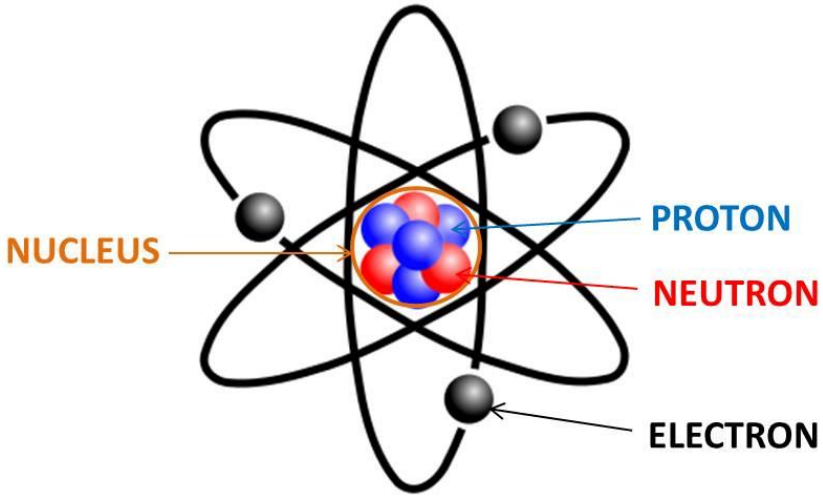
Electronic Devices And Circuits

Introduction

An electronic device controls the movement of electrons. The study of electronic devices requires a basic understanding of the relationship between electrons and the other components of an atom.

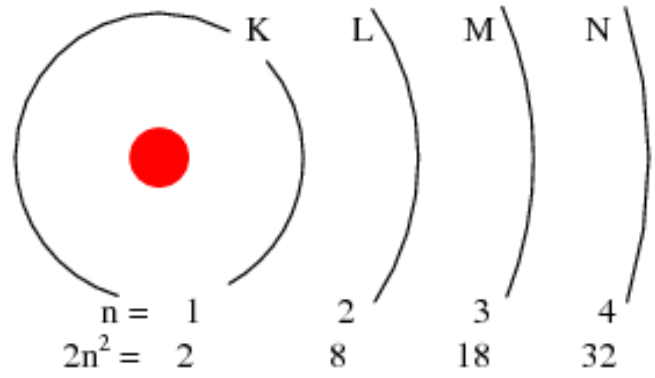
Atomic theory

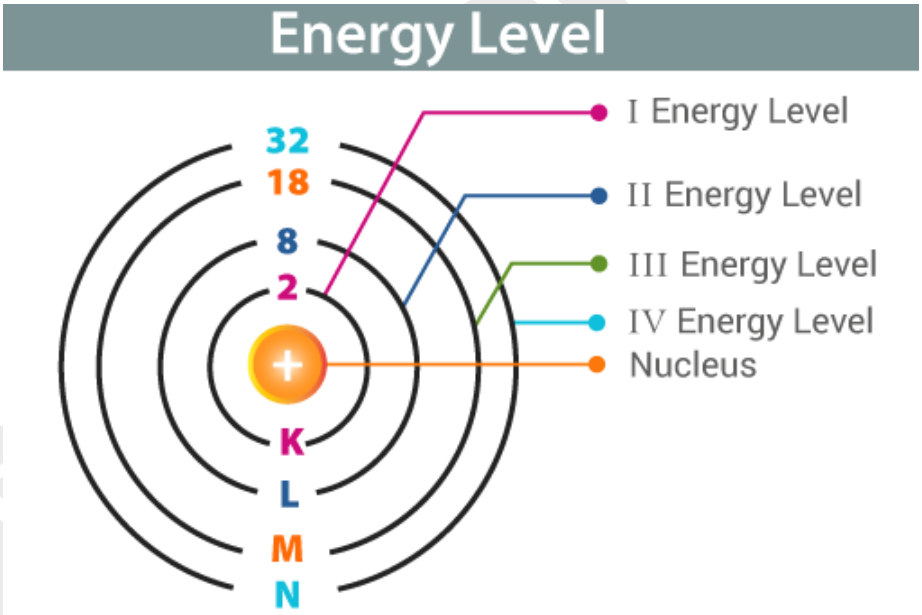
Atom:



- It is the smallest particle of an element. [For example chair, water, air, plants and humans etc.]
- It consists of positively charged protons, negatively charged electrons and neutral neutrons.
- The central part which consists of protons and neutrons is called as nucleus. These protons and neutrons are stick together because of the strong nuclear force present between them.

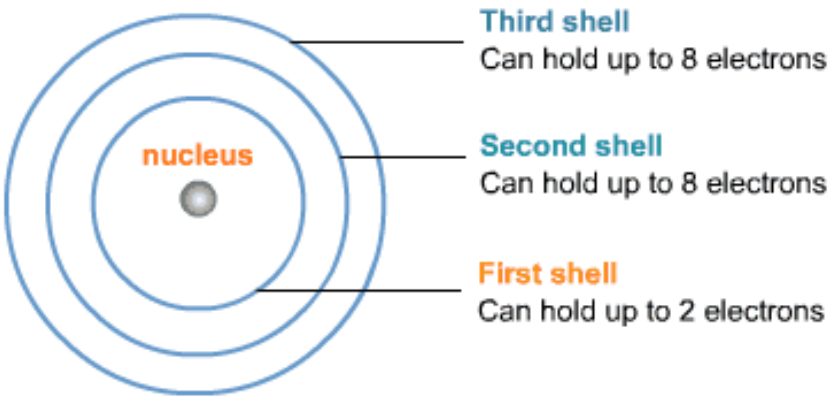
- Electrons revolve around nucleus in various orbits. [Electrons are negatively charged particles which are moving with high velocity around the nucleus of atom in specific paths called orbits.]
- The maximum number of electrons in each orbit is limited by the formula $2n^2$. See the below Image.





K, L, M, N – Energy Levels Or Shells

Electron is denoted by a symbol e- . It has a charge of 1.602×10^{-19} Coulombs (C).



Atomic Number:

The number of protons in the nucleus of a atom is called as **atomic number** "Z" or Proton number.

In a neutral atom number of protons is equal to number of electrons. Therefore in neutral atom, atomic number is equal to number of electrons. Atomic number is also known as proton number.

Neutron Number:

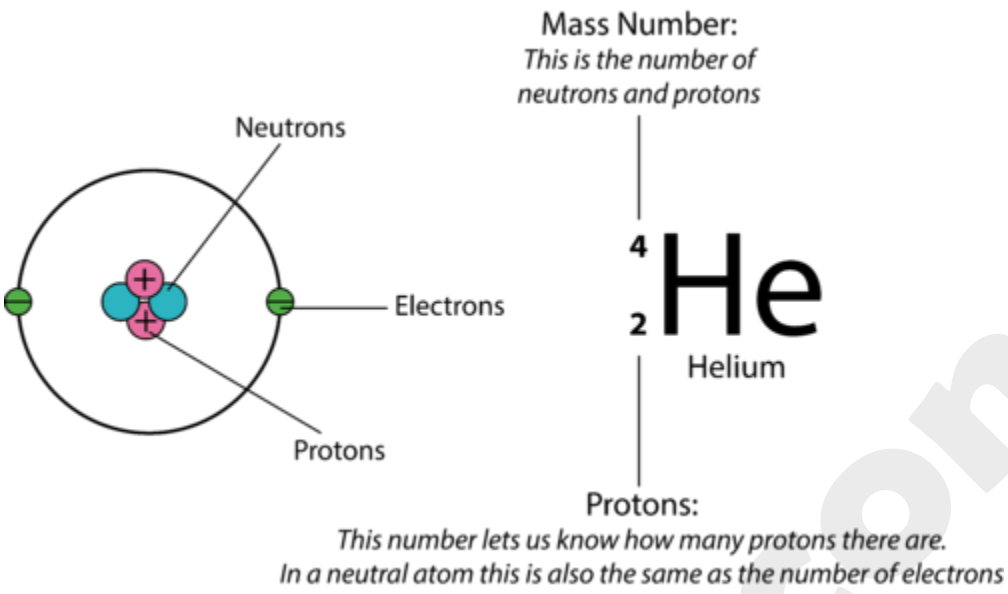
The number of neutrons in the nucleus of a atom is called as neutron number “N”.

Mass Number:

The total number of protons and neutrons in the nucleus of a atom is called as mass number "A"

A = Z + N

Here, N is neutron number, Z is atomic number, A is mass number



In Above Image,

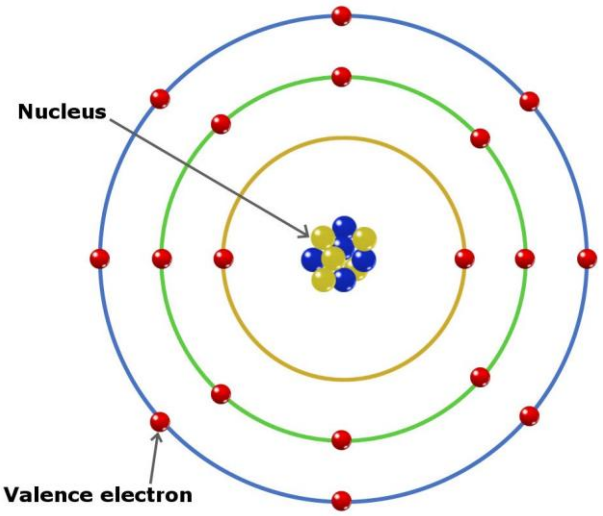
Atomic Number: No of Protons = 2 = Z = Proton Number

Neutron Number = 2 = N

Mass Number = A = Z + N => 2+2 = 4

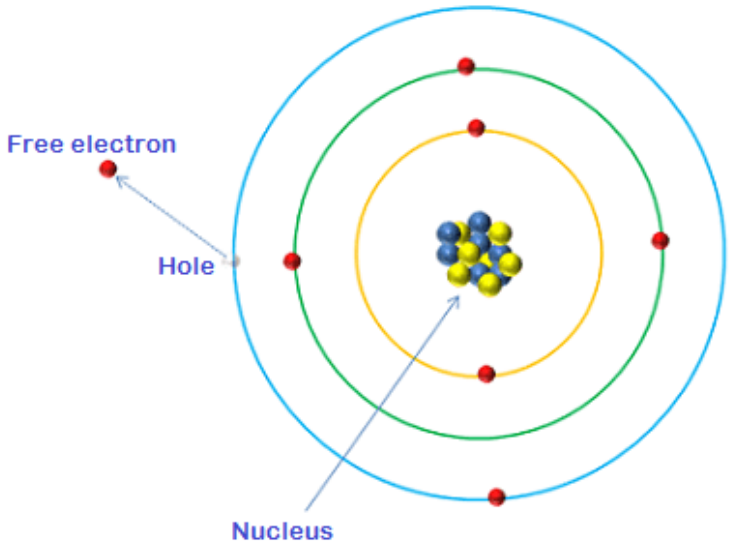
Therefore, Mass number of helium = 4

1. Valence electrons: The electrons in the last orbit are called valence electrons.

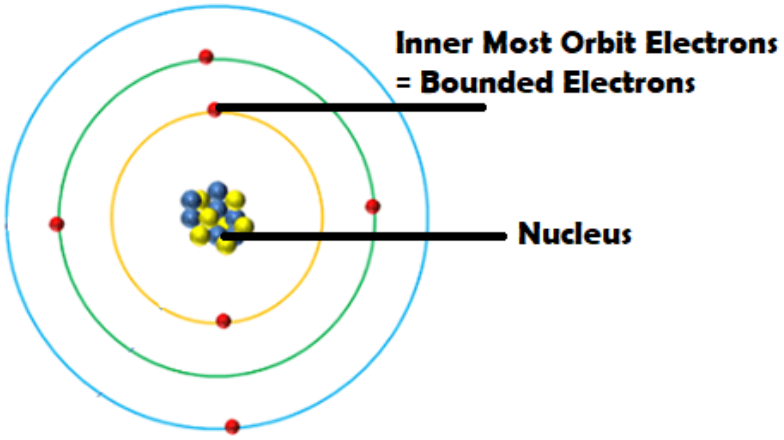


2. Free electrons: The valence electrons which are loosely connected with the nucleus are called free electrons. They can move from atom to other.

- **When small amount of external energy in form of heat or light is applied to the valence electrons then they get pulled away from the parent atom and becomes free.**
- **The force of attraction of the nucleus does not act on the free electron. The flow of free electrons in a material is called an electric current.**
- **The moving free electrons will transmit electric current from one point to other.**
- **Materials which contain free electrons will conduct electric current.**
- **Materials which does not contain free electrons does not conduct electric current.**

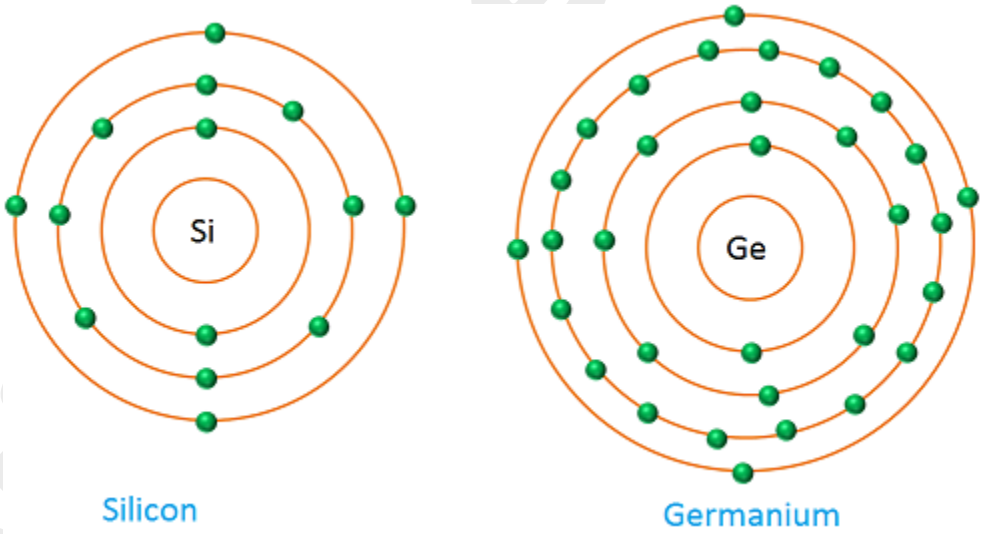


3. Bounded electrons: The electrons which are tightly attached with nucleus are called bounded electrons. They are the innermost orbit electrons.



Atomic structure of Silicon & Germanium

Silicon and germanium are the most common examples of **Pure semiconductors** [intrinsic semiconductors]. Both these semiconductors are most frequently used in the manufacturing of **transistors, diodes and other electronic components.**



Silicon:

- Its atomic number is 14.
- It consists of 14 protons & 14 electrons.
- The 1st orbit consists of 2 electrons.

- The 2nd orbit has 8 electrons. The 3rd has 8 electrons.
- The valence number is 4.

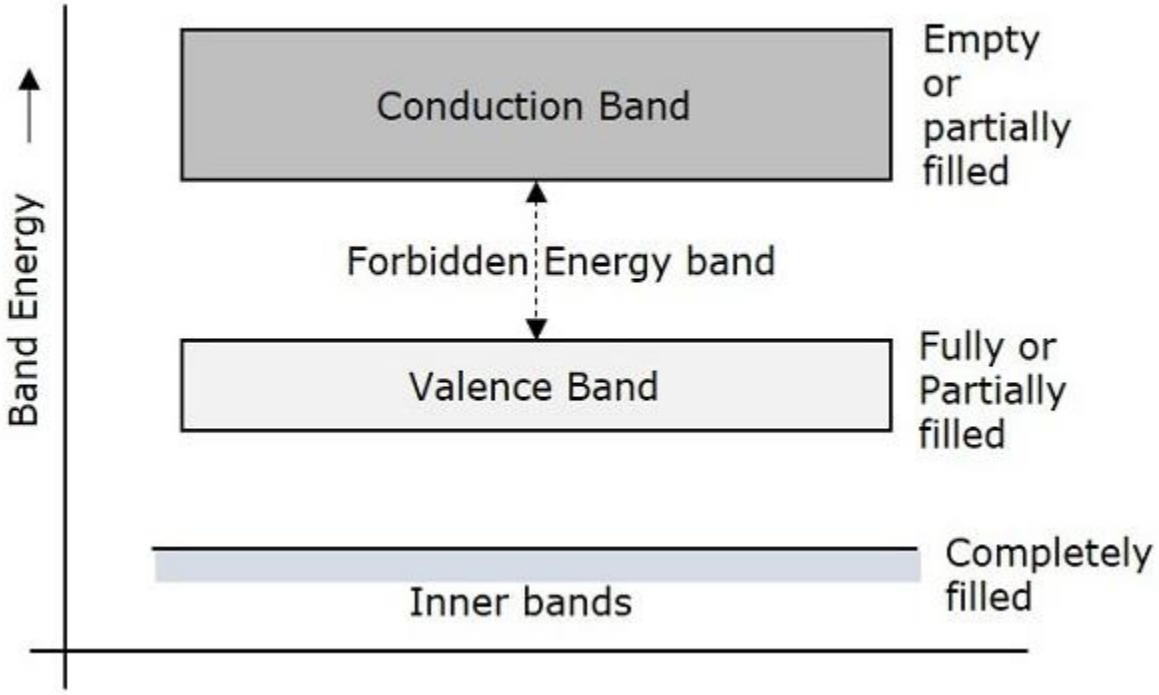
Germanium:

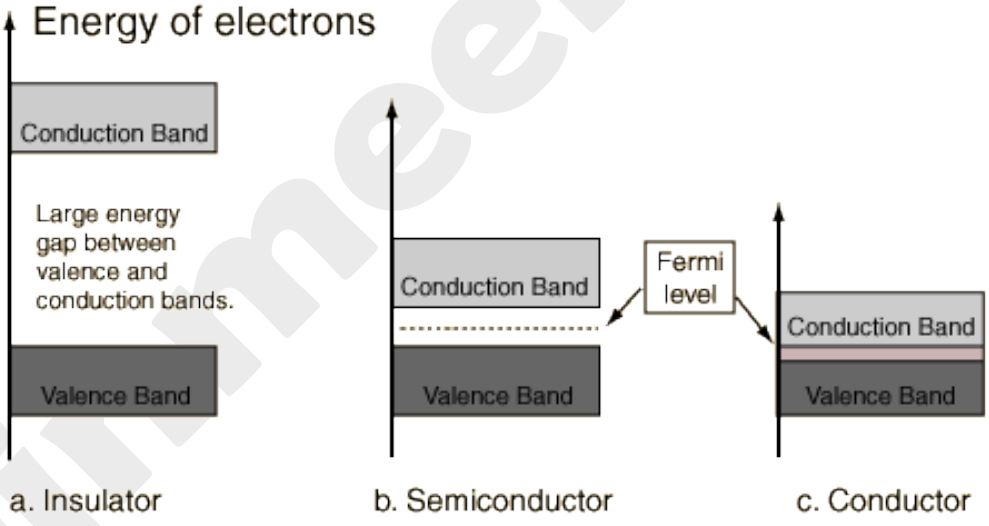
- Its atomic number is 32.
- It consists of 32 protons & 32 electrons.
- The 1st orbit consists of 2 electrons.
- The 2nd orbit has 8 electrons.
- The 3rd has 18 electrons.
- The 4th has 4 electrons.
- The valence number is 4.

Energy Band diagrams

The electrons moving in a particular orbit possess energy. The energies possessed by the electrons of the same orbit are not equal. The range of energies possessed by the electrons of the same orbit is called as energy band of that orbit.

> **Note:** Due to the intermixing of atoms in solids, instead of single energy levels, there will be bands of energy levels formed. These set of energy levels, which are closely packed are called as Energy bands.





Valance band:

It is the highest occupied energy band. It represents the range of energies possessed by valence electrons. The band may be completely or partially filled in.

Note: The electrons that are present in the outermost shell are called as Valance Electrons.

These valance electrons, containing a series of energy levels, form an energy band which is called as Valence Band. The valence band is the band having the highest occupied energy.

Conduction band:

It represents the range of energies possessed by free electrons. These electrons move freely and conduct electric current. This band may be empty or partially filled in.

Note: Free electrons are the ones which conduct the current in a conductor and hence called as Conduction Electrons. The band which contains conduction electrons is called as Conduction Band. The conduction band is the band having the lowest occupied energy.

Forbidden energy gap:

The energy gap between the valence and conduction bands is called forbidden energy gap. There is no allowed energy state in this region. This gap indicates the amount of energy needed to push an electron from valence band to conduction band. It is represented by electron-volt (e-v).

Note: As the name implies, this band is the forbidden one without energy. Hence no electron stays in this band. The valence electrons, while going to the conduction band, pass through this.

The forbidden energy gap if greater, means that the valence band electrons are tightly bound to the nucleus. Now, in order to push the electrons out of the valence band, some external energy is required, which would be equal to the forbidden energy gap.