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Additions to Certain Spectra of Sulphur, Potassium and Calcium

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Twenty-seven lines have been classified in S III. These locate six of the important singlet levels accurately with respect to the known triplets. S VI has been completely revised. Fourteen new terms have been added which classify eighteen new lines. The revised ionization potential is 87.610 ± 0.003 volts. Two new singlet terms with intercombinations have been found in K VI and Ca VII. One new singlet term has been added to K IV and three terms to S VIII. Several of these last few spectra have been investigated in order to test the conclusions drawn from the previous paper in this issue of the *Physical Review.*

It has been possible to extend the classifications of certain sulphur spectra by means of spectrograms obtained in Professor Siegbahn's laboratory in Uppsala, Sweden. Previously published lists of sulphur lines[1–3] have also been used. Certain of the terms have already been published:[4] it was impossible at that time to list the newly classified lines. The new results are given in Tables I and II.

The new measurements show that 6 cm^{-1} must be subtracted from all terms higher than 140,000 cm^{-1}. Since these terms are very accurately known with respect to one another[3] the new values are not listed. The $3s3p^23d\,{}^3D$ terms listed by L. and E. Bloch[1] are erroneous; the lines which they give as the $3s3p^3\,{}^3D-3s3p^23d\,{}^3D$ transitions are in reality the $3s^23p^2\,{}^3P-3s3p^3\,{}^3D$ transitions previously classified by Ingram.[5] Slightly more accurate values for the sp^3 triplet terms have also been added.

Extensions have also been possible in the case of S VI. (Tables III and IV.) The Rydberg denominators have been determined by means of the Princeton tables.[6] The absolute value of the ground state was obtained by setting n^* for $5g\,{}^2G$ equal to 4.9990. This value was extrapolated from the corresponding terms in the other members of the isoelectronic sequence.

It has also been possible to identify the $s^22p^5\,{}^2P-sp^6\,{}^2S$ transition of S VIII. The lines

TABLE I. *S III Classified lines.*

Int.		λ(air)	ν(cm⁻¹)	Classification
7		4677.67	21,372.20	$4s\ {}^1P_1-4p\ {}^3D_1$
5		4613.47	21,669.61	$4s\ {}^1P_1-4p\ {}^3D_2$
0		4125.4	24,233.3	$4s\ {}^1P_1-4p\ {}^3P_0$
3		4099.25	24,387.85	$4s\ {}^1P_1-4p\ {}^3P_1$
00		3899.27	25,638.59	$4s\ {}^1P_1-4p\ {}^3S_1$
00		3008.82	33,226.0	$sp^3\ {}^1P_1-4p\ {}^3D_2?$
1		2749.94	36,353.7	$sp^3\ {}^1P_1-4p\ {}^3P_2$
1		2593.87	38,540.9	$4p\ {}^3P_1-5s\ {}^1P_1$
2		2422.91	41,260.14	$4p\ {}^3D_2-5s\ {}^1P_1$
1		2405.63	41,556.5	$4p\ {}^3D_1-5s\ {}^1P_1$
1	2	λ(vac)	ν(cm⁻¹)	Classification
8	2	1077.135	92,838.9	$3p^2\,{}^1D_2-sp^3\,{}^1D_2$
00	–	911.77	109,677	$3p^2\,{}^1S_0-sp^3\,{}^1P_1$
4	1*Bl*	836.315	119,572	$-4s\ {}^3P_1$
4	0	824.887	121,229	$-4s\ {}^1P_1$
4	5	796.692	125,519	$3p^2\,{}^1D_2-sp^3\,{}^1P_1$
4	3	788.984	126,745	$-sp^3\,{}^3S$
4	1	738.474	135,414	$-4s\ {}^3P_1$
2	–	736.25	135,834	$-4s\ {}^3P_2$
1	–	733.92	136,255	$-3d\ {}^3D_1?$
0	–	733.34	136,362	$-3d\ {}^3D_2$
0	–	732.98	136,492	$-3d\ {}^3D_3$
4	4	729.529	137,075	$-4s\ {}^1P_1$
4	3	735.251	136,008	$3p^2\,{}^3P_2-sp^3\,{}^1P_1$
5	0	732.376	136,542	${}^3P_1-\ {}^1P_1$
3	0*n*	730.783	136,840	${}^3P_0-\ {}^1P_1$
2	0*n*	543.031	184,152	$3p^2\,{}^1S_0-5s\ {}^1P_1$
3	0	499.983	200,006	$3p^2\,{}^1D_2-5s\ {}^1P_1$

Intensities, col. 1 from L. and E. Bloch, reference 1.
Intensities, col. 2 from authors own measurements. All wave-lengths in vacuum from personal data except for those lines for which a dash is given in col. 2. Wave-lengths in air from references 2 or 3.

TABLE II. *S III term table.*

$s^23p^2\,{}^3P_0$	0.0	$sp^3\,{}^1D_2$	104,159?	$sp^3\,{}^3D_1$	84,018.9
${}^3P_1$	297.2			${}^3D_2$	84,046.4
${}^3P_2$	832.5	${}^1P_1$	136,839	${}^3D_3$	84,099.5
${}^1D_2$	11,320	$4s\ {}^1P_1$	148,397.8	$sp^3\,{}^3P_2$	98,743.0
				${}^3P_1$	98,765.6
${}^1S_0$	27,163	$5s\ {}^1P_1$	211,326.8	${}^3P_0$	(98,771)
				$sp^3\,{}^3S$	138,061.4

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[1] L. and E. Bloch, J. de phys. **6**, 441 (1935).

[2] L. and E. Bloch, Ann. de physique **12**, 5 (1929).

[3] A. Hunter, Phil. Trans. Roy. Soc. London **233A**, 303 (1934).

[4] H. A. Robinson, Nature **137**, 992 (1936).

[5] S. B. Ingram, Phys. Rev. **33**, 907 (1929).

[6] A. G. Shenstone, J. C. Boyce and H. N. Russell, *Rydberg Interpolation Table* (Princeton, N. J., 1934).

TABLE III. *Classified lines of S VI.*

INT.	λ(vac.)	ν(cm⁻¹)	CLASSIFICATION
5§	944.517	105,874	$3s\ ^2S - 3p\ ^2P_{1/2}$
4§	933.382	107,137	$^2S - \ ^2P_{3/2}$
3§	712.844	140,283	$3p\ ^2P_{3/2} - 3d\ ^2D_{3/2}$
4§	712.682	140,315	$^2P_{3/2} - \ ^2D_{5/2}$
6§	706.480	141,547	$^2P_{1/2} - \ ^2D_{3/2}$
1	650.430	153,744	$3d\ ^2D_{3/2} - 4p\ ^2P_{1/2}$
1	648.628	154,172	$^2D_{5/2} - \ ^2P_{3/2}$
10§	464.654	215,214	$3d\ ^2D - 4f\ ^2F$
8§	390.859	255,847	$3p\ ^2P_{3/2} - 4s\ ^2S$
6§	388.940	257,109	$^2P_{1/2} - \ ^2S$
6	328.605	304,409	$3d\ ^2D - 5f\ ^2F$
3	290.132	344,671	$3p\ ^2P_{3/2} - 4d\ ^2D_{5/2}$
2	289.092	345,911	$^2P_{1/2} - \ ^2D_{3/2}$
3	283.502	352,731	$3d\ ^2D - 6f\ ^2F$
0*n*	261.810	381,956	$3d\ ^2D - 7f\ ^2F$
2	251.905	396,975	$3p\ ^2P_{3/2} - 5s\ ^2S$
4	249.271	401,170	$3s\ ^2S - 4p\ ^2P_{1/2}$
4	248.985	401,631	$^2S - \ ^2P_{3/2}$
2	227.845	439,895	$3p\ ^2P_{3/2} - 5d\ ^2D_{5/2}$
2	227.197	440,147	$^2P_{1/2} - \ ^2D_{2/2}$
00	214.277	466,686	$3p\ ^2P_{3/2} - 6s\ ^2S$
0*n*	204.190	489,740	$3p\ ^2P_{3/2} - 6d\ ^2D$
00*n*	192.273	520,094	$3p\ ^2P_{3/2} - 7d\ ^2D$
0*n*	192.560	522,030	$3s\ ^2S - 5p\ ^2P_{1/2}$
00	192.480	522,248	$^2S - \ ^2P_{3/2}$
00*n*	171.327	583,679	$3s\ ^2S - 6p\ ^2P_{3/2}$

TABLE IV. *S VI term table with Rydberg denominators.*

$3s\ ^2S$	710,194§	2.3585	$3d\ ^2D_{3/2}$	462,774§	
$4s\ ^2S$	347,211§	3.3732	$^2D_{5/2}$	32 462,742§	2.9219
$5s\ ^2S$	206,082	4.3785	$4d\ ^2D_{3/2}$	258,409	
$6s\ ^2S$	136,371	5.3822	$^2D_{5/2}$	(23) 258,386	3.9101
$3p\ ^2P_{1/2}$	604,320§		$5a\ ^2D_{3/2}$	164,173	
$^2P_{3/2}$	1263 603,057§	2.5595	$^2D_{5/2}$	(11) 164,162	4.9056
$4p\ ^2P_{1/2}$	309,030§		$6d\ ^2D$	113,317	5.9043
$^2P_{3/2}$	457 308,573§	3.5780	$7d\ ^2D$	82,963	6.9007
$5p\ ^2P_{1/2}$	188,164		$4f\ ^2F$	247,541§	3.9949
$^2P_{3/2}$	218 187,946	4.5846	$5f\ ^2F$	158,346	4.9949
$6p\ ^2P_{3/2}$	126,515	5.5880	$6f\ ^2F$	110,024	5.9923
			$7f\ ^2F$	80,799	6.9924
$5g\ ^2G$	158,088§	(4.9990)			

§ Lines and terms previously classified: R. A. Millikan and I. S. Bowen, Phys. Rev. **25**, 295 (1925).

are of intensity 0, wave-length 202.605A ($\nu=493{,}571$ cm⁻¹) and 198.550A ($\nu=503{,}652$ cm⁻¹). This indicates a separation of $-10{,}080$ cm⁻¹ for the $p^5\ ^2P$ which is in good agreement with prediction.

TABLE V.

INT.	λ(vac.)	ν(cm⁻¹)	CLASSIFICATION
2	501.649	199,343	$p^2\ ^1D_2 - sp^3\ ^3S$
10 *d.*	488.120	204,868	$p^2\ ^1D_2 - sp^3\ ^1P_1$
3	452.667	220,913	$p^2\ ^3P_2 - sp^3\ ^1P_1$
3	449.013	222,711	$p^2\ ^3P_1 - sp^3\ ^1P_1$

TABLE VI. *K VI term table.*

$s^2p^2\ ^3P_0$	0	$s^2p^2\ ^1D_2$	18,973
$^3P_1$	1131	$^1S_0$	—
$^3P_2$	2924	$sp^3\ ^1P_1$	223,840

TABLE VII.

6	433.609	230,623	$p^2\ ^1D_2 - sp^3\ ^1P_1$
2	402.551	248,416	$p^2\ ^3P_2 - \ ^1P_1$
2	398.615	250,869	$^3P_1 - \ ^1P_1$
2*Bl*	396.044	252,497	$^3P_0 - \ ^1P_1$

TABLE VIII. *Ca VII term table.*

$s^2p^2\ ^3P_0$	0	$s^2p^2\ ^1D_2$	21,872
$^3P_1$	1629	$^1S_0$	—
$^3P_2$	4070	$sp^3\ ^1P_1$	252,495

Minor additions to the singlet spectra of K IV[7–9] show that the lines λ447.085 ($\nu=223{,}671$ cm⁻¹) and λ384.095 ($\nu=260{,}352$ cm⁻¹) are in all probability the transitions $3p^4\ ^1S_0-p^33d\ ^1P_1$, and $3p^4\ ^1S_0-p^34s\ ^1P_1$ respectively. This places tentatively the $p^4\ ^1S_0$ term at 37,778 cm⁻¹ ($p^4\ ^3P_0=0$).

Two of the singlet states of K VI[4] have also been located: the lines classified are given in Tables V and VI.

The corresponding transitions in Ca VII[7, 9] are given in Tables VII and VIII.

The additions to K IV and CaV II have been made jointly with Dr. George H. Shortley as part of the preceding paper in this issue of the *Physical Review.* They are listed here for convenience.

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[7] Wave-lengths from E. Ekefors, Dissertation, Uppsala (1931).

[8] I. S. Bowen, Phys. Rev. **46**, 791 (1934).

[9] A. E. Whitford, Phys. Rev. **46**, 793 (1934).