



Guide to the Extended Step-Pyramid Periodic Table

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The extended step-pyramid table recognizes that elements can be chemically related in several distinct ways:

1. Their atoms may contain the same number of valence electrons, in which case they are said to be *isodonor* since they can contribute or donate the same number of valence electrons in a bonding situation. Such elements are connected by yellow tie lines on the table.
2. Their atoms may contain the same number of valence vacancies (also known as spin orbitals)*, in which case they are said to be *isoacceptor* since they can accept the same number of electrons in a bonding situation. Such elements are connected by violet tie lines on the table.
3. Their atoms may contain both the same number of valence electrons and the same number of valence vacancies, in which case they are said to be *isovalent*. Such elements are either aligned in the same vertical column or are connected by pale blue tie lines on the table.

Elements which are *isovalent* show strong *primary* analogies with one another. They often display the same progression of oxidation states and can substitute for one another in a molecule or reaction without altering the overall stoichiometry. (e.g. Li and Na or Cl and Br. etc.). Such elements are said to belong to the same *group*. This is the only analogy shown on conventional periodic tables. It depends upon the fact that the chemical properties of atoms are determined as much by the number of available valence vacancies on the atom as by the number of valence electrons, though conventional tables emphasize only the latter property and leave the former property implicit.

Elements which are *isodonor* show weaker *secondary* analogies with one another. They display similarities for their highest positive oxidation states but not for their lower or negative oxidation states (i.e. S and Cr or Cl and Mn, etc.). Such elements are said to belong to the same *family* but not to the same *group*.

Elements which are *isoacceptor* show even weaker *tertiary* analogies with one another. They display similarities for their lowest negative oxidation states but not for their positive oxidation states (e.g. H and F or He and Ne, etc.). Once again such elements belong to the same *family* but not to the same *group*.

The elements may also be sorted into four electronic blocks based on the idealized sum of their valence electron counts (e) and their valence vacancy counts (v):

1. The H-He block, for which $e + v = 2$. These elements employ only the outermost ns orbitals in their bonding and are colored red on the table.
2. The main block, for which $e + v = 8$. These elements employ both the outermost ns and np orbitals in their bonding and are colored blue on the table.
3. The transition block for which $e + v = 18$. These elements employ the $(n-1)d$, ns and np orbitals in their bonding and are colored green on the table.
4. The inner-transition block for which $e + v = 32$. These elements employ the $(n-2)f$, $(n-1)d$, ns and np orbitals in their bonding and are colored orange on the table.

Elements belonging to the same group and block are always *isovalent*

Elements belonging to the same family but different blocks are either *isodonor* or *isoacceptor*.

Application of these definitions leads to the following conclusions concerning certain ambiguities in element placement:

1. La and Ac belong to the inner-transition block rather than to the transition block.
2. Lu and Lr belong to the transition block rather than to the inner-transition block.
3. Zn, Cd and Hg belong to the main block rather than to the transition block.
4. H and He belong neither to the Li and Be groups nor to the F and Ne groups but rather form a separate independent block which shows a weak secondary *isodonor* relation with respect to the Li and Be groups and a weak tertiary *isoacceptor* relation with respect to the F and Ne groups.

In keeping with the older 32-column step-pyramid tables of Bohr and Thomsen, all of the elements appear in order of increasing atomic number and there are no footnoted blocks as in conventional 18- and 8-column tables.

Not shown on the table is a new method of labeling groups based on the $e+v$ values of its atoms which always conform to one of the above equations. Thus H is in group 1+1, He in group 2+0, etc. Note how these labels distinguish between strong primary relationships (both numbers are identical) and weaker secondary and tertiary relationships (only the first or second number is identical). Thus the Li group is 1+7 rather than 1+1 like H. Likewise the F group is 7+1 rather than 1+1 like H. The difference between 1+1 and 1+7 is the difference between an atom which forms a saturated covalent diatomic molecule like H_2 and those that form infinitely extended unsaturated metallic arrays with 8/8 coordination and partially filled conduction bands. Zn, Cd and Hg belong to group 2'+6 and are main-block rather than to group 12+6 as they would if they were transition metals with 12 rather than 2 valence electrons. Likewise La and Ac belong to group 3+29 whereas Lu and Lr belong to group 3+15. In other words these labels are able to make distinctions which labels based solely on e counts or on column counts cannot and avoid ambiguities based on irregular configurations (i.e. La, Ac and Th)

A chart using this notation and summarizing the atomic valence manifolds for each block the periodic table is attached. Obviously this can be rearranged to create the extended step pyramid table if desired.

* Every empty atomic orbital can accommodate two electrons of opposite spin – one in each of its two spin orbitals. I call these spin orbitals valence vacancies instead when dealing with the atom's valence shell. Thus each empty valence orbital contains two valence vacancies, each half filled valence orbital contains one valence vacancy, etc. Just as we count individual electrons rather than electron pairs, so we want to count individual vacancies rather than empty orbitals or pairs of vacancies.

Valence-Manifold Chart

H-He Block
($e + v = 2$)

	1+1	2+0
1	H	He

Main Block
($e + v = 8$)

	1+7	2+6	2'+6	3+5	4+4	5+3	6+2	7+1	8+0
2	Li	Be		B	C	N	O	F	Ne
3	Na	Mg		Al	Si	P	S	Cl	Ar
4	K	Ca	Zn	Ga	Ge	As	Se	Br	Kr
5	Rb	Sr	Cd	In	Sn	Sb	Te	I	Xe
6	Cs	Ba	Hg	Tl	Pb	Bi	Po	At	Rn
7	Fr	Ra	112	113	114	115	116	117	118

Transition Block
($e + v = 18$)

	3+15	4+14	5+13	6+12	7+11	8+10	9+9	10+8	11+7
4	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu
5	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag
6	Lu	Hf	Ta	W	Re	Os	Ir	Pt	Au
7	Lr	Rf	Db	Sg	Hs	Mt	110	111	112

Inner-Transition Block
($e + v = 32$)

	3+29	4+28	5+27	6+26	7+25	8+24	9+23	10+22	11+21	12+20	13+19	14+18	15+17	16+16
6	La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb
7	Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No