Letters

The Periodic Table: Facts or Committees?

I would like to offer two observations relative to the recent letter of Clark and White on the representation of the f-block elements in the periodic table that relate to some disturbing trends in the attitudes of the chemical community towards the nature and use of the periodic table—attitudes that are implicit, though perhaps not intentionally so, in their letter *(1)*.

First, I would note the increasing number of textbooks that use versions of the periodic table whose underlying premises are either ignored or directly contradicted by the text itself. Thus several years ago I called attention to the example of textbooks that used periodic tables in which the elements of the Zn group were explicitly (but incorrectly) labelled as transition elements, but treated (correctly) within the text as main-block elements *(2)*. More relevant to the issue at hand is the case of the well-known text of Cotton and Wilkinson that uses what Clark and White have called the 14CeTh representation[1] of the f-block in the periodic table on the back flyleaf but the 15LaAc interpretation within the text *(3)*, while the textbook by Housecraft and Sharpe uses the 15LaAc representation in the periodic table on the front flyleaf but the 14CeTh interpretation within the text itself *(4)*.

Both the 14LaAc and the 14CeTh representations treat the lanthanoids and actinoids as a fourth independent block of the periodic table and differ only in terms of where the resulting f-block begins and ends. In converting the footnoted 18-column form of the periodic table into a full 32-column table, the points of insertion for the 28 footnoted f-block elements are indicated by asterisks placed either on the lines separating the groups *between* which they are to be inserted or in thin gaps between those groups. In the case of the 15LaAc form, however, an entirely different interpretation is placed on these elements. The 30 elements are treated not as a separate independent electronic block but rather as degenerate members of group 3 of the d-block. The two boxes below Sc and Y are not vacant, as Clark and White state, but rather contain either the atomic numbers 57–71 and 89–103 or the symbols La–Lu and Ac–Lr, respectively, thus indicating that all 30 of the elements in the footnote belong *in* just those two boxes. Expanding such a table into a 32 column

Tafel II. **Periodisches System der Elemente**
mit Ordnungszahlen (fett) und Atomgewichten.

0	I	II	III	IV	V	VI	VII	VIII
	a b	a b	a b	a b	a b	a b	a b	
2 He 4,00	**3** Li 6,94	**4** Be 9,02	**5** B 10,82	**6** C 12,00	**7** N 14,008	**8** O 16,000	**9** F 19,00	
10 Ne 20,18	**11** Na 23,00	**12** Mg 24,32	**13** Al 26,97	**14** Si 28,06	**15** P 31,02	**16** S 32,06	**17** Cl 35,46	
18 A 39,9	**19** K 39,10	**20** Ca 40,07	**21** Sc 45,1	**22** Ti 47,90	**23** V 50,95	**24** Cr 52,01	**25** Mn 54,93	**26** Fe 55,84 **27** Co 58,94 **28** Ni 58,69
	29 Cu 63,57	**30** Zn 65,38	**31** Ga 69,72	**32** Ge 72,60	**33** As 74,96	**34** Se 79,2	**35** Br 79,92	
36 Kr 82,92	**37** Rb 85,45	**38** Sr 87,63	**39** Y 88,93	**40** Zr 91,22	**41** Nb 93,5	**42** Mo 96,0	**43** Ms	**44** Ru 101,7 **45** Rh 102,9 **46** Pd 106,7
	47 Ag 107,88	**48** Cd 112,41	**49** In 114,8	**50** Sn 118,70	**51** Sb 121,76	**52** Te 127,5	**53** J 126,93	
54 X 130,2	**55** Cs 132,81	**56** Ba 137,36	**57—71** La etc.¹)	**72** Hf 178,6	**73** Ta 181,5	**74** W 184,0	**75** Re 188,16	**76** Os 190,9 **77** Ir 193,1 **78** Pt 195,2
	79 Au 197,2	**80** Hg 200,61	**81** Tl 204,39	**82** Pb 207,21	**83** Bi 209,00	**84** Po 210,0	**85** —	
86 Em 222,0	**87**²)	**88** Ra 225,97	**89** Ac 227	**90** Th 232,12	**91**²)	**92** U 238,14		

¹) *Seltene Erden:* 57 La 138,90 58 Ce 140,25 59 Pr 140,92 60 Nd 144,27 61 Il 62 Sm 150,43 63 Eu 152,0 64 Gd 157,3 65 Tb 159,2 66 Dy 162,46 67 Ho 163,5 68 Er 167,64 69 Tu 168,5 70 Yb 173,5 71 Cp 175,0

²) Vgl. Tab. S. 784.

Figure 1. A short 8-column periodic table from the 1929 edition of Fritz Ephraim's inorganic textbook illustrating the origins of the 15LaAc interpretation for the lanthanoids. This table predates Seaborg's actinide hypothesis so the known actinoids are instead distributed throughout the d-block. Illustration used with permission of the Oesper Collections in the History of Chemistry, University of Cincinnati.

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table would require one to stretch the boxes for Sc and Y so that they span all 15 of the inserted columns. This interpretation goes back to the 1920s and the original electronic interpretation of the so-called rare earth elements, as shown in the 8-column table in Figure 1 taken from Ephraim's textbook of 1929 *(5),* and was later reformatted in terms of an 18-column table and extended to the actinoids by Seaborg *(6).* In the case of the lanthanoids it was based on the assumption that all of them had, as per Sc and Y, a common $(n-1)d^1ns^2$ valence configuration and a maximum possible oxidation state of 3+, their only differences being the presence of a variable, but chemically insignificant, [noble gas]$(n-2)f^x$ core. As shown in my original article, all of these assumptions are now known to be false *(7).* Many of these elements have $(n-2)f^xns^2$ valence configurations and exhibit maximum oxidation states greater than 3+, thus making their assignment to group 3 of the d-block chemical nonsense. IUPAC or not, I can hardly believe that a modern inorganic chemist would advocate such an antiquated interpretation of these elements, unless, as noted above, they have lost all contact between the underlying premises of their periodic table and the facts of chemistry.

Second, I note the increasing incidence of teachers and textbook publishers demanding that IUPAC make decisions on certain ambiguous situations in the periodic table, such as the placement of hydrogen or the f-block, or that it officially endorse just one form of the table—however ill advised or arbitrary the result—so that we can give our students an unambiguous black-and-white answer to memorize for exams *(8).* We should be ashamed as both teachers and scientists. As teachers we should expose our students to the ambiguities and challenges of how one goes about interpreting scientific data and to the creative role of alternative representations and not just attempt to reduce everything to oversimplified and largely incorrect tidbits for rote memorization. As scientists we should base our conclusions on a critical examination of the chemical and physical evidence and not on an appeal to authority or the arbitrary whims of committees and popularity polls. Above all, such demands should be tempered by the sobering recollection that IUPAC is the organization that brought us density in units of kg/m^3, $4\pi\varepsilon_0$ in the denominator of Coulomb's law, and the finger-count labels 1–18 in the periodic table.

Note

1. In the 14CeTh representation 14 represents the number of groups in the f-block and Ce and Th are the first elements in each row of the f-block.

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