

Chapter 06

Structure of atom

Electronic Configuration:

The distribution of electrons in shells, subshells and orbital in an atom is known as electronic configuration.

The shorthand notation consists of principal energy level 'n', the letter representing the subshell 'l', and the number of electrons in the subshell, which is written as a superscript.

Electronic configuration is written as 'nl' superscript x (nl^x).

Ex:

The hydrogen atom, which has atomic number one, there is only one electron, so the electronic configuration is $1s^1$. The first one denotes the principal quantum number, 's' denotes the angular quantum number and the superscript one denotes the number of electrons in orbital.

The electronic configuration can be represented by showing the spin of the electron.

Ex:

In a hydrogen atom which has only one electron, we already knew that the principal quantum number 'n' is equals to angular quantum number.

$$l = 0, m_l = 0 \text{ and } m_s = +\frac{1}{2} \text{ or } -\frac{1}{2}.$$

The distribution of electrons in various atomic orbitals provides us an understanding of the electronic behavior of the atom. It shows us many other properties of that particular atom.

Let us now consider Helium atom with atomic number two, which has two electrons.

To properly write the electronic configuration of these many electron atoms like Magnesium, Sodium or Calcium, we need to know three principles that are Pauli's exclusion principle, Aufbau principle, and Hund's rule.

Pauli's Exclusion Principle:

Consider Helium, which has two electrons.

First electron occupies $1s$ orbital, second electron joins the first electron in the $1s$ orbital so that the electronic configuration of the ground state of helium is $1s^2$.

No two electrons of the same atom have all '4' quantum numbers same. Two electrons that are present in helium have same principle quantum number n , same l and m_l value for these two electrons. But comes to ' m_s ' spin quantum number it cannot be same.

One electron is parallel the other one should be antiparallel. So one is in up direction, one is in down direction.

Major consequences of this Pauli's exclusion principle involves in orbital occupancy. Since two ' m_s ' values are allowed an orbital can hold only two electrons. First electron comes if it's arranged parallel or clockwise. The next one should be anticlockwise.

Hence, the electronic configuration of helium is $1s^2$.

Aufbau Principle:

We increase the atomic number, the number of electrons are also increased when you go from hydrogen to helium one electron is increased.

The maximum number of electrons in any shells is $2n^2$ where n is the principle quantum number.

The maximum number of electrons in a subshell like s, p, d, f is equals to $2(2l + 1)$, where $l = 0, 1, 2, \dots$

Ex:

Consider 'p' orbital or p subshell has a l value 1. How many electrons can it accommodate $(2l + 1)2$ which is equals to 6.

'p' subshell accommodate 6 electrons.

'd' subshell can accommodate 10 electrons.

'f' subshell can accommodate 14 electrons with it.

Configuration can be buildup by placing electrons in the lowest available orbitals until the total number of electrons added is equals to atomic number.

To general rules that help to predict electronic configurations are electrons are assigned to orbitals in increasing the order of their values $n + l$. For the subshells, same energy value of $n + l$.

The increasing order of energy of these orbitals are $1s < 2s < 2p < 3s < 3p < 4s < 3d < 4p < 5s < 4d < 5p < 6s < 4f < 5d < 6p < 7s < 5f < 6d < 7p < 8s$.

Hund's rule:

According to this rule, electrons pairing in orbitals start only when all the available empty orbitals of same energy are singly occupied.

Consider carbon atom, which has atomic number 6 it should be $1s^2 2s^2 2p^2$. There are 2 electrons in 'p' orbital and '3' subshells.

Consider Chlorine, which has which has 17 electrons and the electronic configuration $1s^2 2s^2 2p^6 3s^2 3p^5$. There are five electrons in the valence shell.

