

Electron Configurations: How Electrons Occupy Orbitals

Electron Spin and the Pauli Exclusion Principle (Pauli exclusion principle: no two electrons in an atom can have the same four quantum numbers.)

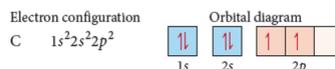
Electron Configurations for Multielectron Atoms

- ▶ Electrons occupy orbitals so as to minimize the energy of the atom; therefore, lower energy orbitals fill before higher energy orbitals. Orbitals fill in the following order: 1s 2s 2p 3s 3p 4s 3d 4p 5s 4d 5p 6s.
- ▶ Orbitals can hold no more than two electrons each. When two electrons occupy the same orbital, their spins are opposite. This is another way of expressing the Pauli exclusion principle (no two electrons in one atom can have the same four quantum numbers).
- ▶ When orbitals of identical energy are available, electrons first occupy these orbitals singly with parallel spins rather than in pairs. Once the orbitals of equal energy are half full, the electrons start to pair (Hund's rule).

"build up"). For lithium, with three electrons, the electron configuration and orbital diagram are:



For carbon, which has six electrons, the electron configuration and orbital diagram are:



Electron Configurations, Valence Electrons, and the Periodic Table

An atom's valence electrons are those that are important in chemical bonding. For main-group elements, the valence electrons are those in the outermost principal energy level. We can now see why the elements in a column of the periodic table have similar chemical properties: they have the same number of valence electrons.

We distinguish between valence electrons and all the other electrons in an atom, which are called core electrons. For example, silicon, with the electron configuration $1s^2 2s^2 2p^6 3s^2 3p^2$, has four valence electrons (those in the $n = 3$ principal level) and ten core electrons as shown in the right margin.

Outer Electron Configurations of Elements 1–18

1A							8A
1 H $1s^1$	2A	3A	4A	5A	6A	7A	2 He $1s^2$
3 Li $2s^1$	4 Be $2s^2$	5 B $2s^2 2p^1$	6 C $2s^2 2p^2$	7 N $2s^2 2p^3$	8 O $2s^2 2p^4$	9 F $2s^2 2p^5$	10 Ne $2s^2 2p^6$
11 Na $3s^1$	12 Mg $3s^2$	13 Al $3s^2 3p^1$	14 Si $3s^2 3p^2$	15 P $3s^2 3p^3$	16 S $3s^2 3p^4$	17 Cl $3s^2 3p^5$	18 Ar $3s^2 3p^6$

Orbital Blocks in the Periodic Table

You can see that the number of columns in a block corresponds to the maximum number of electrons that can occupy the particular sublevel of that block. The *s* block has two columns (corresponding to one *s* orbital holding a maximum of two electrons); the *p* block has six columns (corresponding to three *p* orbitals with two electrons each); the *d* block has 10 columns (corresponding to five *d* orbitals with two electrons each); and the *f* block has 14 columns (corresponding to seven *f* orbitals with two electrons each).

Orbital Blocks of the Periodic Table

Groups																		18
1A												3A	4A	5A	6A	7A	8A	
1	1	2											13	14	15	16	17	18
	H	He											B	C	N	O	F	Ne
	1s ¹	1s ²											2s ² 2p ¹	2s ² 2p ²	2s ² 2p ³	2s ² 2p ⁴	2s ² 2p ⁵	2s ² 2p ⁶
2	3	4											5	6	7	8	9	10
	Li	Be											B	C	N	O	F	Ne
	2s ¹	2s ²											2s ² 2p ¹	2s ² 2p ²	2s ² 2p ³	2s ² 2p ⁴	2s ² 2p ⁵	2s ² 2p ⁶
3	11	12	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	Na	Mg	Al	Si	P	S	Cl	Ar	8B		11B	12B	13	14	15	16	17	18
	3s ¹	3s ²	3s ² 3p ¹	3s ² 3p ²	3s ² 3p ³	3s ² 3p ⁴	3s ² 3p ⁵	3s ² 3p ⁶	3d ¹ 4s ²	3d ² 4s ²	3d ³ 4s ²	3d ⁴ 4s ²	3d ⁵ 4s ¹	3d ⁶ 4s ¹	3d ⁵ 4s ²	3d ⁶ 4s ²	3d ⁵ 4s ²	3d ⁶ 4s ²
4	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
	4s ¹	4s ²	4s ² 3d ¹	4s ² 3d ²	4s ² 3d ³	4s ¹ 3d ⁵	4s ¹ 3d ⁵	4s ² 3d ⁶	4s ² 3d ⁷	4s ² 3d ⁸	4s ¹ 3d ¹⁰	4s ² 3d ¹⁰	4s ² 4p ¹	4s ² 4p ²	4s ² 4p ³	4s ² 4p ⁴	4s ² 4p ⁵	4s ² 4p ⁶
5	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
	5s ¹	5s ²	5s ² 4d ¹	5s ² 4d ²	5s ¹ 4d ⁵	5s ¹ 4d ⁵	5s ² 4d ⁶	5s ¹ 4d ⁷	5s ¹ 4d ⁸	4d ¹⁰	5s ² 4d ¹⁰	5s ² 4d ¹⁰	5s ² 5p ¹	5s ² 5p ²	5s ² 5p ³	5s ² 5p ⁴	5s ² 5p ⁵	5s ² 5p ⁶
6	55	56	57	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
	Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
	6s ¹	6s ²	6s ² 5d ¹	6s ² 5d ²	6s ² 5d ³	6s ² 5d ⁴	6s ¹ 5d ⁵	6s ¹ 5d ⁶	6s ¹ 5d ⁷	6s ¹ 5d ⁹	6s ¹ 5d ¹⁰	6s ² 5d ¹⁰	6s ² 6p ¹	6s ² 6p ²	6s ² 6p ³	6s ² 6p ⁴	6s ² 6p ⁵	6s ² 6p ⁶
7	87	88	89	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118
	Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cn	Nh	Fl	Lv	Ts	Og	
	7s ¹	7s ²	7s ² 6d ¹	7s ² 6d ²	7s ² 6d ³	7s ² 6d ⁴	7s ² 6d ⁵	7s ² 6d ⁶	7s ² 6d ⁷	7s ² 6d ⁹	7s ² 6d ¹⁰	7s ² 6d ¹⁰	7s ² 7p ¹	7s ² 7p ²	7s ² 7p ³	7s ² 7p ⁴	7s ² 7p ⁵	7s ² 7p ⁶