$l=3$	$l=2$	$l=1$	$l=0$	$\bar{N}$	N
89 Ac, 90 Th, 91 Pa, 92 U, 93 Np, 94 Pu, 95 Am, 96 Cm, 97 Bk, 98 Cf, 99 Es, 100 Fm, 101 Md, 102 No	103 Lw, 104 Ku, 105, 106, 107, 108, 109, 110, 111, 112	113, 114, 115, 116, 117, 118	119, 120	3	8
57 La, 58 Ce, 59 Pr, 60 Nd, 61 Pm, 62 Sm, 63 Eu, 64 Gd, 65 Tb, 66 Dy, 67 Ho, 68 Er, 69 Tm, 70 Yb	71 Lu, 72 Hf, 73 Ta, 74 W, 75 Re, 76 Os, 77 Ir, 78 Pt, 79 Au, 80 Hg	81 Tl, 82 Pb, 83 Bi, 84 Po, 85 At, 86 Rn	87 Fr, 88 Ra		7
	39 Y, 40 Zr, 41 Nb, 42 Mo, 43 Tc, 44 Ru, 45 Rh, 46 Pd, 47 Ag, 48 Cd	49 In, 50 Sn, 51 Sb, 52 Te, 53 I, 54 Xe	55 Cs, 56 Ba	2	6
	21 Sc, 22 Ti, 23 V, 24 Cr, 25 Mn, 26 Fe, 27 Co, 28 Ni, 29 Cu, 30 Zn	31 Ga, 32 Ge, 33 As, 34 Se, 35 Br, 36 Kr	37 Rb, 38 Sr		5
		13 Al, 14 Si, 15 P, 16 S, 17 Cl, 18 Ar	19 K, 20 Ca	1	4
		5 B, 6 C, 7 N, 8 O, 9 F, 10 Ne	11 Na, 12 Mg		3
			3 Li, 4 Be	0	2
			1 H, 2 He		1

Fig. 1. The Periodic System of the Elements (PSE). For the shell number holds: $N=n+l$, $\bar{N}=\hat{l}=l_{\max}$ of the shell.

A classification in terms of the conventional principal quantum number n and the orbital quantum number l is given in Fig. 2. Evidently, for each single shell not n is a constant but $N=n+l$. This possibility of characterization has been noticed as early as 1926 by MADELUNG [1] and has again been stressed only recently by GOUDSMIT and RICHARDS [2]; however, no further conclusions were drawn.

8-SHELL-CLASSIFICATION

n, l				N
5f	6d	7p	8s	8
4f	5d	6p	7s	7
	4d	5p	6s	6
	3d	4p	5s	5
		3p	4s	4
		2p	3s	3
			2s	2
			1s	1

$N=n+l$

Fig. 2. 8-Shell-Classification of the PSE in terms of the conventional quantum numbers.

In fact, as evident from Fig. 1, the PSE exhibits high symmetry. It consists of boxes which form a triangular matrix. Each box contains $4(2l+1)$ elements. The multiplicity $(2l+1)$ is due to the well known space degeneracy as described by the magnetic quantum number m with the values

$$-l \leqq m \leqq +l.$$

There is a doubling of states in the horizontal direction which is ascribed to the spin s, $s=\pm 1/2$ and a similar doubling in the vertical direction which we shall describe analogous to the spin by introducing tentatively a new quantum number c, $c=\pm 1/2$.

Clearly, the PSE exhibits a *double shell* structure in a *twofold sense:* a) There is a shell structure both in the horizontal and vertical direction and b) each shell is at least a double shell.

3. Properties of the Elements

From the chemist's point of view, the new PSE preserves at large the relative position of the usual chemical groups. In addition, proceeding along the outer edges either horizontally or vertically, there is in general only a relatively small change in the chemical properties of the elements; if this rule could be put on a physical basis, the chemical similarity of the lantanides would need no special justification. As a byproduct, in the new PSE alkali halides are centered naturally around the noble gases in a similar way as the III – V and II – VI semiconductors are centered around the elemental ones.

It is an essential feature of the conventional PSE that it exhibits a shell structure in the *horizontal direction.* Many physical and chemical properties vary more or less continuous with increasing filling of the $2(2l+1)$ states in a given subshell l, but there is a discontinuous change in going horizontally from one subshell to the next. If the notion of double shells in the *vertical direction* is of physical reality, one should expect a discontinuous behaviour by proceeding along the elements of a given chemical group.

[3] HÜTTE, Taschenbuch der Werkstoffkunde (Stoffhütte), Akademischer Verein Hütte, Hrsgb., Berlin 1967, p. 18.