53. ON THE INTERPRETATION OF X-RAY TERM VALUES

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INTRODUCTION

1. The object of the present paper is to offer a rather radically different interpretation of the X-ray term-values than what is at present usually accepted. The present view-point has been summarized by Pauling and Goudsmit in their book on "Structure of Line Spectra, Chap. X." It is well-known that the diagrammatic lines of X-ray spectra show the same structure as alkali-spectra, and this has given rise to the widespread belief that the X-ray term-values and their differences can be calculated[1] in the same way as term-values for hydrogen or the alkalies, after the introduction of suitable screening constants. But it was pointed out by M. N. Saha and B. B. Ray[2] that the apparent analogy of X-ray spectra to alkali spectra is rather misleading. It is due to the operation of the Pauli Exclusion Principle which says that defect of a single electron from a closed shell gives rise to the same spectroscopic levels as the presence of one single electron outside a closed shell. Thus $2p^5$.....5 electrons in the L-shell give rise to the spectroscopic level $^2P_{\frac{1}{2}}$, $^2P_{\frac{3}{2}}$, while one p electron also gives rise to the same levels. Since the X-ray spectra are due to the removal of an electron from some level, and the subsequent jumping of an electron from some outer level to this, it follows that the term-values have to be calculated in a widely different way than that usually followed.

CALCULATION OF TERM-VALUES

2. To illustrate the above point of view, let us take the procedure usually adopted for calculating ν_K ν_{L_1}, $\nu_{L_{21}}$, $\nu_{L_{22}}$ etc. Now $h\nu_K$ represents the energy required to remove one electron from the K-shell to infinity, hence the theoretical problem before us is to find out the total energy of an electron in the K-shell. This electron moves in the field of force composed of that due to the central charge $+Ze$, the field due to the companion-electron in the K-shell and the field due to the outer electrons. If the field due to the outer electrons could be neglected, we shall have just the helium problem with the central charge equal to $+Z$e. We specially insist that the field due to the companion in the K-shell be treated separately, as this being in the same quantum orbit, produces much greater effect than other electrons. Hence ν_K should correspond to the $^1S_0$ term of He. In no case, can it correspond to the $^2S_{\frac{1}{2}}$ term of hydrogen, as is usually accepted. But the field due to the outer electrons cannot be neglected, hence the actual problem becomes more complicated than that of helium.

These considerations apply equally well to the calculation of the term-values for L_{11}, L_{21}, L_{22}; for L_{11} we find that it corresponds to the $^1S_0$ term of Be, the central charge being different. The $\nu_{L_{21}}$ term corresponds to the removal of an electron from the $2p^6$ shell giving rise to the $^1S_0$ state. For $Z=10$, when the $2p^6$ shell is completed, this corresponds to the $^1S_0$-term of Neon. Hence L_{21}—values have to be linked to the $^1S_0$-term of Neon.

The difference $\nu L_{21} - \nu L_{22}$ ....is usually referred to the $\triangle\nu$-difference for the ^2P terms of hydrogen, but according to the present stand-point, this is to be explained on the same basis as to the ($^2P_{\frac{3}{2}} - {}^2P_{\frac{1}{2}}$) differences of F, Ne^+, Mg^{++}..

These ideas involve a complete re-calculation of the term-values in X-ray spectra on a basis very different from that followed at the present time.

Before embarking on this venture, we want to present a complete survey of the experimental material.

3. *The screening constant for the K-level.*—Usually ν_K, the value of the absorption limit is represented by the formula

$$\sqrt{\frac{\nu_K}{R}} = \frac{Z-\sigma_K}{1}, \qquad (1)$$

where σ_K is known as the screening constant for the K-level.

It was at first thought[3] that σ_K was nearly constant, *viz.*, 3·4, for all elements, but this impression was due to the fact that data regarding only a few elements were available. In Table 1, we have collected all the available data regarding σ_K and these have been plotted in Fig. 1.

The values of ν_K from 92Ur to 12Mg were taken from *Lindh, Hundbuch d. Exp. Physik*, Vol. XXIV, p. 196, and σ_K was calculated according to (1). The values of σ_K for elements below Mg are subject to a certain amount of uncertainty, as a regular K_α-line can be obtained only when the L_2-level is complete. In cases where L_2 is not completed, K_α-line shows increasing diffuseness. The

Table 1.—*Screening constant for the K-level*

Z	σ_K calc.	σ_K obs.	Diff.
2 He*	..	·657	..
3 Li+	..	·85	..
4 Be	..	1·19	..
5 B	..	1·286	..
6 C	1·59	1·43	—·16
7 N	1·69	1·60	—·09
8 O	1·797	1·77	—·027
9 F	1·898	1·894	—·004
10 Ne	2·089	..	..
11 Na	2·09	2·13	+·04
12 Mg	2·18	2·21	+·03
13 Al	2·270	2·30	+·03
14 Si	2·357	2·36	+·003
15 P	2·44	2·44	0·0
16 S	2·52	2·51	—·01
17 Cl	2·598	2·58	—·018
18 A	2·673	2·65	—·023
19 K	2·755	2·70	—·055
20 Ca	2·815	2·78	—·035
21 Sc	2·815	2·80	— 015
22 Ti	2·88	2·87	—·01
23 V	2·945	2·93	—·015
24 Cr	3·01	3·00	—·01
25 Mn	3·06	3·05	—·01
26 Fe	3·12	3·12	0
27 Co	3·17	3·15	—·02
28 Ni	3·22	3·23	+·01
29 Cu	3·27	3·28	+·01
30 Zn	3·31	3·33	+·02
31 Ga	3·35	3·33	—·02
32 Ge	3·39	3·41	+·02
33 As	3·43	3·436	+·006
34 Se	3·46	3·471	+·011
35 Br	3·49	3·495	·005
36 Kr	3·52	..	..
37 Rb	3·55	3·543	—·007
38 Sr	3·57	3·561	—·01
39 Y	3·585	3·56	—·025
40 Zr	3·60	3·59	—·01
41 Nb	3·62	3·601	—·019
42 Mo	3·63	3·615	—·015
43	..	..	..
44 Ru	3·64	3·6	—·04
45 Rh	3·64	3·652	+·012
46 Pd	3·64	3·644	+·004
47 Ag	3·64	3·645	+·005
48 Cd	3·63	3·642	+·012
49 In	3·62	3·644	+·024
50 Sn	3·61	3·637	+·027
51 Sb	3·60	3·629	+·029
52 Te	3·58	3·616	+·036
53 I	3·56	3·602	+·042
54 Xe	3·53	..	..
55 Cs	3·51	3·535	+·025
56 Ba	3·48	3·508	+·028
57 La	3·45	3·481	+·031
58 Ce	3·42	3·452	+·032
59 Pr	3·38	3·39	+·01
60 Nd	3·34	3·413	+·073
61	3·30	..	..
62 Sm	3·25	3·28	+·03
63 Eu	3·20	3·18	—·02
64 Gd	3·15	3·17	+·02
65 Tb	3·097	3·08	—·017
66 Dy	3·05	3·07	+·02
67 Ho	2·98	3·023	+·043
68	2·92	..	..
69 Th	2·85	2·89	+·04
70 Yb	2·78	2·77	—·01
71 Lu	2·72	2·66	—·06
72 Hf	2·64	2·77	+·13
73 Ta	2·57	2·55	—·02
74 W	2·49	2·46	—·03
75	2·41	..	..
76 Os	2·32	2·42	+·1
77 Ir	..	..	..
78 Pt	2·14	2·08	—·06
79 Au	2·04	1·92	—·12
80 Hg	1·95	1·82	—·13
81 Tl	..	1·67	..
82 Pb	..	1·61	..
83 Bi	..	1·50	..
84 Po	..	..	..
85	..	..	..
86 Niton	..	..	..
87	..	..	..
88 Ra	..	..	..
89 Ac	..	·24	..
90 Th	..	..	..
91 Url	..	...	..
92 Ur	..	—·07	..

*Skinner, *Nature*; Feb. 6, 1932.
†Lindh, *Handbuch d. Exp. Physik*, XX, p. 373 (Electron bombardment method).

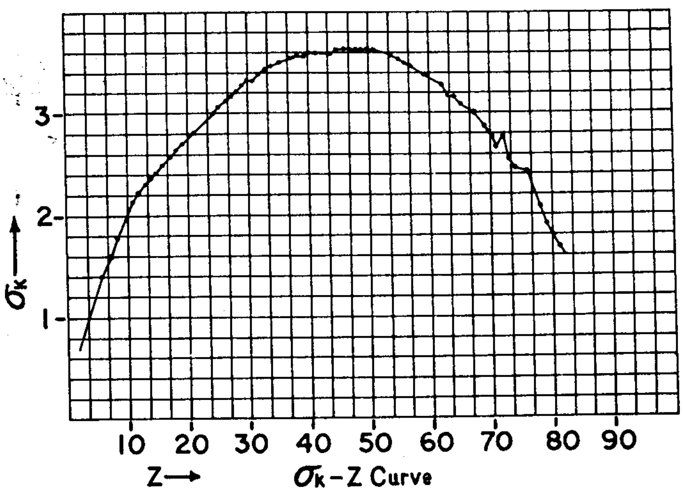

Fig. 1—Showing the relation between σ_K and Z

K-limits have been measured directly by Thibaud[4] for C, N, O. For the other elements, we have slightly increased the frequency values for the K_a-line which have been observed by a number of investigators.[5] Helium is the element giving the first K-series, as it has two electrons in the K-shell. Hence ν_K for He corresponds to the ionisation potential of He, *viz.*, 24·5 volts. The curve shows that the σ_K-curve is continuous up to He. This is a proof of the essential correctness of our method of representing the ν_K-limits.

The (σ_K/Z) curve is approximately parabolic, with small kinks at places where a shell becomes complete, and a new shell begins, *e.g.*, at 20 Ca, $\sigma_K=2{\cdot}78$ while for 21 Sc, $\sigma_K=2{\cdot}80$.

In Sc, the 3*d*-shell is beginning to be formed. The value becomes approximately constant for 37Rb to 56Ba [3·54—3·64—3·48] and this gave rise formerly to the belief that σ_K was constant for all elements. But beyond Ba, σ_K rapidly diminishes, and at 92U, σ_K actually becomes negative, *i.e.*, there is no screening at all.

'σ' can be roughly represented by the formulae

$$\left.\begin{array}{l}\sigma_K={\cdot}895+{\cdot}124Z-{\cdot}0014Z^2 \text{ up to } Z=20\\ \sigma_K={\cdot}895+{\cdot}124\,(Z-1)-{\cdot}0014\,(Z-1)^2,\ Z=20 \text{ to } 92\end{array}\right\}. \quad (2)$$

The differences between observed and calculated values[2] are shown in Table 1.

4. *Causes of Screening*—According to the ideas developed here, ν_K should be calculated from the equation

$$\nabla_1^2\psi+\nabla_2^2\psi+\frac{8\pi^2 m}{h^2}\left[W+\frac{Ze^2}{r_1}+\frac{Ze^2}{r_2}-\frac{e^2}{r_{12}}+V\right]\psi=0, \quad (3)$$

where ∇_1, ∇_2 correspond to the two K-electrons (3), and r_1, r_2 are their respective distances from the nucleus, W= total energy of the two K-electrons, V is the potential due to the outer electrons and r_{12} the distance between the two electrons. If V were zero, the problem would have reduced to the helium one which has been completely solved by Heisenberg, and numerical formula for the calculation of W has been given by Kellner and Hylleras.[6] $W=E_1+E_2=$ sum of the energies of the two electrons. Hylleras gives the following formulae for the ionisation potential of the electrons in the helium shell:

$$\frac{E_1}{Rh}=\left[Z^2-\tfrac{5}{4}Z+{\cdot}31488-{\cdot}01752\frac{1}{Z}+\frac{{\cdot}00548}{Z^2}\right],$$

$$\frac{E_2}{Rh}=(Z+1)^2. \quad (4)$$

The formula (4) is in excellent agreement with experimental data due to Edlen.[7] This is shown in Table 2 below.

TABLE 2

	He	Li	Be
I.P calculated	24·47	75·272	153·140
I.P observed	24·467	75·219±·012	153·09±·10

For finding out the value of ν_K, the value of V must be found. Various methods for determining the value of the potential field in the inside of atoms have lately been developed, and the one due to Fermi[8] seems to be the most promising. But the mathematical difficulties in the solution have not yet been overcome.

We may, however, compare the values of ν_K as experimentally obtained, with the value of the I.P. of the helium like stripped atoms of the group He to Na. This will give us some idea of the outer screening due to the L-electron shell, as this is being formed by the addition of successive electrons. The comparison is shown in Table 3.

TABLE 3

Element	I.P. of Stripped Atoms	$\frac{\nu}{R}$	σ	$\frac{\nu_K}{R}$	σ_K
2 He	24·45	1·81	·655	1·802	·657
3 Li^+	75·272	5·56	·642	3·89	1·03
4 B^{+2}	153·09	11·30	·637	7·87	1·195
5 B^{+3}	258·0	19·05	·634	13·80	1·285
6 C^{+4}	390·0	28·81	·632	20·90	1·428
7 N^{+5}	..	..	..	29·3	1·59
8 O^{+6}	..	..	..	38·8	1·77
9 F^{+7}	..	..	..	50·5	1·894
10 Ne^{+8}	..	..	..	..	2·019

The second column contains the value of the I. P. of the stripped atom, the third shows corresponding ν/R of the stripped atom from which σ in the fourth column has been calculated taking $\sqrt{\frac{\nu}{R}}=Z-\sigma$; we find that σ varies gradually from ·655 to ·625. This is in accordance with Hylleras' formula.

In the fifth column, we have values of ν_K/R and the sixth column shows σ_K. It is seen that $\sigma_K > \sigma$ and increases with the number of L-electrons steadily, but on the lower limit $\sigma_K \rightarrow \sigma$ for He. Thus it is apparent that the outer electrons contribute very essentially to the screening, as was first pointed out by Bohr.

5. *The ν_{L_1}-values.*—The values of the ν_{L_1}-level are given by Lindh[8] up to 37 Rb. For other elements, the absorption limit has not yet been obtained, but we can determine ν_{L1} from the relation

$$\nu_{L_1} = \nu_{\beta_3} + \nu_K - \nu_{K\beta}. \qquad \qquad (5)$$

In this way ν_{L_1} has been calculated for 26 Fe, 28 Ni, 29 Cu and 33 As, from Thoræus' measurement of $L\beta_3$. The ν_{L_1} and σ_{L_1}, values are shown in Table 4, and σ_{L_1}'s are plotted against the atomic number in curve (2). A few other ν_L -values for elements below 26 Fe may be calculated roughly by a number of indirect methods, *e.g.*, from the empirical relation given by Hertz and Sommerfeld:

$$\sqrt{L_{11}} - \sqrt{L_{21}} = \text{const.} = \cdot 64, \qquad \qquad (6)$$

as has been done by Stoner[9].

But there is no certainty that the relation[6] holds for elements below Fe. We can also try to identify $\nu_{L_{11}}$ with some of the critical potentials found by the electron bombardment method. But these values are also uncertain.

Anyhow the values of L_1 below Fe are only provisionally given.

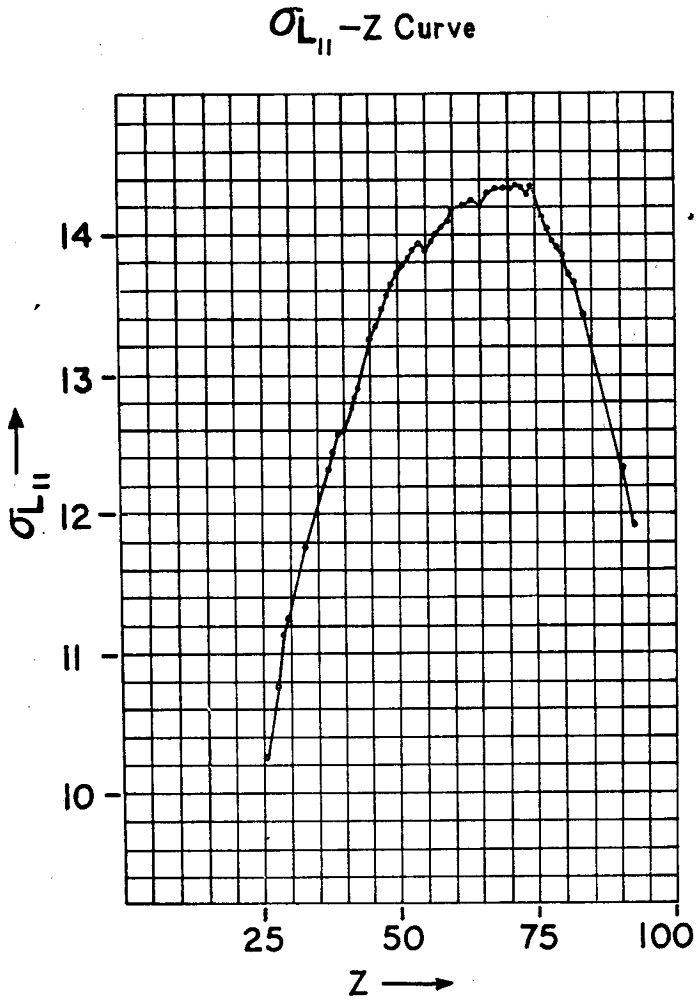

FIG. 2 — Showing the relation between $\sigma_{L_{11}}$ and Z.

TABLE 4

Z	$\frac{\nu}{R}$	$\sqrt{\frac{\nu_{L_{11}}}{R}}$	$\sigma_{L_{11}}$	Remarks
5 B	1·82	1·35	2·30	Electron bombardment method
6 C	..	1·61, 1·71	2·78	
8 O	3·69	1·92	4·16	,,
9 F	4·67	2·16	4·68	,,
13 Al	7·41	2·9	7·20	Lindh
14 Si	10·76	3·28	7·44	..
23 V	43·43	6·59	9·82	
26 Fe	62·13	7·882	10·24	Thoraeus' measurements of $L\beta_3$
27 Co	..	..	..	..
28 Ni	74·29	8·62	10·76	,,
29 Cu	80·86	8·994	11·112	,,
30 Zn	88·19	9·391	11·218	
31 Ga	..	..	..	
32 Ge	..	..	..	
33 As	112·7	10·62	11·76	,,
34 Se	..	..	..	
35 Br	..	..	..	
36 Kr	..	..	..	
37 Rb	152·25	12·34	12·32	Lindh
38 Sr	163·57	12·79	12·42	,,
39 Y	174·52	13·21	12·58	,,
40 Zr	187·60	13·70	12·60	,,
41 Nb	199·33	14·12	12·76	,,
42 Mo	212·43	14·58	12·84	,,
43	..	..	..	,,
44 Ru	..	..	..	,,
45 Rh	251·83	15·87	13·26	,,
46 Pd	266·41	16·32	13·36	,,
47 Ag	280·62	16·76	13·48	,,
48 Cd	296·13	17·21	13·58	,,
49 In	312·14	17·67	13·66	,,
50 Sn	329·03	18·14	13·72	,,
51 Sb	346·3	18·61	13·78	
52 Te	363·9	19·08	13·84	
53 I	382·3	19·55	13·90	
54 Xe	401·02	20·03	13·94	
55 Cs	422·5	20·56	13·88	
56 Ba	441·7	21·02	13·96	
57 La	462·3	21·50	14·00	
58 Ce	482·9	21·97	14·06	
59 Pr	504·0	22·45	14·10	
60 Nd	524·9	22·91	14·18	
62 Sm	571·2	23·90	14·2	
63 Eu	594·3	24·38	14·24	
64 Gd	619·9	24·89	14·22	
65	..	..	..	
66 Dy	667·68	25·84	14·32	
67 Ho	..	..	..	

TABLE 4 *(contd.)*

Z	$\frac{\nu}{R}$	$\sqrt{\frac{\nu_{L_{11}}}{R}}$	$\sigma_{L_{11}}$	Remarks
68 Er	719·78	26·83	14·34	
69 Tu	747·19	27·33	14·34	
70 Yb	774·55	27·83	14·34	
71 Lu	802·05	28·32	14·36	
72 Hf	830·70	28·82	14·36	
73 Ta	861·3	29·35	14·3	
74 W	889·9	29·83	14·34	
75	..	..	..	
76 Os	957·7	30·94	14·12	
77 Ir	991·0	31·47	14·06	
78 Pt	1022	32·02	13·96	
79 Au	1058	32·54	13·92	
80 Hg	1093	33·06	13·88	
81 Tl	1131	33·64	13·72	
82 Pb	1168	34·17	13·66	
83 Bi	1205	34·78	13·44	
84 Po	..	..	..	
85	..	..	..	
86 Niton	..	..	..	
87	..	..	..	
88 Ra	..	..	..	
89	..	..	..	
90 Th	1508	38·83	12·34	
91 Url	..	..	..	
92 Ur	1603	40·04	11·92	

The problem of determining ν_{L_1} may be started from that of Beryllium like atoms. We have therefore added in Table 5 the experimentally determined values of the I.P. of atoms stripped to the Be-shell, *viz.*, of Be,B^+, C^{+2}. The corresponding screening constants are shown in column 4. It is found that σ_L-values tend to the limit 2·34 for N^{+3}. It is found that the I.P. of atoms stripped to the Be-core can be represented by the formula

$$E=(Z-2{\cdot}34)^2+{\cdot}427-\frac{2{\cdot}61}{(Z-2{\cdot}34)}+\frac{3{\cdot}25}{(Z-2{\cdot}34)^2}\cdots \quad (7)$$

TABLE 5

Element	I. P. of Stripped atom.	$\frac{\nu}{R}$	σ	σ_{L_1}
Be	9·49	·701	2·320	..
B^+	24·19	1·39	2·326	2·78
C^{++}	45·49	3·359	2·334	..
N^{+3}	73·46	5·425	2·342	4·16
O^{+4}	*[109·26]	8·07	2·342	..

*Approximate.

6. *The* $\sigma_{L_{21}}$*-absorption levels.*— The L_{21} and L_{22} absorption levels are given by Lindh up to 12 Mg. The values of $\sigma_{L_{21}}$ calculated according to the formula $\sqrt{\frac{\nu_{L_{21}}}{R}}=\frac{Z-\sigma_{L_{21}}}{2}$ are shown in column 4 of Table 6, and the variation of $\sigma_{L_{21}}$ values with the atomic number is shown in curve (3).

TABLE 6

Z	$\frac{\nu}{R}$	$\sqrt{\frac{\nu}{R}}$	σ	Z	$\frac{\nu}{R}$	$\sqrt{\frac{\nu}{R}}$	σ
10 Ne	1·59	1·26	7·48	54 Xe	375·74	19·38	15·24
12 Mg	3·50	1·87	8·26	55 Cs	396·4	19·91	15·18
13 Al	5·20	2·28	8·44	56 Ba	414·67	20·36	15·28
15 P	9·92	3·15	8·70	57 La	434·4	20·84	15·32
16 S	11·68	3·42	9·16	58 Ce	454·44	21·32	15·36
17 Cl	14·81	3·85	9·38	59 Pr	474·68	21·79	15·42
19 K	21·43	4·63	9·74	60 Nd	495·90	22·27	15·46
20 Ca	25·42	5·09	9·82	62 Sm	538·9	23·21	15·58
21 Sc	30·35	5·51	9·98	63 Eu	561·5	23·70	15·6
22 Ti	32·6	5·71	10·58	64 Gd	584·66	24·18	15·64
23 V	38·3	6·18	10·64	66 Dy	632·22	25·14	15·72
24 Cr	43·3	6·57	10·86	68 Er	682·62	26·13	15·74
25 Mn	48·2	6·94	11·12	69	709·23	26·63	15·74
26 Fe	53·42	7·31	11·38	70 Yb	733·70	27·09	15·82
27 Co	59·00	7·68	11·64	71 Lu	762·87	27·62	15·76
28 Ni	64·10	8·04	11·92	72 Hf	791·37	28·13	15·74
29 Cu	70·4	8·39	12·22	73 Ta	819·6	28·63	15·74
30 Zn	77·1	8·78	12·44	74 W	849·59	29·15	15·70
33 As	101·00	10·01	12·98	76 Os	912·6	30·21	15·58
34 Se	108	10·41	13·18	77 Ir	944·3	30·73	15·54
35 Br	117·1	10·85	13·4	78 Pt	977·6	31·27	15·46
37 Rb	137	11·71	13·58	79 Au	1011·3	31·83	15·34
38 Sr	147·88	12·16	13·68	80 Hg	1047·4	32·36	15·28
39 Y	158·84	12·60	13·80	81 Tl	1082·9	32·91	15·18
40 Zr	169·83	13·03	13·94	82 Pb	1120·5	33·47	15·06
42 Mo	193·39	13·91	14·18	83 Bi	1157·5	34·02	14·96
44 Ru	218·57	14·78	14·44	84	..	..	..
45 Rh	231·64	15·22	14·56	85	..	..	..
46 Pd	245·28	15·66	14·68	86	..	..	..
47 Ag	259·87	16·09	14·82	87	..	..	..
48 Cd	274·55	16·57	14·86	88	..	..	..
49 In	290·26	17·04	14·92	89	..	..	..
50 Sn	306·59	17·51	14·98	90 Th	1449·7	38·07	13·86
51 Sb	322·9	17·97	15·06	91	..	..	..
52 Te	340·1	18·44	15·12	92 Mr	1539·8	39·24	13·52
53 I	357·77	18·91	15·18				

The starting point for the calculation of the $\sigma_{L_{21}}$-values should be the Neon-atom. This has not yet been attempted. In Table 7 we have given the I.P. of atoms ionised to the Ne-like core as far as known, and the calculated values of screening constants are shown in column 4. It is seen at once that $\sigma_{L_{21}}$ tends in the limit to σ_L for Ne. The $\sigma_{L_{21}}$-values are roughly represented by the empirical formula

$$\sigma=7{\cdot}728+{\cdot}277\,(Z-10)-{\cdot}00231(Z-10)^2 -{\cdot}000001(Z-10)^3, \quad \ldots \quad (8)$$

the I.P. of atoms stripped to the Ne-core can be represented by the empirical formula

$$E=(Z-6{\cdot}745)^2+1{\cdot}917-\frac{42{\cdot}8}{(Z-6{\cdot}745)}\times\frac{70{\cdot}165}{(Z-6{\cdot}745)^2}. \quad (9)$$

The value of the electron-affinity of fluorine calculated from this formula comes out to be 7·10 volts, which is in

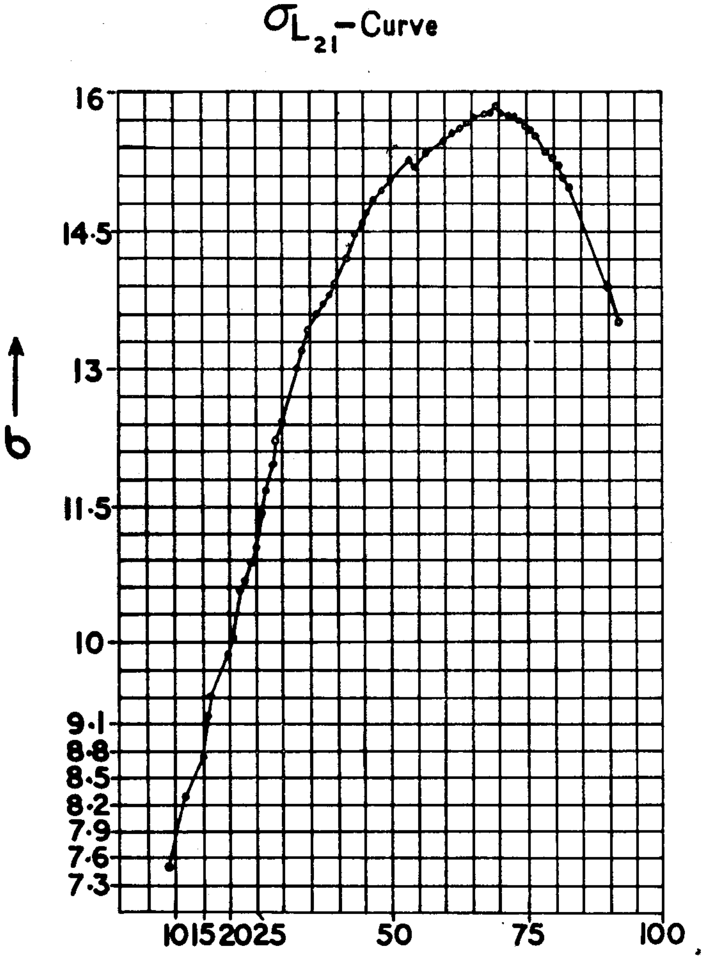

Fig. 3—Showing the relation between $\sigma_{L_{21}}$ and Z

TABLE 7

Element	I. P. of Stripped atom.	ν/R	σ	$\frac{\nu}{R}$	$\sigma_{L_{21}}$
Ne	21·49	1·59	7·48	1·59	7·48
Na^{++}	46·78	..	7·28	..	..
Mg^{++}	80·91	5·975	7·112	3·5	8·26
Al^{+3}	121·77	8·993	7·018	5·2	8·44
Si^{+4}	168·72	12·473	6·940	..	..
P^{+5}	221·9	..	..	9·92	8·70

agreement with the value got by Mulliken from extrapolation of corresponding values for Cl, Br, I. The formula is similar to Hylleras' formula for He-like stripped atoms, but it has still to be justified on theoretical grounds.

7. *The Probable Cause of Negative Screening.*—It is seen that in all cases, the screening factor shows a negative term involving Z^2. This reduces the screening constant ultimately to almost zero in the case of Ur. As far as we are aware, no explanation has yet been given of this negative screening.

A term $-\alpha Z^2$ in the screening factor, is due to a term involving Z^2 in the energy-value of the electron; the power four of Z at once suggests that this factor is due to some polarisation effect, and the only explanation we can give is that the K-electrons produce a polarisation of the nucleus. Further thoughts and actual calculation do not, however, encourage the idea. Firstly, the K-shell is He-like, hence the distribution of charge is spherical, and no polarisation of the nucleus is expected. Secondly, supposing there is a polarisation $=\alpha E$, where E=field produced by the disturbing cause (here the K-electrons), α must be identified with b, b=the radius of the nucleus. But on actually calculating b from the αZ^2—term, we find that b is about 6×10^{-11}, *i.e.*, b is about sixty times larger than the radius usually ascribed to the nucleus. The explanation therefore seems to fail, and we are not in a position to offer any alternative suggestion.

8. This paper is rather in the nature of a survey of the existing problems. The problems suggested which may be taken up later are:—

(1) To calculate a theoretical expression for the Ionisation Potential of atoms stripped to the Be-core.

(2) To calculate a theoretical expression for the Ionisation Potential of Ne-like atoms.

(3) To find a theoretical expression for the screening effect of outer electrons in the general case.

(4) To find an expression for the potential inside the atom.

(5) To find an expression for the negative squared terms in the screening constant.

(6) To find an expression for the doublet separations.

(7) To calculate energy-values for removing two electrons out of the atoms simultaneously.

(8) To extend the same treatment to the other X-ray levels.

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