

Electronic Structure of Atoms

Electrons in an atom are grouped around the nucleus into **shells**.

Shell (electron): A grouping of electrons in an atom according to energy.

The farther a shell is from the nucleus, the larger it is, the more electrons it can hold, and the higher the energies of those electrons.

The first shell (closest to the nucleus) can hold two electrons. The second shell can hold 8 electrons. The third shell can hold 32 electrons.

Within the shells, electrons are further grouped into **subshells** of four different types, identified as s, p, d, and f in order of increasing energy. The first shell has only an s subshell; the second shell has an s and a p subshell; the third shell has s, p, and d subshells, and the fourth has s, p, d and f subshells. The number of subshells is equal to the shell number. A specific subshell is symbolized by writing the number of the shell, followed by the letter for the subshell.

Subshell (electron): A grouping of electrons in a shell according to the shape of the region of space they occupy.

Within each subshell, electrons are grouped into **orbitals**, regions of space within an atom where the specific electrons are most likely to be found. Within each subshell, electrons are grouped into orbitals, regions of space within an atom where the specific electrons are most likely to be found. Each orbital holds two electrons which differ in a property known as spin.

Orbital: A region of space within an atom where an electron in a given subshell can be found.

Shell number:	1	2	3	4
Subshell designation:	s	s, p	s, p, d	s, p, d, f
Number of orbitals:	1	1, 3	1, 3, 5	1, 3, 5, 7

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Any orbital can hold a maximum of 2 electrons with opposite spin. The first shell has one 1s orbital and holds 2 electrons. The second shell holds 8 electrons; 2 in a 2s orbital and 6 in three 2p orbitals. The third shell holds 18 electrons; 2 in a 3s orbital; 6 in three 3p orbitals; and 10 in five 3d orbitals. The fourth shell holds 32 electrons; 2 in a 4s orbital; 6 in three 4p orbitals; 10 in five 4d orbitals; and 14 in seven 4f orbitals.

TABLE 2.2 Electron Distribution in Atoms

SHELL NUMBER:	1	2	3	4
Subshell designation:	<i>s</i>	<i>s , p</i>	<i>s , p , d</i>	<i>s , p , d , f</i>
Number of orbitals:	1	1 , 3	1 , 3 , 5	1 , 3 , 5 , 7
Number of electrons:	2	2 , 6	2 , 6 , 10	2 , 6 , 10 , 14
Total electron capacity:	2	8	18	32

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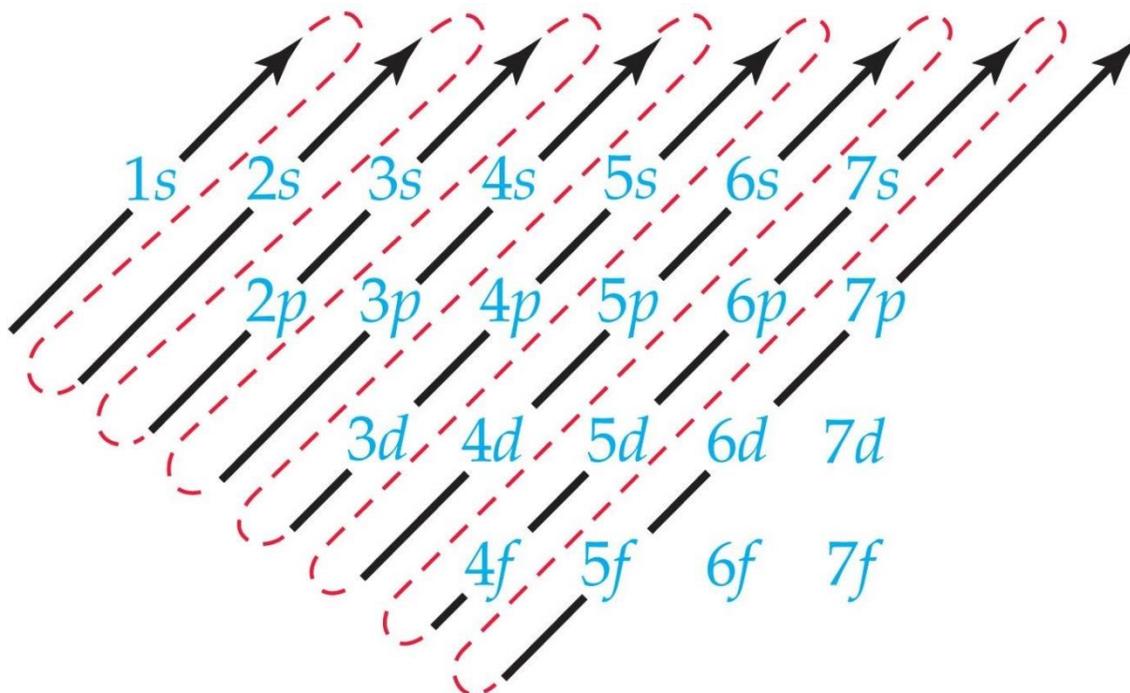
Electron Configurations

The exact arrangement of electrons in an atom's shells and subshells is the atom's **electron configuration**. It can be predicted by applying three rules.

Electron Configuration: The specific arrangement of electrons in an atom's shell and subshells.

Rule 1: Electrons occupy the lowest energy orbitals available. This is complicated by "crossover" of energies above the 3p level.

Below is a simple scheme to help remember the order in which the orbitals are filled.



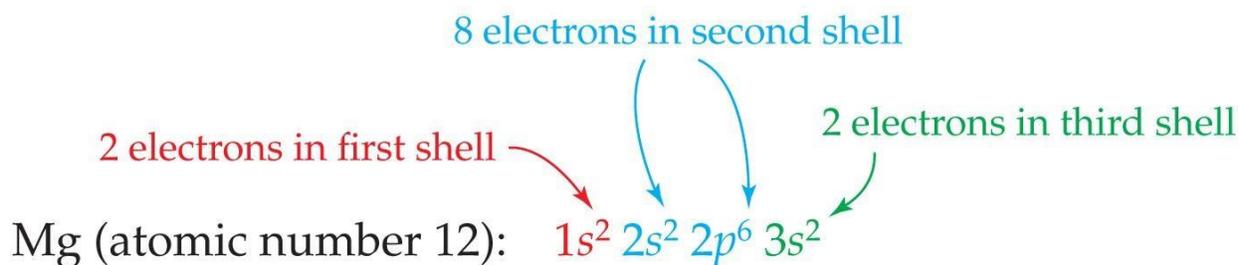
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Rule 2: Each orbital can hold only two electrons, which must be of opposite spin.

Rule 3: Two or more orbitals with the same energy are each half-filled by one electron before any one orbital is completely filled by addition of the second electron.

- The number of electrons in each subshell is indicated by a superscript.



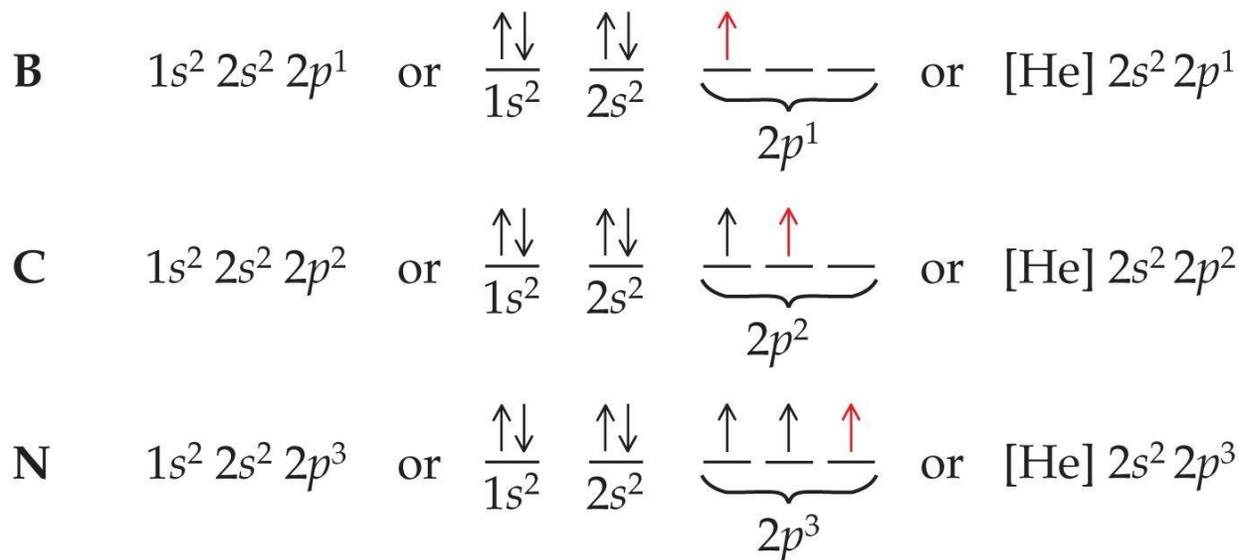
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TABLE 2.3 Electron Configurations of the First 20 Elements

	Element	Atomic Number	Electron Configuration
H	Hydrogen	1	$1s^1$
He	Helium	2	$1s^2$
Li	Lithium	3	$1s^2 2s^1$
Be	Beryllium	4	$1s^2 2s^2$
B	Boron	5	$1s^2 2s^2 2p^1$
C	Carbon	6	$1s^2 2s^2 2p^2$
N	Nitrogen	7	$1s^2 2s^2 2p^3$
O	Oxygen	8	$1s^2 2s^2 2p^4$
F	Fluorine	9	$1s^2 2s^2 2p^5$
Ne	Neon	10	$1s^2 2s^2 2p^6$
Na	Sodium	11	$1s^2 2s^2 2p^6 3s^1$
Mg	Magnesium	12	$1s^2 2s^2 2p^6 3s^2$
Al	Aluminum	13	$1s^2 2s^2 2p^6 3s^2 3p^1$
Si	Silicon	14	$1s^2 2s^2 2p^6 3s^2 3p^2$
P	Phosphorus	15	$1s^2 2s^2 2p^6 3s^2 3p^3$
S	Sulfur	16	$1s^2 2s^2 2p^6 3s^2 3p^4$
Cl	Chlorine	17	$1s^2 2s^2 2p^6 3s^2 3p^5$
Ar	Argon	18	$1s^2 2s^2 2p^6 3s^2 3p^6$
K	Potassium	19	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$
Ca	Calcium	20	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$

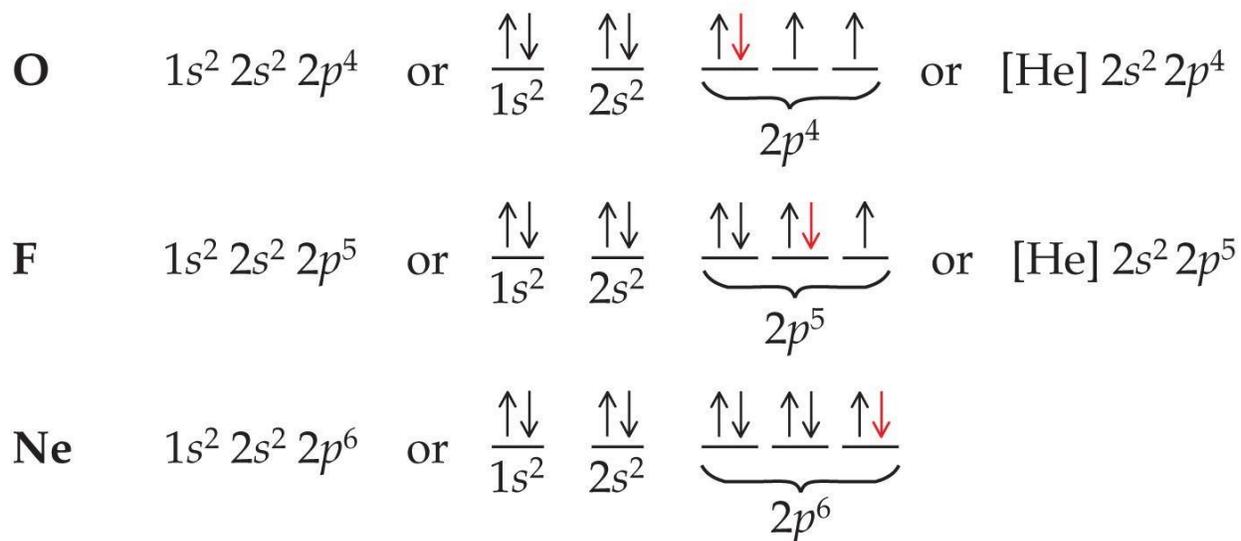
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These are the electron configurations for B – N in which the 2p shell begins to fill.



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These are the electron configurations for O – Ne in which the 2p shell is completed.



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