كلية مدينة العلم الجامعة

قسم هندسة الحاسوب

محاضرات المرحلة الاولى لمادة الهندسة الالكترونية

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المحاضرة الاولى

التركيب الذري Atomic Theory

Electronic Devices and Circuit Theory

Eleventh Edition

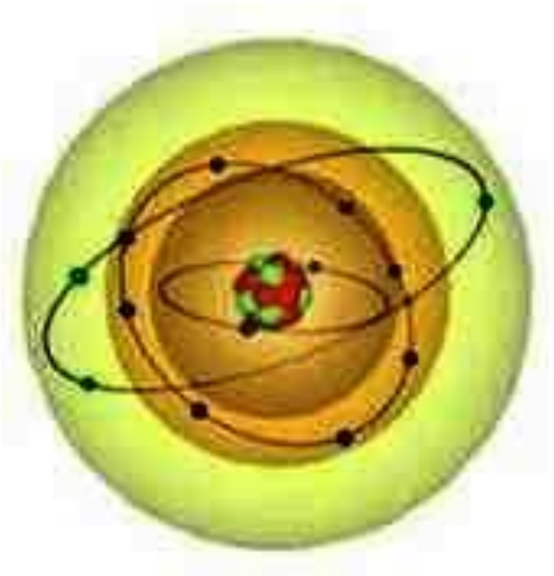
Robert L. Boylestad and Louis Nashelsky

Atomic Theory

Atom is smallest piece of an element that keeps its chemical properties

Atom contains 3 basic particles

- ***Protons***
- ***Neutrons***
- ***Electrons – orbit around nucleus***



Electron Configuration of Atoms

By electron configuration of an atom is meant the distribution of its electrons in its various subshells around the nucleus.

Following three rules govern the electron distribution :

The Electron Configuration of Atoms

1- Maximum number of electrons in a shell can have is = $2n^2$.

2. In the nth shell, there are n sub-shells having different values of l such as 0, 1, 2..... (n - 1).

3. Each sub-shell can accommodate a maximum of 2(2l + 1) electrons. Consider the following atoms

The Electron Configuration of Atoms

(*i*) Sodium atom, Z = 11. It has 11 electrons. Hence, its electronic configuration is $1s^2, 2s^2, 2p^6, 3s^1$. Obviously, *Na* has a single electron in its outermost sub-shell and hence is said to be mono-covalent. Same property is possessed by other alkali metals like Li, K, Rb and Cs. They have similar chemical properties and are, therefore, included in the same group in the periodic table.

The electrons in the inner sub-shells are very tightly bound to the nucleus and cannot be easily removed. In other words, they have high *binding energy*.

ℓ : determines the orbital angular momentum

Orbital Magnetic Quantum Number (m_ℓ)

m_ℓ :represents the magnitude of the component of angular momentum along the direction of the magnetic field. Looked from a different angle .

m_l : determines the number of sub-shells in a given shell. This quantum number can have any one of the (2l + 1) values ranging from + l to - l including zero i.e.

$m_l = \ell, (\ell - 1), (\ell - 2) \ldots\ldots\ldots 2, 1, 0, -1, -2, \ldots\ldots\ldots\ldots -(\ell - 2), -(\ell - 1), -\ell.$

Each sub-shell can accommodate a maximum of 2 electrons, so that maximum number of electrons in a shell becomes $2(2\ell + 1)$

Pauli's Exclusion Principle

This principle which was enunciated by Pauli in 1925 states that :

" in an atom, no two electrons can have the same set of values for its four quantum number n, l, ml and ms".

In other words, no two electrons can be described by an identical set of four quantum numbers. They may have at the most three numbers alike but at least one must be different. Consequently, it restricts the number of electrons an atom can have. Consider the case of He atom which has two electrons. These electrons occupy *K*-shell (n = 1) and are designated as 1*s*2 electrons. Their four quantum numbers are as follows

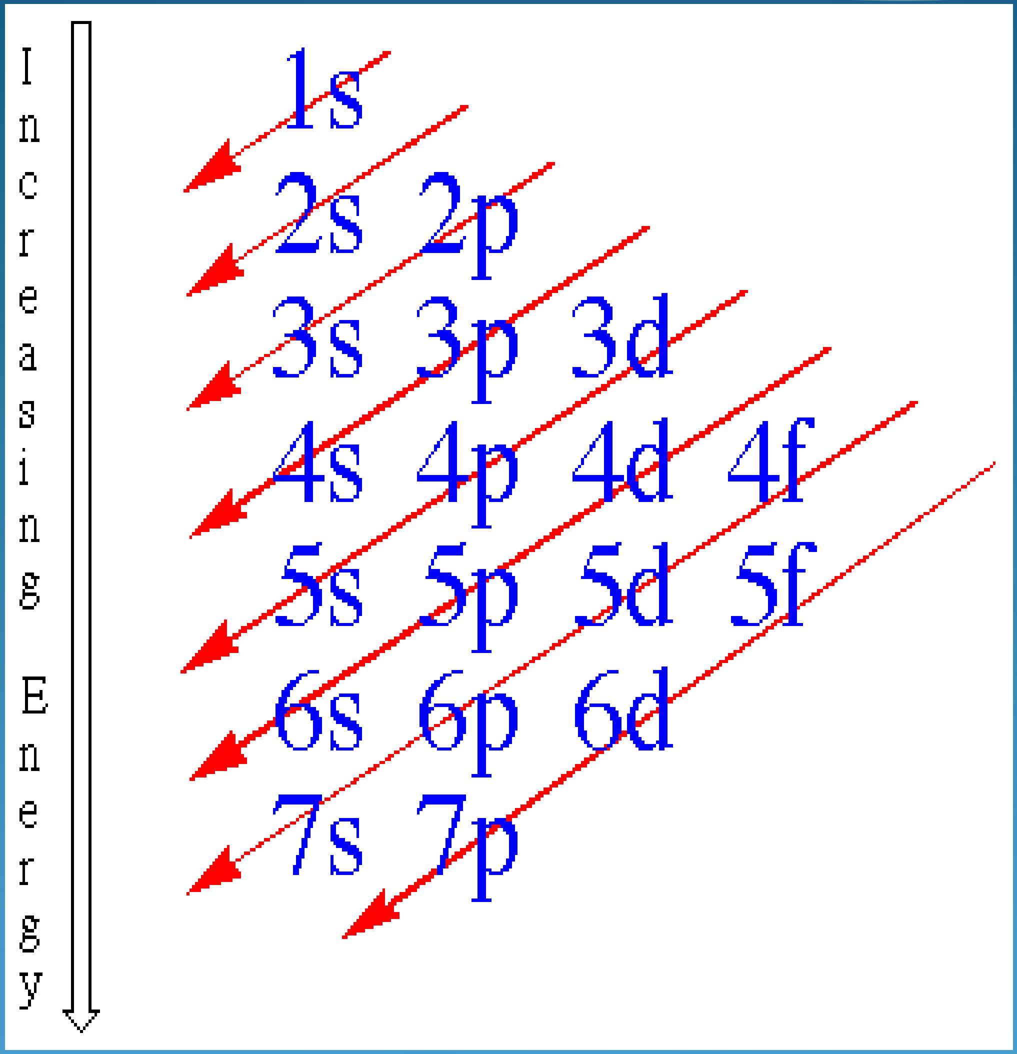
Pauli's Exclusion Principle

Electron number	Principle quantum number	orbital quantum number	Magnetic quantum number	Spin quantum number
	n	l	ml	ms
1st electron :	1	0	0	1/2
2nd electron :	1	0	0	-1/2

Symbol of Q-number	Principle Q-number n	No. of Electrons $2n^2$ in principle level	No. of sublevels (2l+1)	No. of Electrons in sublevels 2(2l+1)
K	1	2	l =0 (s) 1	2
L	2	8	l =0 (s) 1 l =1 (p) 3	2 6
M	3	18	l =0 (s) 1 l =1 (p) 3 l =2 (d) 5	2 6 10

Symbol of Q-number	Principle Q-number n	No. of Electrons $2n^2$ in principle level	No. of sublevels (2l+1)	No. of Electrons in sublevels 2(2l+1)
N	4	32	l =0 (s) 1 l =1 (p) 3 l =2 (d) 5 l =3 (F) 7	2 6 10 14
O	5	50	l =0 (s) 1 l =1 (p) 3 l =2 (d) 5 l =3 (F) 7 l =4 (G) 9	2 6 10 14 18

Electron Configuration of Atoms



$1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $4s^2$ $3d^{10}$ $4p^6$ $5s^2$ $4d^{10}$ $5p^6$ $5s^2$

Fig :1

HOW TO FIND THE ELECTRON CONFIGURATION OF AN ATOM

1. Use fig 1 to get the energy level configuration

   As follows :

1s 2s 2p 3s 3p 4s 3d 4p 5s 4d 5p 6s 4f 5d 6p 7s

2- fill each shell with the appropriate number of electrons

Example : find the electron configuration of

the following atoms

The Electron Configuration Of An Atom

Si (14) : $1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^2$

The outer most shell is : **$3s^2$ $3p^2$** which means that the element has 4-valenc in the outer-most shell

Cu (29) : $1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $4s^2$ $3d^9$

This is not true because we know that copper has one-valence in the outer-most shell

The Electron Configuration Of An Atom

so the electron configuration of copper according to principle should be

$1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $3d^{10}$ $4s^1$

Valence And Conduction Bands

The outermost electrons of an atom *i.e.* those in the shell farthermost from the nucleus are called *valence* electrons and have the *highest* energy* or least binding energy.

The band of energy occupied by the valence electrons is called the *valence band* and is, obviously, the *highest occupied band*. It may be completely filled or partially filled with electrons but never empty.

The Conduction Band

The next higher permitted energy band is called the *conduction* band and may either be *empty or partially filled* with electrons. In fact, it may be defined as the lowest unfilled energy band.

In conduction band, electrons can move freely and hence are known as *conduction* electrons.

Forbidden Energy Gap

The gap between these two bands is known as the *forbidden energy gap*.

It may be noted that the covalent force of the crystal lattice have their source in the valence band.

If a valence electron happens to absorb enough energy, it jumps across the forbidden energy gap and enters the conduction band

Insulators

- **Electrons tightly bound to host ion**
  - **need large amounts of energy to break free**
  - **very low numbers of free electrons low conductivity**
  - **electric currents do not pass easily**

  e.g. paper, rubber, PVC

Conductors

Electrons very loosely bound to host ions

- **- very easy to break free from ions**

- **- free to "wander" around crystal large numbers of free electrons**

- **- about one per atom high conductivity**

- **- movement of electrons produces current in opposite direction**

e.g. metals - Cu, Ag, Al etc

Semiconductors

- **Electrons have moderate binding energies**

  - at absolute zero, all electrons are tightly bound (insulator)

  - at very high temps, material can conduct (conductor)

  - usually moderate numbers of free electrons about one per million atoms

e.g. Si, Ge, GaAs