

A Note on the Term "Transition Metal"

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The term "transition element" originally applied only to the groups Fe, Co, Ni; Ru, Rh, Pd; and Os, Ir, Pt; that is, only to those metals which are today generally placed in group VIII. In the older "chemical" periodic table, classification was largely based on maximum valence or oxidation state. Before the discovery of the noble gases, maximum oxidation states for the known elements were found to undergo a cyclic variation from one to seven (Newland's law of octaves). Each short period of the periodic table corresponded to one such cycle (e.g., Na to Cl), whereas each long period corresponded to two such cycles (e.g., K to Mn and Cu to Br), the two cycles being separated by a group of three metals of intermediate valence (e.g., Fe, Co, Ni) whose properties represented a gradual transition between those of the last member of the first cycle (e.g., Mn(VIII) in Mn_2O_7) and the first member of the second cycle (e.g., Cu(I) in Cu_2O) - hence the name "transition" metal or element.

These two cycles correspond to what are now called (according to IUPAC) the A and B subgroups. When the noble gases were discovered, it was suggested that they also be classified as a new group of transition elements, as they again fell between the end of one cycle (e.g., Cl(VII) in Cl_2O_7) and the beginning of a new cycle (e.g., K(I) in K_2O) (1).

The earliest use of the term transition element in its modern "electronic" sense, that I could locate, was in a paper on the electronic structure of atoms and the periodic table published by Bury in 1921 (2), where it is used to describe those elements which are undergoing a transition from a noble gas $(n-1)s^2(n-1)p^6$ core to a "pseudonoble" gas $(n-1)s^2(n-1)p^6(n-1)d^{10}$ core. Bury also used the term

"inner transition" element for those f-block elements undergoing a transition from a $(n-1)s^2(n-1)p^6$ core to a $(n-1)s^2(n-1)p^6(n-2)f^4$ core. It should be noted that the term "transition" element and the term "d-block" element are not synonymous. Though Zn, Cd, and Hg are d-block elements, they are not transition elements, as they already have complete $(n-1)s^2(n-1)p^6(n-1)d^{10}$ cores.

This current usage of the term transition element should probably be abandoned. Not only is it at variance with the older chemical usage and the term d-block element, it also incorrectly suggests that the d electrons are always core electrons. In actual fact, if any transition occurs on moving across the d-block, it is the transition of the d electrons from the status of valence electrons at the beginning to the status of core electrons at the end. This change is particularly sharp between Mn and Cu, accounting for the rapid decrease in the maximum oxidation state from seven to one or two. Thus, restriction of the term transition to its original meaning would not only be in keeping with the older chemical table, but could be given a consistent electronic interpretation as well.

References and Notes

1. J. W. Mellor, *Modern Inorganic Chemistry*, Longmans: London, 1927, p 993.
2. C. R. Bury, *J. Am. Chem. Soc.*, **1921**, *43*, 1602.

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