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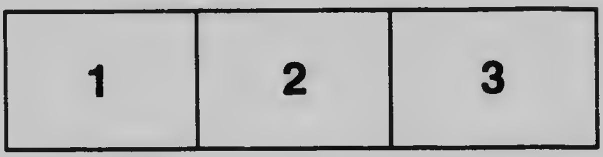
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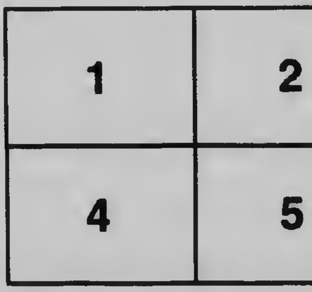
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UNIVERSITY OF TORONTO
STUDIES

PAPERS FROM THE
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No. 60: REGULARITIES IN THE SPECTRA OF LEAD AND TIN, BY R. V. ZUMSTEIN

(REPRINTED FROM TRANSACTIONS OF THE ROYAL SOCIETY OF CANADA, SERIES III, VOL. XII)

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Regularities in the Spectra of Lead and Tin.

By R. V. ZUMSTEIN, M.A.

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Presented by PROFESSOR E. F. BURTON, Ph.D., F.R.S.C.

(Read May Meeting, 1918).

Lead and tin belong to a group in Mendeleeff's table in which series of spectral lines have not been recognised.

Kayser and Runge,[1] who made the first exact measurements on the lead arc, pointed out that a group of ten lines repeated itself three times in the spectrum with constant frequency difference. They will be denoted as Kayser and Runge's I, II, and III groups. The frequency differences are 1081·08, and 2832·0. Seven additional lines have recently been added to these groups by Saunders.[2]

On carefully examining the work of Kayser and Runge, and some unpublished researches of Fuller and Ainslie of this laboratory, it was found that a symmetrical group of three lines repeated itself five times in the spectrum. This gives five groups with constant frequency difference.

TABLE I.

SPECTRUM OF LEAD.

I	II	III	IV	V
7229·30	4057·97	3683·60	3639·71	2833·17
3220·68	2388·89	2254·02	2237·52	1904·20
3119·09	2332·97	2204·18	2187·99	1868·58

The frequency difference between:
I and II is 1081·2.
II and III is 2504·5.
III and IV is 327·3.
IV and V is 8147·1.

[1] H. Kayser, Handb. der Spect., p. 574 (1902).
[2] F. A. Saunders, Ast. Journal, 43, p. 240 (1916).

Since 2504·5+327·3=2831·8, we see groups I, II, and IV are respectively Kayser and Runge's, I, II, and III groups, the III and V groups being new.

The lines 2332·96, 2204·18 and 1868·59 were obtained by Saunders with a lead vacuum arc and a vacuum grating spectroscope. The line 1904·2 was found by Fuller and Ainslie with a lead vacuum arc and a fluorite vacuum spectroscope. Saunders has also pointed out that the lines 5201, 5005, 4340 form part of a group additional to those of Kayser and Runge. This bears no relation to the grouping here proposed.

An attempt was made to see if the five groups are in reality five series, the corrresponding members of which have constant frequency difference.

In looking for new series we are guided by three facts:—

(1) the analogy which exists with other elements in the same group of the Mendeleeff table.

(2) All members of a series show the same Zeeman effect.

(3) The heads of series are the lines which are fundamental for that element. They are usually the only lines which appear in the flame and absorption spectra. They alone are observed when the metallic vapour is bombarded by electrons having the requisite speed. When we examine the light from the electric spark in solutions of the metal with increasing dilution, they remain long after other lines in the arc have disappeared.

In the case of lead we cannot derive aid from the first method, for no series have been discovered in germanium, tin, lead, or the other elements of this group.

Purvis[1] is the only one who has studied the Zeeman effect with lead. He found two lines, 3740, 2873, were broken up into four components, the remainder into triplets.

We have thus only the third method available for this element. In the flame it was formerly supposed that lead always gave a band spectrum which was attributed to lead oxide. Later, under certain conditions, a flame spectrum was observed consisting of three lines, 4057·97, 3683·60, and 3639·71.

Spectrograms were taken of the flame of a Mecker burner, into which was fed the vapour of lead from a small globule of lead supported by the gauze at the top of the burner. The above three lines always appeared, but there was no trace of the band spectrum.

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[1] J. E. Purvis, Camb. Phil. Soc. Proc., Vol. 14, p. 216 (1907).

In table II are arranged these results, together with the results of Hartly (with the pure metal in an oxy-hydrogen flame), Eder and Valenta (with lead chloride), and de Watteville (with lead nitrate).

TABLE II.

Zumstein........	....	....	4058	....	3684	3640	....		
Hartly..........	4455	....	4058	....	3684	3640	....	....	2833
Eder & Valenta.	....	4062	4058	....	3684	3640	3573		
de Watteville....	....	....	4058	3740	3684	3640	3573	2873	2833

The continued appearance of the lines 4058, 3684 and 3640 indicates that these lines are fundamental.

Table III is made up from Eder and Valenta's spectrum charts, showing the lead lines which occur when lead is contained as an impurity in other metals.

TABLE III.

Element	Lead Lines as Impurities					
Cadmium. .	4058	....	3684	3640		
Zinc.......	4058	....	3684	....	2833	
Antimony .	4058	3740	3684	3640	2833	
Bismuth...	4058	3740	3584	3640		
Telurium .	4058	3740	3684	3640	2833	2802
Gold......	4058					

This again shows the prominence of the lead lines 4058, 3684, 3640, as well as 2833.

Experiments on the absorption due to Lead vapor in a carbon arc showed that these lines were absorbed in addition to some others. This was tested in two ways. Spectrograms were taken of (1) a lead spark the light from which traversed a carbon arc containing lead vapor, and (2) the glowing filament of a Nernst lamp, the light from which traversed a carbon arc containing lead vapor.

The plates used were not sensitive to the line 7229 [illegible], so no test was applied which succeeded in linking this line up with the others.

The results of these experiments point to the possibility of the lines 7229·30, 4057·97, 3683·60, 3639·71 and 2833·17 being similarly related to the lead spectrum—being in fact, the heads of analogous groups of lines.

Regularities in The Spectrum of Tin.

As tin falls in the same group with lead in the periodic table we should expect similarities in their spectra, as has been often recorded. Kayser and Runge[1] found a group of thirteen lines which repeated itself with the same frequency difference, three times through the spectrum. The frequency differences were 5187·03 and 1736·73.

In the work on lead it was pointed out that a group of three lines existed which repeated itself five times with constant frequency difference. This was immediately found for tin when looked for. The five groups are:

I	II	III	IV	V
3801·16*	3175·12*	3009·24*	2863·41*	2840·06*
2785·14	2433·53*	2334·89	2246·15	2231·80
2524·05	2231·85	2148·59	2073·01	2061·00

The marked lines are absorbed in the tin-carbon arc.
The line 2061·00 has not yet been observed.
The frequency difference between:
I and II is 5186·2
II and III is 1736·1.
III and IV is 1692·4.
IV and V is 288·1.

From this we see that I, II and III are included under Kayser and Runge's first three groups. This was in agreement with the work on lead which suggests a series of quintets. The flame spectrum of tin in the Mecker burner was photographed to see if the heads of the five series 3801·16, 3175·12, 3009·24, 2863·41, 2840·06 appeared. However, in no case was a line spectrum obtained; the band spectrum always appeared.

Only two experimenters have observed a line spectrum from the flame fed by a tin salt.

De Watteville[2] used the protochloride of tin, Eder and Valenta observed a few lines along with the band spectrum. The work of these two is here given.

[1] Loc. cit.
[2] loc.cit.

Intensity in arc	de Watteville flame	Eder & Valenta flame
8	4524·92	4524·92
6	3801·16	3801·16
8	3175·12	
10	3034·21	3034·21
10	3009·24	3009·24
10	2863·41	
10	2840·06	

Those underlined are the heads of the five groups. This would suggest that the five lines are fundamental. Tin is seldom present as an impurity in other metals used in spectroscopic work.

This work was carried out under the direction of Professor E. F. Burton.

UNIVERSITY OF TORONTO STUDIES

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