZP **5,** 331 (1921). Theory of intensity dissymmetry in the Stark effect.
76. Saha: PM **41,** 267 (1921). Problems of temperature radiation of gases.
77. Saha: PRS **99,** 135 (1921). A physical theory of stellar spectra.
78. Saunders: JOSA **5,** 1 (1921). A review of the series in the spectra of the elements.
79. Schrödinger: ZP **4,** 347 (1921). Interpretation of terms of sharp subordinate series. Interaction of outer electron and inner shells.
80. Seeliger: PZ **22,** 610 (1921). Excitation of light by electron impacts.
81. Seeliger: ZP **4,** 424 (1921). Theory of intensity distribution.
82. Seeliger and Mierdel: ZP **5,** 182 (1921). Excitation by electron impact.
83. Seeliger and Schramm: ZP **7,** 93 (1921). Excitation by electron impact.
84. Seeliger and Thaer: AP **65,** 423 (1921). Displacement law. Study of excitation energies.
85. Sommerfeld: AP **65,** 36 (1921). On the second order Stark effect.
86. Sommerfeld and Wentzel: ZP **7,** 86 (1921). Regular and irregular doublets.
87. Stern: ZP **7,** 249 (1921). A way to the experimental proof of space quantization in a magnetic field.
88. Waran: IACS **6,** 195 (1921); PCPS **20,** 428 (1921). Effect of a magnetic field on spectra.
89. Webster and Page: BNC **2,** pt. 6, No. 14, 336 and 356 (1921). General survey of atomic structure problem.
90. Wentzel: ZP **6,** 84 (1921). System in x-ray spectra. Regular and irregular doublets.
91. Whittaker: PRSE **42,** 129 (1921/22). Quantum mechanism in the atom. (Connection with Bohr's theory of spectra.)
92. Wien: AP **66,** 229 (1921). Duration of light emission.

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93. Anderson: PNAS **8,** 231 (1922). Spectral energy distribution and opacity of wire explosion vapours.
94. Barnett: BNC **3,** pt. 3, No. 18, 235 (1922). Angular momentum of the elementary magnet.
95. Becker: ZP **9,** 332 (1922). Theory of Stark effect for alkalies.
96. Bohr: PM **43,** 1112 (1922). On exceptions to the selection principle.
97. Bohr: ZP **9,** 1 (1922). Atomic structure and the physical and chemical properties of the elements.
98. Born and Pauli: ZP **10,** 137 (1922). Quantization of perturbed mechanical systems.
99. Brillouin: JPR **3,** 65 (1922). Bohr's atom. Lagrange's function about the nucleus.
100. Broughall: PM **44,** 204 (1922). Complex spectra. Theory of neon spectrum.
101. Cabrera: JPR **3,** 443 (1922). Paramagnetism and atomic structure.
102. Chuckerbutti: BCMS **12,** 221 (1922). Non-radiating electronic orbits and normal Zeeman triplet.
103. Compton: PM **43,** 531 (1922); PR **20,** 282 (1922). Theory of ionization by culminative action of successive impacts.
104. Croze: CR **175,** 1143 (1922). Place of the ultimate rays of the elements in the spectral series and their relations to the resonance rays.
105. Datta: N **110,** 39 (1922). An exception to the selection principle.
106. Dauvillier: JPR **3,** 154 and 221 (1922). Electronic structure of the elements.
107. Dushman: JOSA **6,** 235 (1922). Applications of the quantum theory to spectral series.
108. Ehrenfest and Bohr: N **109,** 745 (1922). Series spectra of isotopes.
109. Ehrenfest and Breit: ZP **9,** 207 (1922). Quantization of rigid electric dipole.
110. Einstein and Ehrenfest: ZP **11,** 31 (1922). Quantum theoretical remarks on the Stern-Gerlach experiment.

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111. Epstein: ZP **8**, 211 and 305 (1922); ZP **9**, 92 (1922). Perturbation theory.
112. Foote and Mohler: JOSA **6**, 54 (1922). Significance of the 1/2 terms in spectral series formulae.
113. Försterling: ZP **10**, 387 (1922). Quantum theory of radiation.
114. Füchtbauer and Joos: PZ **23**, 73 (1922). Intensities and broadening of spectral lines.
115. Fues: ZP **11**, 364 (1922). Calculation of hydrogen like terms from the central motion of the electrons.
116. Gehrcke: PZ **23**, 432 (1922). Group spectra.
117. Goudsmit: ANSE **6**, 116 (1922). Relativistic nature of optical doublets.
118. de Gramont: CR **175**, 1025 (1922). Ultimate lines and spectral series.
119. Grotrian: ZP **8**, 116 (1922). L doublet of Ne I. An analogy between x-ray and optical spectra.
120. Haber and Zisch: ZP **9**, 302 (1922). Excitation of gas spectra by chemical reaction.
121. Heisenberg: ZP **8**, 273 (1922). Quantum theory of line structure and the anomalous Zeeman effect.
122. Hicks: PM **44**, 346 (1922). Assumptions in the quantum orbit theory.
123. Hornle: JRE **18**, 297 (1921/22). Centers and space distribution of light emission in metallic arcs.
124. Ingersoll: BNC **3**, pt. 3, No. 18, 251 (1922). Magneto-optics.
125. Kennard: PR **19**, 420 (1922). Moment of momentum of magnetic electrons.
126. King: AJ **55**, 380 (1922). Electric furnace spectra involving ionization phenomena. Saha's theory.
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128. Landé: ZP **11**, 353 (1922). Theory of the anomalous Zeeman effect and magneto-mechanical effect.
129. Lyman: S **55**, 161 (1922). Spectroscopy of extreme ultraviolet.
130. Meggers: JOSA **6**, 135 (1922). Standard wave-lengths. Report of 1921 Committee.
131. Merton: RIGB **23**, 526 (1922). Problems in the variability of spectra.
132. Mosharrafa: PM **43**, 943 (1922); PM **44**, 371 (1922). Unsymmetrical components. Stark effect for strong fields.
133. Nicholson: N **110**, 37 (1922). Spectra of isotopes.
134. Ray: N **110**, 215 (1922). Frequency and energy relations in the quantum theory of line spectra.
135. Rogestwensky: JRPC **50**, 11 (1922). Intensity ratio of alkali doublets.
136. Russell: AJ **55**, 119 (1922). Theory of ionization and the sun spot spectrum. Relative intensity of arc and enhanced lines. Ionization potential as a function of atomic number.
137. Schrödinger: PZ **23**, 301 (1922). Doppler effect and Bohr's frequency condition.
138. Seeliger: ZP **11**, 197 (1922). Excitation by electron impact.
139. Sen: PZ **23**, 397 (1922). Doppler effect and fine structure.
140. Smekal: ZP **11**, 294 (1922). Quantization of periodic systems.
141. Sommerfeld: ZP **8**, 257 (1922). Quantum mechanical interpretation of Voigt's theory of the anomalous Zeeman effect of the *D* type.
142. Sommerfeld and Heisenberg: ZP **10**, 393 (1922). Note on relativistic x-ray doublets and line sharpness.
143. Sommerfeld and Heisenberg: ZP **11**, 131 (1922). Intensities of multiplets and their Zeeman components. Theoretical.
144. Stern: PZ **23**, 476 (1922). Space quantization in an electric field. Stark effect.
145. Wentzel: EEN **1**, 298 (1922). Progress in atomic and spectral theory.
146. Wien: AP **69**, 325 (1922). A method of separating arc and spark lines.
147. Wilson: PRS **102**, 478 (1922). Quantum theory and electromagnetic phenomena.
148. Transactions, International Astronomical Union, **1**, p. 35 (1922). Standard wave-lengths.

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149. Adams: BNC **7**, pt. 3, No. 39, 3 (1923). The quantum theory. Application to spectral structure.

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150. Babcock: AJ **58,** 149 (1923). Determination of $e/m$ from the Zeeman effect.
151. Back: AP **70,** 333 (1923). On knowledge of the Zeeman effect.
152. Bazzoni: JFI **196,** 627 (1923). Ionization and resonance phenomena. General survey.
153. Boguslawski: PM **45,** 145 (1923). Problem of two moving charges.
154. Bohr: AP **71,** 228 (1923). Line spectra and atomic structure.
155. Bohr: Nw **11,** 606 (1923). Atomic structure and series spectra.
156. Bohr: PPS **35,** 275 (1923). Effect of electric and magnetic fields on spectral lines.
157. Bohr: ZP **13,** 117 (1923). Quantum theory and atomic structure. I. Fundamental postulates.
158. Bohr and Coster: ZP **12,** 342 (1923). X-ray spectra and the periodic system of the elements.
159. Born: Nw **11,** 537 (1923). Quantum theory and perturbation calculations.
160. Born and Heisenberg: ZP **14,** 44 (1923). Phase relations in the Bohr model.
161. Breit: N **112,** 396 (1923). Heisenberg theory of the anomalous Zeeman effect.
162. Breit: PNAS **9,** 244 (1923). Width of spectral lines due to collisions, and quantum theory.
163. Burns: JOSA **7,** 419 (1923). Measurement of standard wave-lengths. A review.
164. Cabrera: AFQ **21,** 505 (1923). The Weiss and Bohr magnetons.
165. Carrelli: NC **25,** 213 (1923). Stark effect.
166. Cario and Franck: ZP **17,** 202 (1923). Sensitized fluorescence of gases.
167. Catalan: AFQ **21,** 162 (1923). The ground state of an atom.
168. Compton: JOSA **7,** 955 (1923). Properties of excited atoms and reversible effects of electron impacts in gases.
169. Compton: PM **45,** 750 (1923). Properties of resonance radiation and excited atoms.
170. Conway: PM **45,** 324 (1923). Orientation of Bohr-Sommerfeld orbits.
171. Croze: CR **177,** 1285 (1923). Relations between "raies ultimes" and resonance lines.
172. Das: BCMS **13,** 183 (1923). Spectra of isotopes. Theory.
173. Dempster: AJ **57,** 193 (1923). Duration of light emission. Stark effect.
174. Dorgelo: ZP **13,** 206 (1923). Multiplet intensities. Experimental.
175. Dunoyer: CR **176,** 953 (1923). On the nature of induction spectra and of spark spectra.
176. Ehrenfest: Nw **11,** 543 (1923). Adiabatic transformations and Bohr's theory.
177. Epstein: PM **46,** 964 (1923). Stark effect for strong fields.
178. Epstein: PR **22,** 202 (1923) (A). Simultaneous action of an electric and a magnetic field on a hydrogen like atom.
179. Epstein: S **57,** 532 (1923). Paramagnetism and the theory of quanta.
180. Fermi: AAL **32,** part 2, 493 (1923). Probability of quantum states.
181. Foote, Ruark, and Mohler: JOSA **7,** 415 (1923). The $D_2$ Zeeman pattern for resonance radiation.
182. Fowler: N **112,** 655 (1923). Origin of optical spectra.
183. Füchtbauer, Joos and Dinkelacker: AP **71,** 204 (1923). Intensity, broadening and pressure displacement of spectral lines.
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185. Fues: ZP **13,** 211 (1923). Derivation of atomic potential function. Relationship of Na I, Mg II and Al III.
186. Gerlach: EEN **II,** 124 (1923). Magnetism and atomic structure.
187. Gerlach and Schütz: Nw **11,** 637 (1923). Magneto-optical effects in weak fields.
188. Halpern: ZP **18,** 287 (1923). Quantum theory of effect of crossed electric and magnetic fields on spectral lines.
189. Halpern: ZP **18,** 352 (1923). Quantum theory of normal Zeeman effect.
190. Hanle: Nw **11,** 690 (1923). Zeeman effect in resonance fluorescence.
191. Hartree: PCPS **21,** 625 (1923). Approximate numerical applications of Bohr's theory of spectra. Strength of atomic field. Calculation of terms.
192. Hicks: PM **45,** 480 (1923). Radiation and ionization potentials of the rare gases.
193. Hopfield and Leifson: AJ **58,** 59 (1923). Extreme ultraviolet standards.

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194. Hoyt: PM **46,** 135 (1923). Correspondence principle and intensity of spectral lines. Relative intensity of x-ray lines.
195. Kar: PM **45,** 610 (1923). Theory of generalized quanta and the Balmer lines.
196. Kimura and Nakamura: JJP **2,** 61 (1923). Broadening of lines caused by increased current density, and their Stark effects.
197. Kossel: Nw **11,** 598 (1923). Bohr's theory and the interpretation of chemical processes.
198. Kramers: Nw **11,** 550 (1923). The correspondence principle and atomic structure.
199. Ladenburg and Reiche: Nw **11,** 584 (1923). Absorption, scattering, and dispersion according to Bohr's theory.
200. Landé: EEN **II,** 147 (1923). Progress in the Zeeman effect.
201. Landé: PZ **24,** 441 (1923). Difficulties in the quantum theory of atomic structure, especially those of a magnetic nature.
202. Landé: ZP **15,** 189 (1923). Term structure and Zeeman effect.
203. Landé: ZP **16,** 391 (1923). Theory of x-ray spectra. Doublet laws and optical spectra.
204. Landé: ZP **19,** 112 (1923). Part II. Term structure and Zeeman effect of multiplets.
205. Mackay: PM **46,** 828 (1923). Ionization potentials of He and some multi-atomic gases.
206. McLennan: CN **127,** 198 and 212 (1923); E **116,** 422 (1923). The origin of spectra. A review.
207. Moore: AJ **58,** 86 (1923). Excitation stages in the open arc-light spectra.
208. Mosharrafa: PM **46,** 177 (1923). Quantum theory of the complex Zeeman effect.
209. Mosharrafa: PM **46,** 514 (1923); PRS **102,** 529 (1923). Quantum theory of simple Zeeman effect.
210. Mosharrafa: PM **46,** 751 (1923). Stark effect for strong fields.
211. Nagaoka and Sugiura: JJP **2,** 167 (1923). Spectroscopic evidence of isotopy.
212. Narayan: N **112,** 651 (1923). Spectra of isotopes.
213. Newboult: PM **45,** 1081 (1923). Stark effect in strong fields.
214. Nicholson: PM **45,** 801 (1923). Quantum theory and isotopes. Orbits passing through nucleus.
215. Noyes, Jr.: S **57,** 314 (1923). Ionization and resonance potentials. General survey.
216. Paschen: Nw **11,** 434 (1923). Remarks on frequency difference of doublet lines.
217. Paschen: Nw **11,** 638 (1923). On the combination principle.
218. Paschen: PZ **24,** 401 (1923). The spectroscopic investigation of atomic structure. The combination principle. Term magnitude. Properties of term sequences. Term multiplicity. A review.
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221. Planck: Nw **11,** 535 (1923). Bohr's theory of the atom.
222. Robertson: JOSA **7,** 983 (1923). Methods of intensity measurements.
223. Runge: Nw **11,** 640 (1923). On the combination principle.
224. Sawyer and Becker: AJ **57,** 98 (1923). Relation of explosion spectra to the theory of spectra.
225. Smekal: Nw **11,** 873 (1923). Quantum theory of dispersion.
226. Smekal: VDPG **4,** 17 (1923). Space quantization in a magnetic field.
227. Smekal: ZP **15,** 58 (1923). Quantization of periodic systems.
228. Sommerfeld: AP **70,** 32 (1923). Interpretation of complex spectra by use of inner quantum numbers. Spectroscopic magneton numbers.
229. Sommerfeld: ZP **19,** 221 (1923). Theory of the magneton. Space quantization. Distribution of magneton numbers over the periodic system.
230. Turner: AJ **58,** 176 (1923). The relation between the spectra and the sizes of the alkali metal atoms.
231. van Urk: ZP **13,** 268 (1923). Normal orbits of the series electrons of the alkalies.
232. Wentzel: PZ **24,** 104 (1923). Series spectra whose emission involves more than one electron. Metastable states in positive ions. Two-electron transitions.

Qg

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234. Wereide: PR **21,** 391 (1923). General principle of relativity applied to the Rutherford-Bohr atom model.
235. Werner: FT **21,** 113 (1923). Quantum theory of spectra. A review.
236. Wien: AP **70,** 1 (1923). Radiation from canal rays. Duration of light emission.

**1924**

237. Becker: ZP **27,** 173 (1924). Absorption and dispersion in Bohr's quantum theory. Line breadth.
238. Birge: JOSA **8,** 233 (1924). Series of divalent elements.
239. Bohr: Nw **12,** 1115 (1924). Polarization of fluorescent light.
240. Bohr, Framers and Slater: PM **47,** 785 (1924); ZP **24,** 69 (1924). Quantum theory of radiation; broadening of spectral lines.
241. Born: ZP **26,** 379 (1924). Correspondence principle. Heisenberg formulation of rule for anomalous Zeeman effect.
242. Born and Heisenberg: ZP **23,** 388 (1924). Ion deformation and the Rydberg correction. Polarizability of the atom core.
243. Bowen and Millikan: PR **24,** 209 (1924). Extension of the x-ray doublet laws into the field of optics.
244. Brackett and Birge: JOSA **8,** 213 (1924). Quantum defect.
245. Breit: N **114,** 310 (1924). Quantum theory of dispersion.
246. Breit: PM **47,** 832 (1924). Polarization of resonance radiation.
247. de Broglie and Dauvillier: JPR **5,** 1 (1924). Analogies between x-ray and optical spectra.
248. Burger and Dorgelo: ZP **23,** 258 (1924). Relation between inner quantum numbers and intensities of multiplet lines.
249. Catalán: N **114,** 192 (1924). Relation between pressure shift, temperature class, and spectral terms.
250. Compton and Mohler: BNC **9,** part 1, No. 48, 1 (1924). Critical potentials. Methods and interpretation.
251. Darrow: BNC **8,** pt. 5, No. 47, 1 (1924). Classified list of published bibliographies in physics (1910–1922).
252. Dirac: PAPC **22,** 432 (1924). Doppler effect and Bohr's frequency condition.
253. Eldridge: PR **23,** 772 (1924) (A). Classical theory explanation of Wood and Ellet's polarization experiment.
254. Ellett: N **114,** 931 (1924). Polarization of resonance radiation in magnetic fields.
255. Epstein: PNAS **10,** 337 (1924); PR **24,** 205 (1924). Two electron jumps and Bohr's model.
256. Fermi: P **4,** 340 (1924). Calculation of intensities of multiplet lines.
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258. Foote: JFI **198,** 344 and 517 (1924). Spectroscopy and Bohr's theory of atomic structure. A general review.
259. Fowler: RASC **18,** 373 (1924). Origin of spectra. A review.
260. Free: IEC **16,** 192 (1924). Bohr's model of the atom. A review.
261. Fues: ZP **21,** 265 (1924). Motion of electron in central field. Calculation of terms.
262. Geppert: ZP **24,** 208 (1924). Adiabatic transformation of the Kepler ellipse into the harmonic ellipse.
263. Gerlach: EEN **III,** 182 (1924). "Atomstrahlen".
264. Gerlach and Stern: AP **74,** 673 (1924). Space quantization in a magnetic field.
265. Goudsmit: P **4,** 75 (1924). Anomalous Zeeman effect and the structure of spectra.
266. Grotrian: Nw **12,** 945 (1924). Interpretation of complex spectra.
267. Hartree: PCPS **22,** 409 (1924). Identification of lines of Li and Na like atoms. Quantitative relations.
268. Hartree: PCPS **22,** 464 (1924). Methods of estimating successive ionization potentials of any element.

Qg

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270. Heisenberg: ZP **26,** 291 (1924). An amendment of formal quantum rules in the problem of the anomalous Zeeman effect. Energy of coupling defined by two quantum numbers.
271. Hertz: ZP **22,** 18 (1924). Excitation by electron impact.
272. Hicks: PM **48,** 321 (1924). Application of the oun to series grouping.
273. Hicks: PM **48,** 1036 (1924). On Sommerfeld's and Landé's rules for classification of terms and Zeeman patterns in spectra.
274. Holtsmark: PZ **25,** 73 (1924). Broadening of spectral lines.
275. Hund: ZP **22,** 405 (1924). Rydberg correction and radius of the atom core.
276. Joos: PZ **25,** 130, 298 and 400 (1924). Influence of a magnetic field on the polarization of resonance radiation.
277. Jones: PRS **105,** 650 (1924). Dielectric constant computed on the basis of the Stark effect.
278. Jones and Boyce: PRS **106,** 773 (1924). Constants of the Rydberg-Ritz equation. Quantum defect.
279. Kapitza and Skinner: N **114,** 273 (1924). Zeeman effect in strong fields.
280. Kramers: N **113,** 673 (1924); N **114,** 310 (1924). Quantum theory of dispersion and Bohr's theory of spectra.
281. Ladenburg: Nw **12,** 248 (1924). Normal state of atoms with incomplete subshells.
282. Landé: Nw **12,** 332 (1924); ZP **24,** 88 (1924). The character of relativistic doublets.
283. Landé: ZP **25,** 46 (1924). The absolute intervals of optical doublets and triplets. Doublet laws.
284. Landé: ZP **27,** 149 (1924). Primed and displaced terms in spectra.
285. Landé and Heisenberg: ZP **25,** 279 (1924). Term structure of multiplets of higher degree.
286. Laporte: ZP **23,** 166 (1924). A more general selection principle.
287. Landé: ZP **30,** 329 (1924). Theory of quadratic Zeeman effect.
288. Lenz: ZP **24,** 197 (1924). Quantum states of perturbed Kepler motion.
289. Lindsay: MIT **3,** 191 (1924). Electronic orbits in the alkali metals.
290. Mackay: PR **24,** 319 (1924). Ionization potentials of multi-atomic gases.
291. McLennan, Millikan, Fowler, Bohr and others: N **113,** 217 (1924). Series spectra of the lighter elements. A review.
292. Meggers, Kiess and Walters Jr.: JOSA **9,** 355 (1924). Displacement law. Multiplets in various spectra.
293. Menzies: N **114,** 861 (1924). Optical separations and atomic numbers.
294. Mie: AP **73,** 195 (1924). Duration of emission from canal rays.
295. Millikan: JCS **125,** 1405 (1924). Electrons and atomic structure. Faraday lecture.
296. Millikan and Bowen: PR **23,** 1 (1924). Extreme ultraviolet spectra. Progression of spectra with atomic number. Spectra of stripped atoms.
297. Millikan and Bowen: PR **24,** 223 (1924). The Bohr atom; screening constants; extension of doublet laws.
298. Milne: PM **47,** 209 (1924). Statistical equilibrium in relation to the photoelectric effect. Application to determination of absorption coefficient and transition probabilities.
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300. Mosharrafa: PRS **105,** 641 (1924). Half-integral quantum numbers in the theory of the Stark effect and a general hypothesis of fractional quantum numbers.
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303. Ornstein and Burger: PZ **25,** 298 (1924). Influence of a magnetic field on polarization of resonance radiation.
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305. Ornstein and Burger: ZP **28,** 135 (1924); ZP **29,** 241 (1924). Intensities of Zeeman components.

Qg

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307. Payne: PNAS **10**, 322 (1924). Synopsis of ionization potentials of elements.
308. Pringsheim: Nw **12**, 247 (1924); ZP **23**, 324 (1924). On the polarization of resonance radiation of vapours.
309. Royds: KB **43**, 109 (1924). Different character of lines belonging to the same series.
310. Ruark, Mohler and Chenault: N **114**, 575 (1924). Fine structure in non-hydrogenic atoms.
311. Ruark, Mohler, Foote and Chenault: BSP No. 490, Vol. **19**, 463 (1924). Spectra and critical potentials of fifth group elements.
312. Russell: S **59**, 512 (1924). A new form of the exclusion principle in optical spectra.
313. Saunders: S **59**, 47 (1924). Some aspects of modern spectroscopy. Semi-popular survey.
314. Sommerfeld: AP **73**, 209 (1924). Theory of multiplets and their Zeeman effects. Spectroscopic magneton numbers.
315. Stewart: AJ **59**, 30 (1924). Width of absorption lines in a rarefied gas.
316. Stoner: PM **48**, 719 (1924). Distribution of electrons among atomic levels.
317. Turner: AJ **60**, 81 (1924). On spectra and the sizes of atoms.
318. Turner: PM **48**, 384 and 1010 (1924). Quantum defect and atomic number.
319. Urey: ZP **29**, 86 (1924). Disturbance of the Zeeman effect by electric fields.
320. Van Vleck: PR **24**, 330 (1924). Some extensions of the correspondence principle.
321. Van Vleck: PR **24**, 347 (1924). Calculation of absorption by multiply periodic orbits.
322. Wall: PM **48**, 378 (1924). A development of the selection principle based upon the Stokes-Thomson pulse theory.
323. Wallerath: AP **75**, 37 (1924). Secondary wave-length standards.
324. Weigert: Nw **12**, 38 (1924). Influence of weak magnetic fields on polarization of resonance radiation.
325. Wentzel: PZ **25**, 182 (1924). Series spectra in whose emission more than one electron is involved.
326. Wentzel: ZP **22**, 193 (1924). On quantum optics. Theory of spectra.
327. Werner: FT **22**, 37 (1924). Quantum theory of spectra. A review.
328. Wien: AP **73**, 483 (1924). Duration of light emission.
329. von Wisniewski: PZ **25**, 135, 330, 477 and 480 (1924). Method of calculating term corrections. Applications.

**1925**

330. Back: PZ **26**, 833 (1925). Experimental basis of Zeeman effect. A review.
331. Back: ZP **33**, 579 (1925). Irregular Zeeman effect of multiplets of the first degree.
332. Bartels: ZP **32**, 415 (1925). Distribution of transition probabilities in the alkali atoms.
333. Bowen and Millikan: PR **25**, 295 (1925). Series spectra of stripped atoms.
334. Bowen and Millikan: PR **25**, 884 (1925) (A); PR **26**, 150 (1925). Relations of *PP′* groups in atoms of the same electronic structure.
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**Qg**

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349. Fabry: JFI **199,** 13 (1925). Spectroscopy in the past and in the future.
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351. Foote, Takamine and Chenault: PR **26,** 165 (1925). Violations of the Bohr selection rules. Forbidden lines.
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353. Fränz and Kallman: ZP **34,** 924 (1925). Excitation of gas spectra by chemical reaction.
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355. Gehrcke: PZ **26,** 674 (1925). New results of fine structure research.
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361. Goudsmit: P **5,** 419 (1925). Zeeman effect in spectra of higher degree.
362. Goudsmit: ZP **32,** 794 (1925). Structure of complex spectra. Derivation of allowed states.
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366. Hanle: EEN IV, 214 (1925). Influence of magnetic fields on resonance fluorescence.
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375. Holtsmark and Trumpy: ZP **31,** 803 (1925). Broadening of spectral lines.
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**1926**

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**Qg**

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**Qg**


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516. Richter: PR **28**, 849 (1926) (A). Spinning electron in hydrogen like spectra.
517. Rolla and Piccardi: CI **16**, 531 (1926). Chemical properties and ionization potentials.
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**Qg**

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**1927**

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**Qg**

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**Qg**


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