$$
\begin{aligned}
A_k=&(1/\beta^4)\{2(131)+2(113)+2(122)-(213)\\
&-(231)-(222)+4k[(131)+(113)+(122)]\\
&-4k^2[(031)+(013)+(022)]\}\\
&+(1/\alpha\beta^3)\{2(221)+2(212)+4(122)+(231)\\
&+(213)-(321)-(312)-(132)-(123)\\
&+4k[(221)+(212)-\tfrac{1}{2}(131)-\tfrac{1}{2}(113)]\\
&+4l[-\tfrac{1}{2}(221)+\tfrac{1}{2}(113)+\tfrac{1}{2}(122)+(121)]\\
&+4m[-\tfrac{1}{2}(212)+\tfrac{1}{2}(131)+\tfrac{1}{2}(122)+(112)]\\
&-4k^2[(121)+(112)]-4l^2[(112)+(103)]\\
&-4m^2[(121)+(130)]+4kl(121)+4km(112)\\
&+4lm[(121)+(112)]\}\\
&+(1/\alpha^2\beta^2)\{4(221)+4(212)-2(311)\\
&-2(222)+(321)+(312)-(231)-(213)\\
&+4k[(211)-\tfrac{1}{2}(221)-\tfrac{1}{2}(212)]+4l[(221)\\
&+(212)-\tfrac{1}{2}(311)]+4m[(221)+(212)\\
&-\tfrac{1}{2}(311)]-4l^2[(211)+(202)]\\
&-4m^2[(211)+(220)]+4kl(211)+4km(211)\}\\
&+(1/\alpha^3\beta)\{4(311)-(321)-(312)+4l(311)\\
&+4m(311)-4l^2(301)-4m^2(310)\},
\end{aligned}
$$

$$
\begin{aligned}
N=&(1/\alpha\beta^5)[(132)+(123)]+(1/\alpha^2\beta^4)[(231)\\
&+(213)+2(222)]+(1/\alpha^3\beta^3)[(321)+(312)],
\end{aligned}
$$

where $(123)=\Gamma(\kappa+k+1)\Gamma(\lambda+l+2)\Gamma(\mu+m+3)$;

$$
\begin{aligned}
A_{12}=&(\alpha/\gamma)^{\kappa+k}(\beta/\gamma)^{\mu+m}\{(1/\beta\gamma^4)2(212)\\
&+(1/\beta^2\gamma^3)2[(221)+(122)]\\
&+(1/\beta^3\gamma^2)2(131)\},
\end{aligned}
$$

where $\gamma=(\alpha+\beta+1/2)$ and $(123)=\Gamma(\kappa+m+1)\times\Gamma(\lambda+l+2)\Gamma(\mu+k+3)$;

$A_{13}=A_{12}$ with μ replaced by λ and m replaced by l;

$$
\begin{aligned}
A_{23}=&(\beta/\delta)^{\lambda+\mu+l+m}\{(1/\alpha\delta^4)2(122)\\
&+(1/\alpha^2\delta^3)2[(221)+(212)]\\
&+(1/\alpha^3\delta^2)2(311)\},
\end{aligned}
$$

where $\delta=(\beta+\frac{1}{2})$ and $(123)=\Gamma(\kappa+k+1)\Gamma(\lambda+m+2)\Gamma(\mu+l+3)$. Their numerical evaluation for given values of α and β is a matter of simple arithmetic.

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The Spectra of Y V and Zr VI

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The Br I isoelectronic sequence has been extended to Y V and Zr VI. Spectrograms covering the region from 150A to 1000A were obtained with a three-meter grazing incidence vacuum spectrograph having a dispersion of 1.0A/mm at 500A. The separations of the ground doublets $4s^24p^5$ were predicted by the regular doublet law and observed to be 12,068 cm^{-1} for Y V and 15,600 cm^{-1} for Zr VI. With the aid of the irregular doublet law and Moseley diagram curves, most of the expected $4s4p^6$, $4s^24p^44d$ and $4s^24p^45s$ levels with $j\leq 5/2$ were found. Forty-two lines of the spectrum of Y V and forty-six lines of the spectrum of Zr VI have been classified. The absolute term values of the $^2P^0{}_{3/2}$ ground levels of Y V and Zr VI were estimated to be 620,000 cm^{-1} and 798,000 cm^{-1}, respectively.

THE spectra of Br I,[1] Kr II,[2] Rb III[3] and Sr IV[3] have been analyzed to the extent that in each case the term values for nearly all the important lower lying levels are known. The ground state of a member of this sequence is determined by the configuration $4s^24p^5$ which gives rise to two odd levels: $^2P^0{}_{1\frac{1}{2}}$ and $^2P^0{}_{\frac{1}{2}}$, of which the former lies the deeper. The strongest emission lines in this sequence should arise from transitions between the ground state doublet and the configurations $4s4p^6$, $4s^24p^44d$ and $4s^24p^45s$. These lines should exhibit, except when j is $\geqslant 2\frac{1}{2}$, a constant frequency difference equal to the doublet separation of the ground state.

The analysis of Rb III and Sr IV was based on spectrograms made with a vacuum spectrograph covering the extreme ultraviolet region from 250A to 1200A. Only transitions into the ground doublet were considered. In the present

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[1] C. C. Kiess and T. L. de Bruin, Nat. Bur. Stand. J. Research **4**, 667 (1930).

[2] De Bruin, Humphreys and Meggers, Nat. Bur. Stand. J. Research **11**, 409 (1933).

[3] D. H. Tomboulian, Phys. Rev. **54**, 350 (1938).

work a similar analysis was undertaken of the spectra of Y V and Zr VI, the next two members in the sequence. The important lines needed to establish the higher lying odd levels fall outside the range covered by the spectrograms upon which this analysis is based.

Experimental

The spectrograms were obtained with a grazing incidence vacuum spectrograph designed to cover the region below 1000A, and equipped with a 3-meter grating having 30,000 lines per inch. The dispersion is 1.0A/mm at 500A. A condensed spark discharge was used as the source of radiation. Power was supplied to the electrodes at 50 kv from a circuit consisting of a 5-kw transformer, a Kenetron rectifier and a system of condensers having a total capacitance of 0.1 μf.

Aluminum, copper and carbon rods cored with yttrium oxide were used to obtain three sets of spectrograms of yttrium covering the region from 150A to 1000A. In the case of zirconium a similar procedure was followed, the salts being ZrO and $ZrOCl_2$, but in addition, a set of spectrograms was obtained by using electrodes of zirconium metal in carbon. The exposure times varied from one to three hours. Ilford type Q-II plates were used.

Wave-lengths of carbon, oxygen and nitrogen lines taken from a list compiled by Boyce and Robinson,[4] and of copper and chlorine lines from lists by Kruger and Cooper,[5] and I. S. Bowen,[6] respectively, were used as standards. It is estimated that the wave-lengths obtained are accurate to 0.01A.

The lines classified as belonging to the spectrum of Y V are listed in Table I and those of Zr VI in Table III. In these tables the first column gives the intensity; the second the wavelength in angstroms; the third the frequency in cm^{-1}, and the fourth the transition to which this line has been assigned. The symbols used to designate line characteristics in the intensity columns are those used in the *M.I.T. Wavelength Tables*.[7]

The Spectrum of Y V

The screening constant for Y V was found by extrapolating the results given in Tomboulian's paper.[3] By the regular doublet law, the separation of the two ground levels was then computed to be 12,100 cm^{-1}. From the data, a frequently occurring constant difference of 12,068 cm^{-1} was

TABLE II. *Relative term values for* Y V.

Term Symbol	Relative Term Value	Term Symbol	Relative Term Value
$4s^24p^5\,{}^2P^0_{1\frac{1}{2}}$	0	$4s^24p^4(^1D)4d\,{}^2D_{2\frac{1}{2}}$	289,836
$4s\ 4p^5\,{}^2P^0_{\frac{1}{2}}$	12,068	$4s^24p^4(^1D)4d\,{}^2D_{1\frac{1}{2}}$	297,072
$4s4p^6\,{}^2S_{\frac{1}{2}}$	170,936	$4s^24p^4(^1D)4d\,{}^2F_{2\frac{1}{2}}$	291,052
$4s^24p^4(^3P)4d\,{}^4D_{2\frac{1}{2}}$	202,902	$4s^24p^4(^1D)4d\,{}^2P_{\frac{1}{2}}$	299,567
$4s^24p^4(^3P)4d\,{}^4D_{1\frac{1}{2}}$	213,254	$4s^24p^4(^1D)4d\,{}^2P_{1\frac{1}{2}}$	300,217
$4s^24p^4(^3P)4d\,{}^4D_{\frac{1}{2}}$	219,116	$4s^24p^4(^1S)4d\,{}^2D_{1\frac{1}{2}}$	318,885
$4s^24p^4(^3P)4d\,{}^4P_{\frac{1}{2}}$	247,473	$4s^24p^4(^3P)5s\,{}^4P_{2\frac{1}{2}}$	280,932
$4s^24p^4(^3P)4d\,{}^4P_{1\frac{1}{2}}$	248,352	$4s^24p^4(^3P)5s\,{}^4P_{1\frac{1}{2}}$	287,205
$4s^24p^4(^3P)4d\,{}^4P_{2\frac{1}{2}}$	250,406	$4s^24p^4(^3P)5s\,{}^4P_{\frac{1}{2}}$	290,911
$4s^24p^4(^3P)4d\,{}^2D_{1\frac{1}{2}}$	253,678	$4s^24p^4(^3P)5s\,{}^2P_{1\frac{1}{2}}$	296,745
$4s^24p^4(^3P)4d\,{}^2D_{2\frac{1}{2}}$	263,524	$4s^24p^4(^3P)5s\,{}^2P_{\frac{1}{2}}$	306,349
$4s^24p^4(^3P)4d\,{}^2P_{\frac{1}{2}}$	258,518	$4s^24p^4(^1D)5s\,{}^2D_{2\frac{1}{2}}$	315,430
$4s^24p^4(^3P)4d\,{}^2P_{1\frac{1}{2}}$	258,567	$4s^24p^4(^1D)5s\,{}^2D_{1\frac{1}{2}}$	317,192
$4s^24p^4(^3P)4d\,{}^2F_{2\frac{1}{2}}$	274,254		

[4] J. C. Boyce and H. A. Robinson, J. Opt. Soc. Am. **26**, 133 (1936).

[5] P. Gerald Kruger and F. S. Cooper, Phys. Rev. **44**, 826 (1934).

[6] I. S. Bowen, Phys. Rev. **45**, 401 (1934).

[7] G. R. Harrison, *Wavelength Tables* (John Wiley and Sons, 1939).

TABLE I. *Classified lines of* Y V.

I	$\lambda(A)$	$\nu(cm^{-1})$	Classification	I	$\lambda(A)$	$\nu(cm^{-1})$	Classification
2	629.478	158,862	$4s^24p^5\,{}^2P^0_{\frac{1}{2}} - 4s4p^6\,{}^2S_{\frac{1}{2}}$	10	355.958	280,932	$4s^24p^5\,{}^2P^0_{1\frac{1}{2}} - 4s^24p^4(^3P)5s\,{}^4P_{2\frac{1}{2}}$
20	584.995	170,942	$4s^24p^5\,{}^2P^0_{1\frac{1}{2}} - 4s4p^6\,{}^2S_{\frac{1}{2}}$	2	351.273	284,679	$4s^24p^5\,{}^2P^0_{\frac{1}{2}} - 4s^24p^4(^3P)5s\,{}^2P_{1\frac{1}{2}}$
10	497.069	201,179	$4s^24p^5\,{}^2P^0_{\frac{1}{2}} - 4s^24p^4(^3P)4d\,{}^4D_{1\frac{1}{2}}$	5	350.877	285,000	$4s^24p^5\,{}^2P^0_{\frac{1}{2}} - 4s^24p^4(^1D)4d\,{}^2D_{1\frac{1}{2}}$
2	492.848	202,902	$4s^24p^5\,{}^2P^0_{1\frac{1}{2}} - 4s^24p^4(^3P)4d\,{}^4D_{2\frac{1}{2}}$	15	348.188	287,201	$4s^24p^5\,{}^2P^0_{1\frac{1}{2}} - 4s^24p^4(^3P)5s\,{}^4P_{1\frac{1}{2}}$
60	482.973	207,051	$4s^24p^5\,{}^2P^0_{\frac{1}{2}} - 4s^24p^4(^3P)4d\,{}^4D_{\frac{1}{2}}$	( )	347.827	287,499	$4s^24p^5\,{}^2P^0_{\frac{1}{2}} - 4s^24p^4(^1D)4d\,{}^2P_{\frac{1}{2}}$
1	468.911	213,260	$4s^24p^5\,{}^2P^0_{1\frac{1}{2}} - 4s^24p^4(^3P)4d\,{}^4D_{1\frac{1}{2}}$	2	347.039	288,152	$4s^24p^5\,{}^2P^0_{\frac{1}{2}} - 4s^24p^4(^1D)4d\,{}^2P_{1\frac{1}{2}}$
100	456.384	219,114	$4s^24p^5\,{}^2P^0_{1\frac{1}{2}} - 4s^24p^4(^3P)4d\,{}^4D_{\frac{1}{2}}$	5	345.023	289,836	$4s^24p^5\,{}^2P^0_{1\frac{1}{2}} - 4s^24p^4(^1D)4d\,{}^2D_{2\frac{1}{2}}$
40	424.796	235,407	$4s^24p^5\,{}^2P^0_{\frac{1}{2}} - 4s^24p^4(^3P)4d\,{}^4P_{\frac{1}{2}}$	1	343.749	290,910	$4s^24p^5\,{}^2P^0_{1\frac{1}{2}} - 4s^24p^4(^3P)5s\,{}^4P_{\frac{1}{2}}$
15	423.210	236,289	$4s^24p^5\,{}^2P^0_{\frac{1}{2}} - 4s^24p^4(^3P)4d\,{}^4P_{1\frac{1}{2}}$	1	343.581	291,052	$4s^24p^5\,{}^2P^0_{1\frac{1}{2}} - 4s^24p^4(^1D)4d\,{}^2F_{2\frac{1}{2}}$
1	413.898	241,605	$4s^24p^5\,{}^2P^0_{\frac{1}{2}} - 4s^24p^4(^3P)4d\,{}^2D_{1\frac{1}{2}}$	1	339.812	294,280	$4s^24p^5\,{}^2P^0_{\frac{1}{2}} - 4s^24p^4(^3P)5s\,{}^2P_{\frac{1}{2}}$
5w	405.787	246,435	$4s^24p^5\,{}^2P^0_{\frac{1}{2}} - 4s^24p^4(^3P)4d\,{}^2P_{\frac{1}{2}};\ {}^2P_{1\frac{1}{2}}$	1	336.991	296,744	$4s^24p^5\,{}^2P^0_{1\frac{1}{2}} - 4s^24p^4(^3P)5s\,{}^2P_{1\frac{1}{2}}$
10	404.086	247,472	$4s^24p^5\,{}^2P^0_{1\frac{1}{2}} - 4s^24p^4(^3P)4d\,{}^4P_{\frac{1}{2}}$	40	336.613	297,077	$4s^24p^5\,{}^2P^0_{1\frac{1}{2}} - 4s^24p^4(^1D)4d\,{}^2D_{1\frac{1}{2}}$
1	402.660	248,348	$4s^24p^5\,{}^2P^0_{1\frac{1}{2}} - 4s^24p^4(^3P)4d\,{}^4P_{1\frac{1}{2}}$	30	333.815	299,567	$4s^24p^5\,{}^2P^0_{1\frac{1}{2}} - 4s^24p^4(^1D)4d\,{}^2P_{\frac{1}{2}}$
40	399.352	250,406	$4s^24p^5\,{}^2P^0_{1\frac{1}{2}} - 4s^24p^4(^3P)4d\,{}^4P_{2\frac{1}{2}}$	40	333.095	300,215	$4s^24p^5\,{}^2P^0_{1\frac{1}{2}} - 4s^24p^4(^1D)4d\,{}^2P_{1\frac{1}{2}}$
5	394.191	253,684	$4s^24p^5\,{}^2P^0_{1\frac{1}{2}} - 4s^24p^4(^3P)4d\,{}^2D_{1\frac{1}{2}}$	2	327.731	305,128	$4s^24p^5\,{}^2P^0_{\frac{1}{2}} - 4s^24p^4(^1D)5s\,{}^2D_{1\frac{1}{2}}$
5	386.821	258,518	$4s^24p^5\,{}^2P^0_{1\frac{1}{2}} - 4s^24p^4(^3P)4d\,{}^2P_{\frac{1}{2}}$	1	326.424	306,350	$4s^24p^5\,{}^2P^0_{1\frac{1}{2}} - 4s^24p^4(^3P)5s\,{}^2P_{\frac{1}{2}}$
5	386.747	258,567	$4s^24p^5\,{}^2P^0_{1\frac{1}{2}} - 4s^24p^4(^3P)4d\,{}^2P_{1\frac{1}{2}}$	5	325.928	306,816	$4s^24p^5\,{}^2P^0_{\frac{1}{2}} - 4s^24p^4(^1S)4d\,{}^2D_{1\frac{1}{2}}$
20	379.472	263,524	$4s^24p^5\,{}^2P^0_{1\frac{1}{2}} - 4s^24p^4(^3P)4d\,{}^2D_{2\frac{1}{2}}$	1	317.028	315,430	$4s^24p^5\,{}^2P^0_{1\frac{1}{2}} - 4s^24p^4(^1D)5s\,{}^2D_{2\frac{1}{2}}$
1	364.626	274,254	$4s^24p^5\,{}^2P^0_{1\frac{1}{2}} - 4s^24p^4(^3P)4d\,{}^2F_{2\frac{1}{2}}$	2	315.269	317,189	$4s^24p^5\,{}^2P^0_{1\frac{1}{2}} - 4s^24p^4(^1D)5s\,{}^2D_{1\frac{1}{2}}$
5	363.450	275,141	$4s^24p^5\,{}^2P^0_{\frac{1}{2}} - 4s^24p^4(^3P)5s\,{}^4P_{1\frac{1}{2}}$	1	313.593	318,885	$4s^24p^5\,{}^2P^0_{1\frac{1}{2}} - 4s^24p^4(^1S)4d\,{}^2D_{1\frac{1}{2}}$
5w	358.624	278,844	$4s^24p^5\,{}^2P^0_{\frac{1}{2}} - 4s^24p^4(^3P)5s\,{}^4P_{\frac{1}{2}}$				

TABLE III. *Classified lines of* Zr VI.

I	$\lambda(A)$	$\nu(\text{cm}^{-1})$	Classification	I	$\lambda(A)$	$\nu(\text{cm}^{-1})$	Classification
300	568.277	175,971	$4s^24p^5\,{}^2P^0_{\frac{1}{2}}-4s4p^6\,{}^2S_{\frac{1}{2}}$	40	312.993	319,496	$4s^24p^5\,{}^2P^0_{1\frac{1}{2}}-4s^24p^4({}^3P)4d\,{}^2F_{2\frac{1}{2}}$
300	522.007	191,568	$4s^24p^5\,{}^2P^0_{1\frac{1}{2}}-4s4p^6\,{}^2S_{\frac{1}{2}}$	250	302.347	330,746	$4s^24p^5\,{}^2P^0_{\frac{1}{2}}-4s^24p^4({}^1D)4d\,{}^2D_{1\frac{1}{2}}$
15	434.027	230,400	$4s^24p^5\,{}^2P^0_{\frac{1}{2}}-4s^24p^4({}^3P)4d\,{}^4D_{1\frac{1}{2}}$	60	302.103	331,013	$4s^24p^5\,{}^2P^0_{\frac{1}{2}}-4s^24p^4({}^3P)5s\,{}^4P_{\frac{1}{2}}$
2*w*	428.571	233,334	$4s^24p^5\,{}^2P^0_{\frac{1}{2}}-4s^24p^4({}^3P)4d\,{}^4D_{\frac{1}{2}}$	200	298.779	334,696	$4s^24p^5\,{}^2P^0_{1\frac{1}{2}}-4s^24p^4({}^3P)5s\,{}^4P_{1\frac{1}{2}}$
70	414.768	241,099	$4s^24p^5\,{}^2P^0_{1\frac{1}{2}}-4s^24p^4({}^3P)4d\,{}^4D_{2\frac{1}{2}}$	60	298.039	335,527	$4s^24p^5\,{}^2P^0_{1\frac{1}{2}}-4s^24p^4({}^1D)4d\,{}^2D_{2\frac{1}{2}}$
200	406.481	246,014	$4s^24p^5\,{}^2P^0_{1\frac{1}{2}}-4s^24p^4({}^3P)4d\,{}^4D_{1\frac{1}{2}}$	50	297.314	336,345	$4s^24p^5\,{}^2P^0_{1\frac{1}{2}}-4s^24p^4({}^1D)4d\,{}^2F_{2\frac{1}{2}}$
130	401.698	248,943	$4s^24p^5\,{}^2P^0_{1\frac{1}{2}}-4s^24p^4({}^3P)4d\,{}^4D_{\frac{1}{2}}$	200	294.398	339,676	$4s^24p^5\,{}^2P^0_{\frac{1}{2}}-4s^24p^4({}^1D)4d\,{}^2P_{\frac{1}{2}}$
25	365.332	273,724	$4s^24p^5\,{}^2P^0_{\frac{1}{2}}-4s^24p^4({}^3P)4d\,{}^4P_{\frac{1}{2}}$	50	294.117	340,003	$4s^24p^5\,{}^2P^0_{\frac{1}{2}}-4s^24p^4({}^1D)4d\,{}^2P_{1\frac{1}{2}}$
50	362.237	276,062	$4s^24p^5\,{}^2P^0_{\frac{1}{2}}-4s^24p^4({}^3P)4d\,{}^4P_{1\frac{1}{2}}$	60	290.193	344,598	$4s^24p^5\,{}^2P^0_{\frac{1}{2}}-4s^24p^4({}^1S)4d\,{}^2D_{1\frac{1}{2}}$
90	356.430	280,560	$4s^24p^5\,{}^2P^0_{\frac{1}{2}}-4s^24p^4({}^3P)4d\,{}^2D_{1\frac{1}{2}}$	100	288.732	346,342	$4s^24p^5\,{}^2P^0_{1\frac{1}{2}}-4s^24p^4({}^1D)4d\,{}^2D_{1\frac{1}{2}}$
50	352.938	283,336	$4s^24p^5\,{}^2P^0_{\frac{1}{2}}-4s^24p^4({}^3P)4d\,{}^2P_{\frac{1}{2}}$	100	288.501	346,619	$4s^24p^5\,{}^2P^0_{1\frac{1}{2}}-4s^24p^4({}^3P)5s\,{}^4P_{\frac{1}{2}}$
60	352.293	283,855	$4s^24p^5\,{}^2P^0_{\frac{1}{2}}-4s^24p^4({}^3P)4d\,{}^2P_{1\frac{1}{2}}$	90	282.397	354,111	$4s^24p^5\,{}^2P^0_{1\frac{1}{2}}-4s^24p^4({}^3P)5s\,{}^2P_{1\frac{1}{2}}$
20	346.493	288,606	$4s^24p^5\,{}^2P^0_{1\frac{1}{2}}-4s^24p^4({}^3P)4d\,{}^4F_{2\frac{1}{2}}$	60	281.466	355,283	$4s^24p^5\,{}^2P^0_{1\frac{1}{2}}-4s^24p^4({}^1D)4d\,{}^2P_{\frac{1}{2}}$
20	346.404	288,680	$4s^24p^5\,{}^2P^0_{1\frac{1}{2}}-4s^24p^4({}^3P)4d\,{}^4F_{1\frac{1}{2}}$	100	281.217	355,606	$4s^24p^5\,{}^2P^0_{1\frac{1}{2}}-4s^24p^4({}^1D)4d\,{}^2P_{1\frac{1}{2}}$
90*w*	345.636	289,322	$4s^24p^5\,{}^2P^0_{1\frac{1}{2}}-4s^24p^4({}^3P)4d\,{}^4P_{\frac{1}{2}}$	200	277.630	360,192	$4s^24p^5\,{}^2P^0_{1\frac{1}{2}}-4s^24p^4({}^1S)4d\,{}^2D_{1\frac{1}{2}}$
40	342.869	291,657	$4s^24p^5\,{}^2P^0_{1\frac{1}{2}}-4s^24p^4({}^3P)4d\,{}^4P_{1\frac{1}{2}}$	100	274.588	364,182	$4s^24p^5\,{}^2P^0_{\frac{1}{2}}-4s^24p^4({}^3P)5s\,{}^2P_{\frac{1}{2}}$
80	337.930	295,919	$4s^24p^5\,{}^2P^0_{1\frac{1}{2}}-4s^24p^4({}^3P)4d\,{}^4P_{2\frac{1}{2}}$	180	270.862	369,192	$4s^24p^5\,{}^2P^0_{\frac{1}{2}}-4s^24p^4({}^1D)5s\,{}^2D_{1\frac{1}{2}}$
90	337.668	296,149	$4s^24p^5\,{}^2P^0_{1\frac{1}{2}}-4s^24p^4({}^3P)4d\,{}^2D_{1\frac{1}{2}}$	200	270.474	369,721	$4s^24p^5\,{}^2P^0_{1\frac{1}{2}}-4s^24p^4({}^3P)5s\,{}^2P_{1\frac{1}{2}}$
70	334.520	298,923	$4s^24p^5\,{}^2P^0_{1\frac{1}{2}}-4s^24p^4({}^3P)4d\,{}^2P_{\frac{1}{2}}$	200	263.312	379,778	$4s^24p^5\,{}^2P^0_{1\frac{1}{2}}-4s^24p^4({}^3P)5s\,{}^2P_{\frac{1}{2}}$
100	333.945	299,451	$4s^24p^5\,{}^2P^0_{1\frac{1}{2}}-4s^24p^4({}^3P)4d\,{}^2P_{1\frac{1}{2}}$	50	262.919	380,383	$4s^24p^5\,{}^2P^0_{1\frac{1}{2}}-4s^24p^4({}^1D)5s\,{}^2D_{2\frac{1}{2}}$
250	326.282	306,483	$4s^24p^5\,{}^2P^0_{1\frac{1}{2}}-4s^24p^4({}^3P(4d\,{}^2D_{2\frac{1}{2}}$	160	259.884	384,787	$4s^24p^5\,{}^2P^0_{1\frac{1}{2}}-4s^24p^4({}^1D)5s\,{}^2D_{1\frac{1}{2}}$
100	317.982	314,483	$4s^24p^5\,{}^2P^0_{1\frac{1}{2}}-4s^24p^4({}^3P)5s\,{}^4P_{2\frac{1}{2}}$	150	245.327	407,619	$4s^24p^5\,{}^2P^0_{\frac{1}{2}}-4s^24p^4({}^1S)5s\,{}^2S_{\frac{1}{2}}$
180	313.392	319,089	$4s^24p^5\,{}^2P^0_{\frac{1}{2}}-4s^24p^4({}^3P)5s\,{}^4P_{1\frac{1}{2}}$	70	236.288	423,212	$4s^24p^5\,{}^2P^0_{1\frac{1}{2}}-4s^24p^4({}^1S)5s\,{}^2S_{\frac{1}{2}}$

observed, and the lines involved were examined as those possibly due to Y V. The term table resulting from this analysis is given in Table II.

Lines from the transition $4s^24p^5({}^2P^0{}_{1\frac{1}{2}},\,{}^2P^0{}_{\frac{1}{2}})-4s^24p^44d$ were considered first. The wave-lengths of these lines were predicted by a linear extrapolation of the data on Rb III and Sr IV in accordance with the irregular doublet law. In nearly every case it was found that of the observed lines on the list, only one would fall near a predicted position, so that the classification was readily established. In a similar manner the two resonance lines $4s^24p^5({}^2P^0{}_{1\frac{1}{2}},\,{}^2P^0{}_{\frac{1}{2}})-4s4p^6\,{}^2S_{\frac{1}{2}}$ were easily identified. The Moseley diagram drawn from Tomboulian's data was helpful in locating lines resulting from the $4s^24p^45s$ transitions. There is some doubt concerning the relative assignment of the levels $4s^24p^4({}^3P)5s\,{}^2P_{1\frac{1}{2}}$ and $4s^24p^4({}^1D)4d\,{}^2D_{1\frac{1}{2}}$, for they fall so close together that the criteria used here are not sufficient to distinguish between them. The brighter pair of lines was assigned to the $4d{}^2D_{1\frac{1}{2}}$ transition in accordance with the observation that the $4d$ transitions give rise to more intense lines than the $5s$ transitions in the other members of this iso-electronic sequence.

Pairs of lines from transitions to the ground doublet from the levels $4s^24p^4({}^3P)4d\,{}^2P_{\frac{1}{2}}$, ${}^4F_{1\frac{1}{2}}$, $4s^24p^4({}^1D)4d\,{}^2P_{\frac{1}{2}}$ and $4s^24p^4({}^1S)4d\,{}^2D_{1\frac{1}{2}}$ were not observed by Tomboulian for Rb III and Sr IV. Of these levels only the ${}^4F_{1\frac{1}{2}}$ is known for both Br I and Kr II, so that predicted positions for the levels would not be very reliable. It was observed, however, that one of the two lines of the pair tentatively classified as $4s^24p^5({}^2P^0{}_{1\frac{1}{2}},\,{}^2P^0{}_{\frac{1}{2}})-4s^24p^4({}^3P)4d\,{}^2P_{1\frac{1}{2}}$ was a close double, and the other line, very broad. Furthermore, both lines of the pair tentatively classified as $4s^24p^5({}^2P^0{}_{1\frac{1}{2}},\,{}^2P^0{}_{\frac{1}{2}})-4s^24p^4({}^1D)4d\,{}^2P_{1\frac{1}{2}}$ were close doubles of approximately equal separation. Accordingly, the view was taken that in both cases the ${}^2P_{\frac{1}{2}}$ and ${}^2P_{1\frac{1}{2}}$ levels were very close, and the classification here given was made on this basis. The order is taken to be inverted because the corresponding terms in the one member of the sequence for which they were known are listed as inverted. The $4s^24p^4({}^1S)4d\,{}^2D_{1\frac{1}{2}}$ level was known for only Kr II, but by using the irregular doublet law and extrapolating along a straight line parallel to the available curves of the $({}^1D)4d$ levels, it was possible to estimate roughly the wave-lengths of the lines $4s^24p^5({}^2P^0{}_{1\frac{1}{2}},\,{}^2P^0{}_{\frac{1}{2}})-4s^24p^4({}^1S)4d\,{}^2D_{1\frac{1}{2}}$. The lines here classified fall near their predicted positions. The lines from the ${}^4F_{1\frac{1}{2}}$ level were not

TABLE IV. *Relative term values for* Zr VI.

Term Symbol	Relative Term Value	Term Symbol	Relative Term Value
$4s^24p^5\,{}^2P^0_{1\frac{1}{2}}$	0	$4s^24p^4({}^3P)4d\,{}^2F_{2\frac{1}{2}}$	319,496
$4s^24p^5\,{}^2P^0_{\frac{1}{2}}$	15,600	$4s^24p^4({}^1D)4d\,{}^2D_{2\frac{1}{2}}$	335,527
$4s4p^6\,{}^2S_{\frac{1}{2}}$	191,570	$4s^24p^4({}^1D)4d\,{}^2D_{1\frac{1}{2}}$	346,344
$4s^24p^4({}^3P)4d\,{}^4D_{2\frac{1}{2}}$	241,099	$4s^24p^4({}^1D)4d\,{}^2F_{2\frac{1}{2}}$	336,345
$4s^24p^4({}^3P)4d\,{}^4D_{1\frac{1}{2}}$	246,007	$4s^24p^4({}^1D)4d\,{}^2P_{\frac{1}{2}}$	355,280
$4s^24p^4({}^3P)4d\,{}^4D_{\frac{1}{2}}$	248,938	$4s^24p^4({}^1D)4d\,{}^2P_{1\frac{1}{2}}$	355,604
$4s^24p^4({}^3P)4d\,{}^4F_{2\frac{1}{2}}$	288,606	$4s^24p^4({}^1S)4d\,{}^2D_{1\frac{1}{2}}$	360,195
$4s^24p^4({}^3P)4d\,{}^4F_{1\frac{1}{2}}$	288,680	$4s^24p^4({}^3P)5s\,{}^4P_{2\frac{1}{2}}$	314,483
$4s^24p^4({}^3P)4d\,{}^4P_{\frac{1}{2}}$	289,323	$4s^24p^4({}^3P)5s\,{}^4P_{1\frac{1}{2}}$	334,692
$4s^24p^4({}^3P)4d\,{}^4P_{1\frac{1}{2}}$	291,660	$4s^24p^4({}^3P)5s\,{}^4P_{\frac{1}{2}}$	346,616
$4s^24p^4({}^3P)4d\,{}^4P_{2\frac{1}{2}}$	295,919	$4s^24p^4({}^3P)5s\,{}^2P_{1\frac{1}{2}}$	369,716
$4s^24p^4({}^3P)4d\,{}^2D_{1\frac{1}{2}}$	296,155	$4s^24p^4({}^3P)5s\,{}^2P_{\frac{1}{2}}$	379,780
$4s^24p^4({}^3P)4d\,{}^2D_{2\frac{1}{2}}$	306,483	$4s^24p^4({}^1D)5s\,{}^2D_{2\frac{1}{2}}$	380,383
$4s^24p^4({}^3P)4d\,{}^2P_{\frac{1}{2}}$	298,923	$4s^24p^4({}^1D)5s\,{}^2D_{1\frac{1}{2}}$	384,790
$4s^24p^4({}^3P)4d\,{}^2P_{1\frac{1}{2}}$	299,453	$4s^24p^4({}^1S)5s\,{}^2S_{\frac{1}{2}}$	423,215

found, probably because they were too faint to show on the spectrograms.

Transitions from even levels with $j=2\frac{1}{2}$ can occur only to the $^2P_{1\frac{1}{2}}$ level of the ground doublet, so that but one line instead of a pair can be associated with these levels. The lines fixing the $4s^24p^4(^3P)4d\ ^4D_{2\frac{1}{2}}$, $^4P_{2\frac{1}{2}}$ and $4s^24p^4(^3P)5s\ ^4P_{2\frac{1}{2}}$ levels were identified on the basis of the Lande interval rule which was assumed to hold approximately for this spectrum. The lines from the levels $4s^24p^4(^3P)4d\ ^2D_{2\frac{1}{2}}$, $^2F_{2\frac{1}{2}}$ and $4s^24p^4(^1D)4d\ ^2D_{2\frac{1}{2}}$, $^2F_{2\frac{1}{2}}$ were identified by their proximity to positions calculated by extrapolating the data on Br I and Kr II. The wave-length of the line $4s^24p^5\ ^2P^0_{1\frac{1}{2}}$ $-4s^24p^4(^1D)5s\ ^2D_{2\frac{1}{2}}$ was predicted by extending a Moseley diagram curve through the two known points for Br I and Kr II, and making it parallel to the corresponding curve through the $(^1D)5s\ ^2D_{1\frac{1}{2}}$ points.

The ionization potential of Y V was estimated to correspond approximately to 620,000 cm^{-1}, since it was found that this value gave the smoothest and most nearly parallel curves (for the same n) on the Moseley diagram.

The Spectrum of Zr VI

In the analysis of Zr VI, the wave-lengths of the two resonance lines $4s^24p^5(^2P^0_{1\frac{1}{2}}, {}^2P^0_{\frac{1}{2}})$ $-4s4p^6\ ^2S_{\frac{1}{2}}$ were predicted by means of the irregular doublet law. Two intense lines were found very near to these positions. The observed frequency difference of 15,597 cm^{-1} agrees well with a separation of 15,200 cm^{-1} computed from the regular doublet law. An examination of the data revealed the presence of almost a score of pairs of lines having a frequency difference equal to 15,600 cm^{-1} to within the accuracy of measurement. A procedure similar to that used in the analysis of Y V lead to the results given in Table III and Table IV.

A few terms not found for Y V were observed in the spectrum of Zr VI, namely the terms $4s^24p^4(^3P)4d\ ^4F_{2\frac{1}{2}}$, $^4F_{1\frac{1}{2}}$ and $4s^24p^4(^1S)5s\ ^2S_{\frac{1}{2}}$. Of these, the first two are somewhat doubtful because of the absence of the line $4s^24p^5\ ^2P_{\frac{1}{2}}$ $-4s^24p^4(^3P)4d\ ^4F_{1\frac{1}{2}}$ on the spectrograms. The observed lines fall very near the predicted positions, however. There is also some doubt concerning the relative assignments of the terms $4s^24p^4(^1D)4d\ ^2D_{1\frac{1}{2}}$ and $4s^24p^4(^3P)5s\ ^4P_{\frac{1}{2}}$, which fall very nearly together.

A study of the Moseley diagram curves leads to an estimate of 798,000 cm^{-1} for the ionization potential of Zr VI.

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The Fundamental Rotation-Vibration Band of Nitric Oxide

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The fundamental rotation-vibration band of nitric oxide has been measured with the high dispersion of an echellette grating spectrometer, and has been subjected to a complete analysis. The resulting constants have been carefully combined with those derived from the existing electronic data to yield the following molecular constants for the normal state of the molecule: $\omega_e=1904.03\ (^2\Pi_{1/2})$, $1903.68\ (^2\Pi_{3/2})$ cm^{-1}, $\omega_ex_e=13.97$ cm^{-1}, $\omega_ey_e=-1.20\times10^{-3}$cm^{-1}, $B_e=1.7046$ cm^{-1}, $I_e=16.423\times10^{-40}$ g cm^2, $r_e=1.1508$A.

Introduction

Although nitric oxide is one of the relatively few diatomic molecules which is chemically stable under ordinary conditions, the values of its molecular constants are still somewhat uncertain. The β and γ electronic band systems of this molecule have been extensively in-

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