Atomic Orbitals and Electron configurations

The BIG idea: four types of atomic orbitals emerge from the solutions to the Schrödinger equation. Each type is a different *shape*. Electrons fill these orbitals to build up the structure of an atom until the number of electrons is equal to the number of protons in the nucleus. The orbitals fill in a predictable way, following a pattern that can be traced on the periodic table. This is the essential information we need to understand *why* elements have various chemical properties.

The ground rules:

1. Each row or *period* in the periodic table represents an energy level (1 through 7). These levels are often designated by the letter **n** (called the principal quantum number).

Thus H and He have electrons in level n = 1.

Li, Be, B, C, N, O, F and Ne have electrons in levels n = 1 and n = 2.

Na, Mg, Al, Si, P, S, Cl and Ar have electrons in levels n = 1, n = 2 and n = 3.

Get the idea?

2. Each orbital (regardless of type) may contain 1 or 2 electrons but no more.

3. The number of *types* of orbitals is equal to **n**. The total number of orbitals on an energy level is equal to $\mathbf{n^2}$.

4. The types of orbitals are: s, p, d, f. These are listed in order of increasing energy *within* an energy level (i.e., energy levels have sub-levels).

Thus on n = 1, there is only one s orbital.

On n = 2, there is an s orbital and three p orbitals.

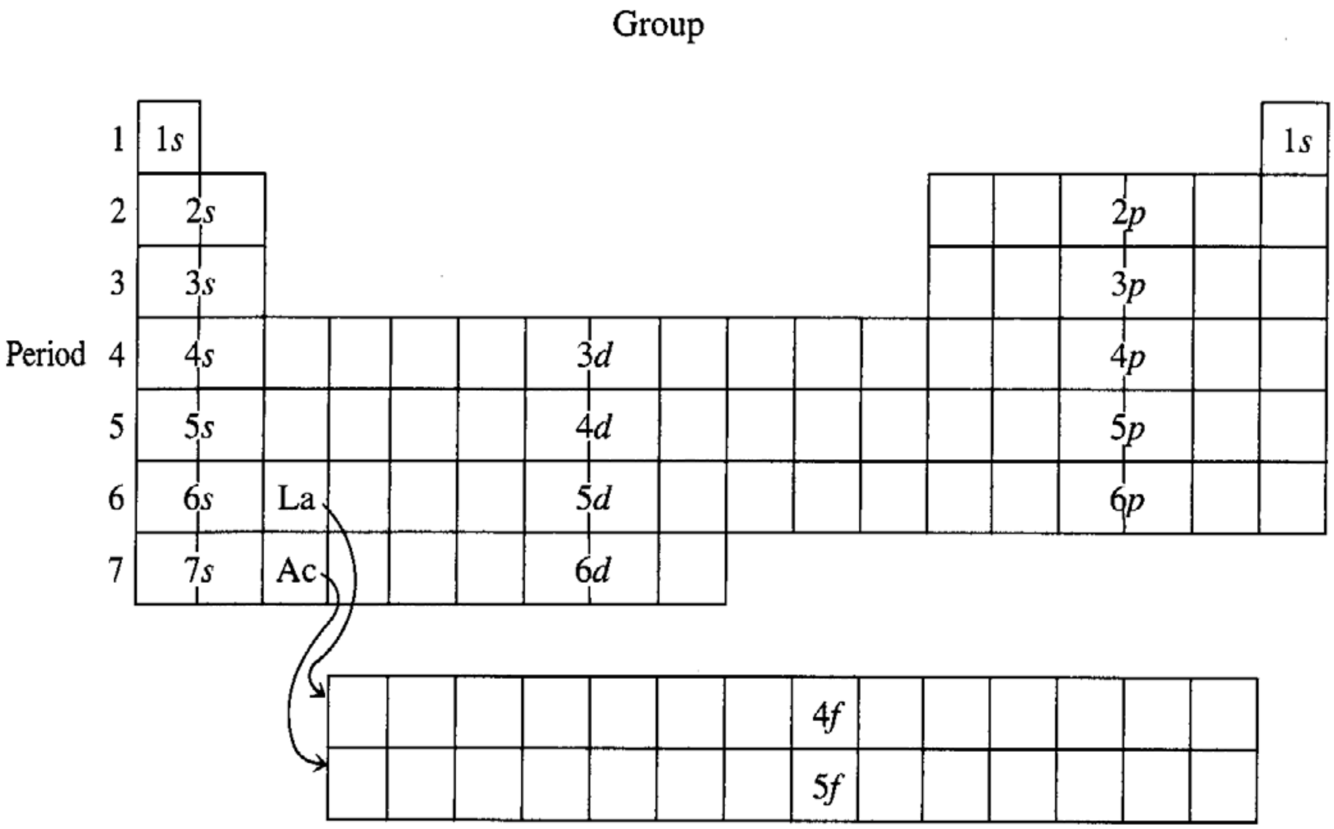
On n = 3, there is an s orbital, three p orbitals and five d orbitals.

On n = 4 and higher there is an s orbital, three p orbitals, five d orbitals and seven f orbitals.

[the result of this progression is that there can only be **one** s orbital on a level, **three** p orbitals, **five** d orbitals, and **seven** f orbitals]

The easier way

All of this information is summarized neatly in the periodic table if you learn to read it correctly. The first two columns of the table consist of s-orbitals. The last six are p-orbitals, the middle 10 are d-orbitals, and the bottom two rows are f-orbitals. The diagram below summarizes this information.



The electron *structure* surrounding the nucleus is of prime importance in understanding the chemistry of the elements. This structure can be read directly off the periodic table and expressed in abbreviated form. Some examples follow:

H $1s^1$
He $1s^2$
Li $1s^2 2s^1$
Be $1s^2 2s^2$
B $1s^2 2s^2 2p^1$
C $1s^2 2s^2 2p^2$
N $1s^2 2s^2 2p^3$
O $1s^2 2s^2 2p^4$
F $1s^2 2s^2 2p^5$
Ne $1s^2 2s^2 2p^6$
Na $1s^2 2s^2 2p^6 3s^1$ OR $[Ne]3s^1$

Note: although the first d-orbitals appear on the periodic table in row 4, they are called 3d orbitals. Thus the entire d-section of the table is numbered one less than the row in which it appears. A similar offset occurs for the f-orbital block, but it is two numbers less.