Module 1

DIODE

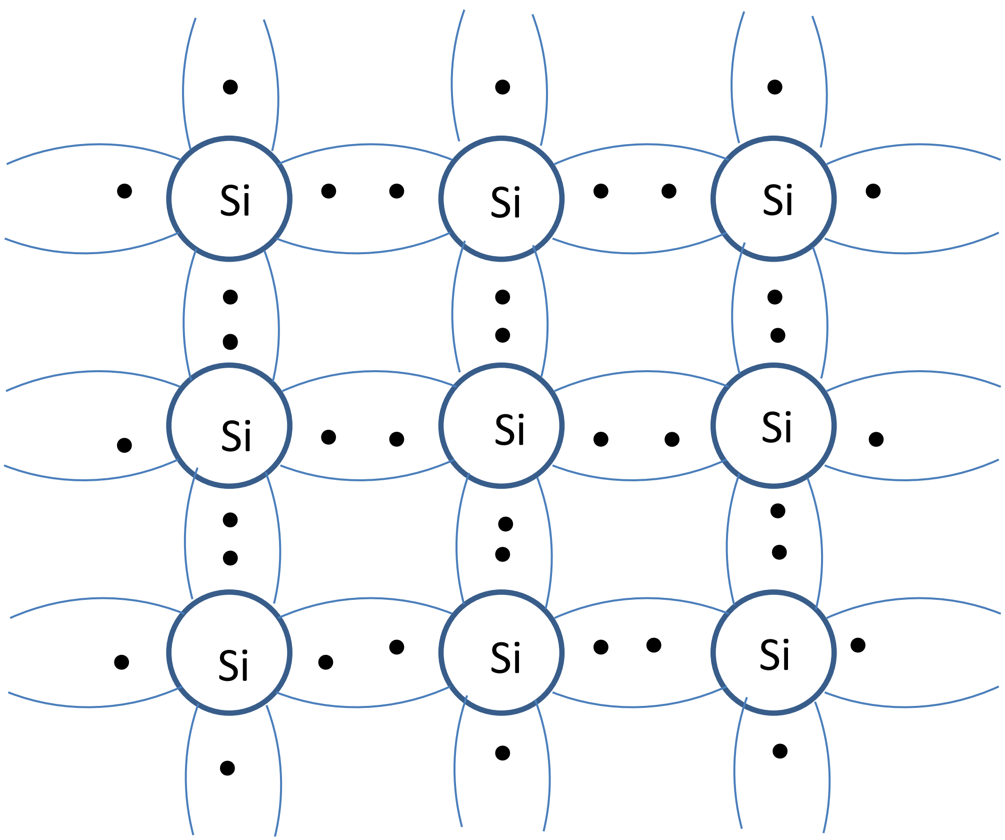
Semi conductors

Semiconductors are of two types

- Intrinsic semiconductors
- Extrinsic semiconductors

Intrinsic Semi conductors

Semiconductors such as Si or Ge in its extremely purest form is known as intrinsic semiconductors.



Below figure shows the solid structure of Silicon.

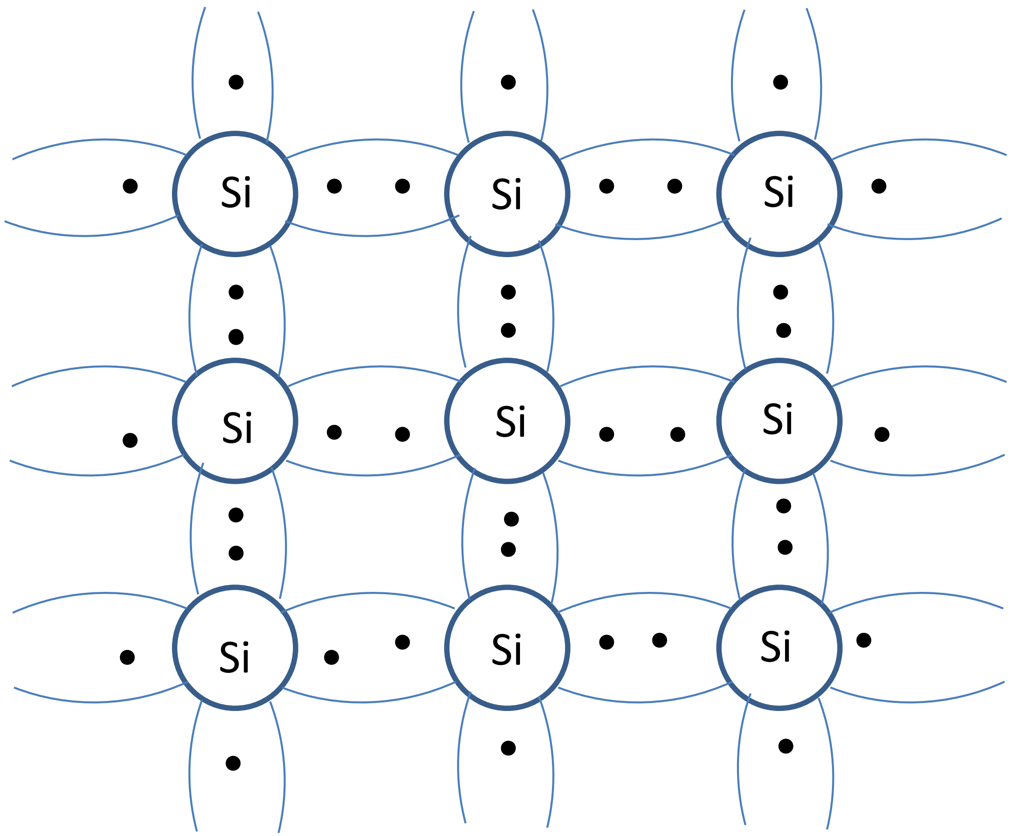
Here we see that each of the 4 valence electrons form covalent bond with the 4 adjacent atoms.

At absolute zero all the valence electrons are tightly bound to their parent atoms.

Therefore we see that no free electrons are available for conduction.

Therefore it is concluded that semiconductor behaves as a perfect insulator at absolute zero.

Concept of hole

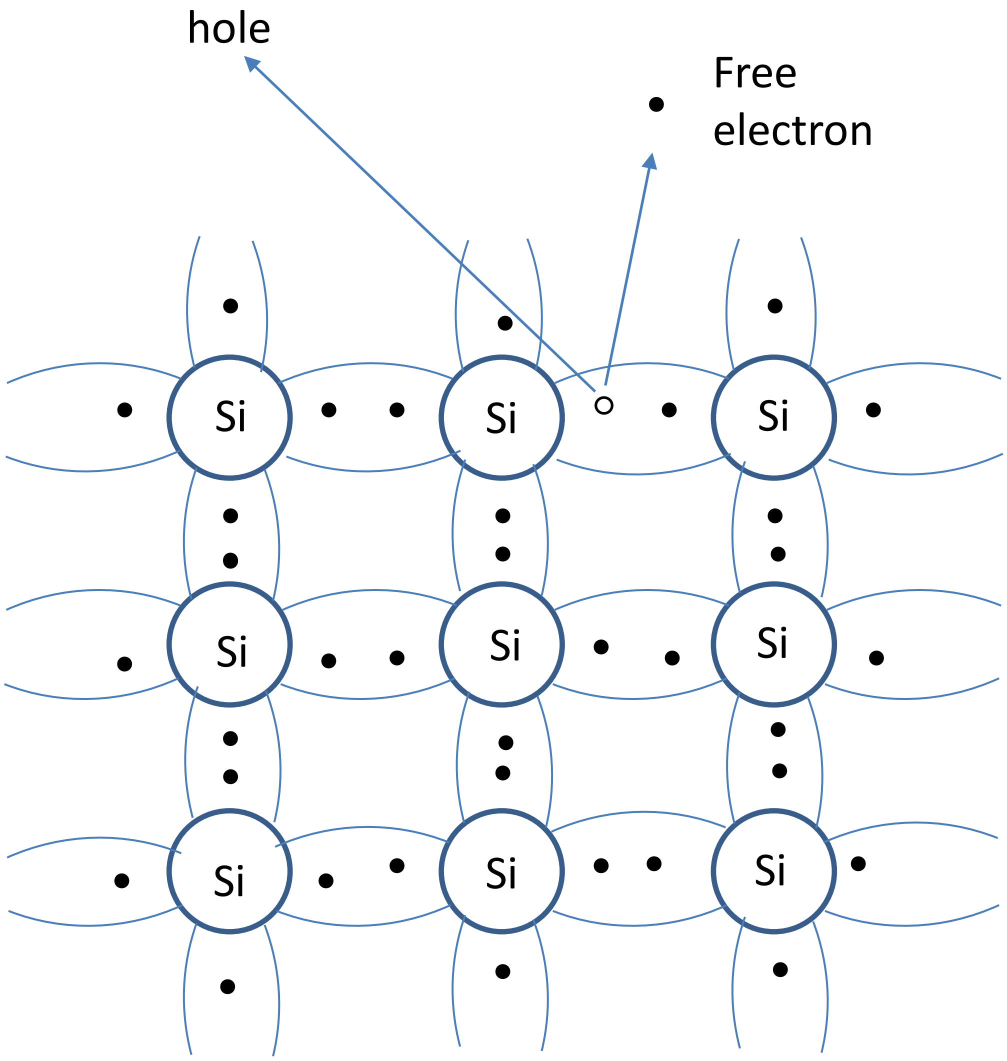


We have seen that semiconductor behaves as a perfect insulator at absolute zero because all the valence electrons are bounded to their parent atom.

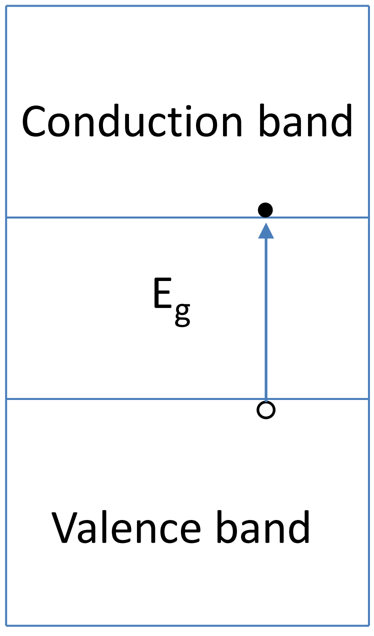
But what will happen it temperature is increased? Let us investigate this condition at room temperature.

Will there be any electrical current in the intrinsic semiconductor at room temperature?

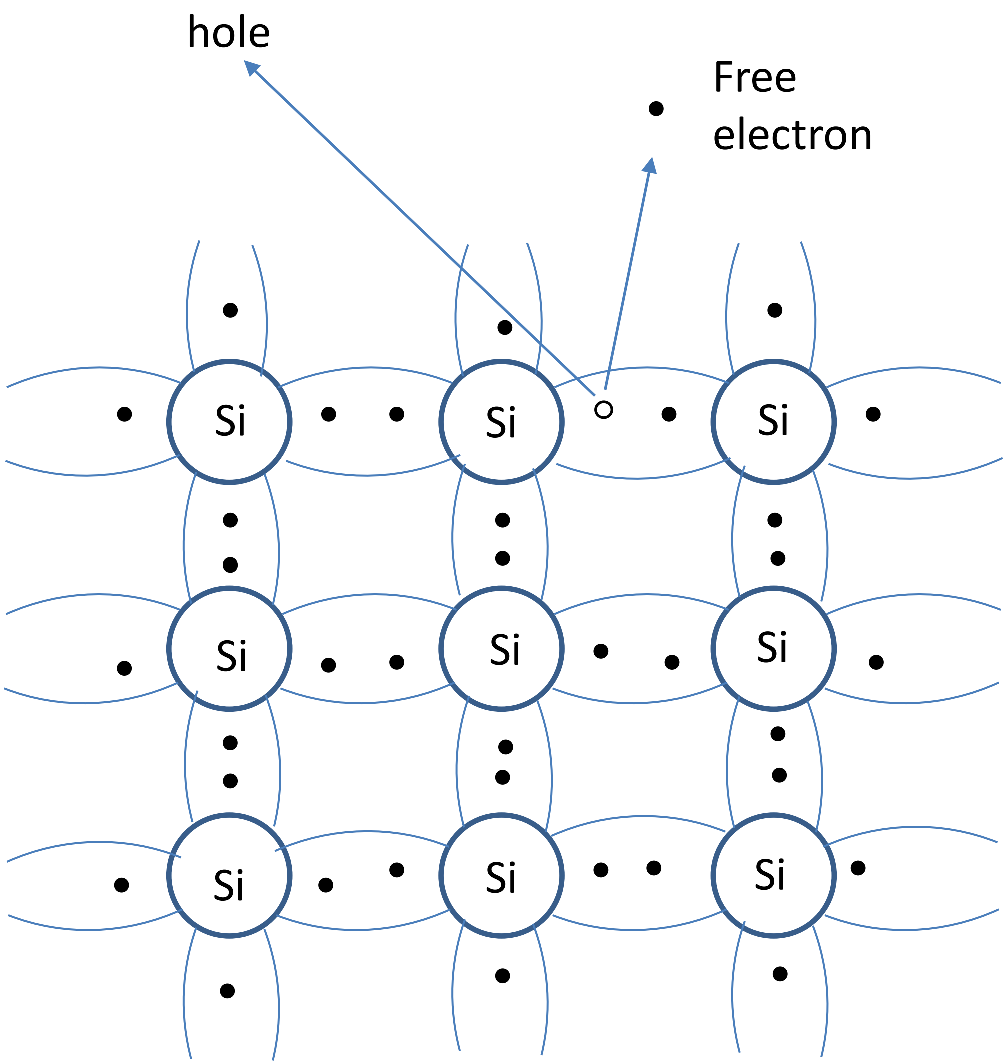
Concept of hole



At room temperature such as 300 K heat is sufficient to make a valence electron to move away from the influence of its nucleus.
We this phenomenon occurs we say that a covalent bond is broken.
When this happens the electron becomes free to move in the crystal.



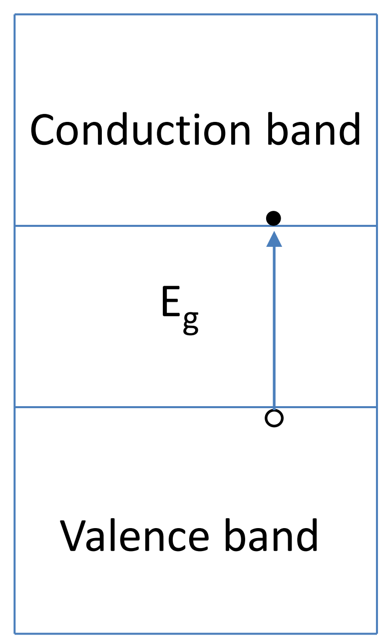
Concept of hole



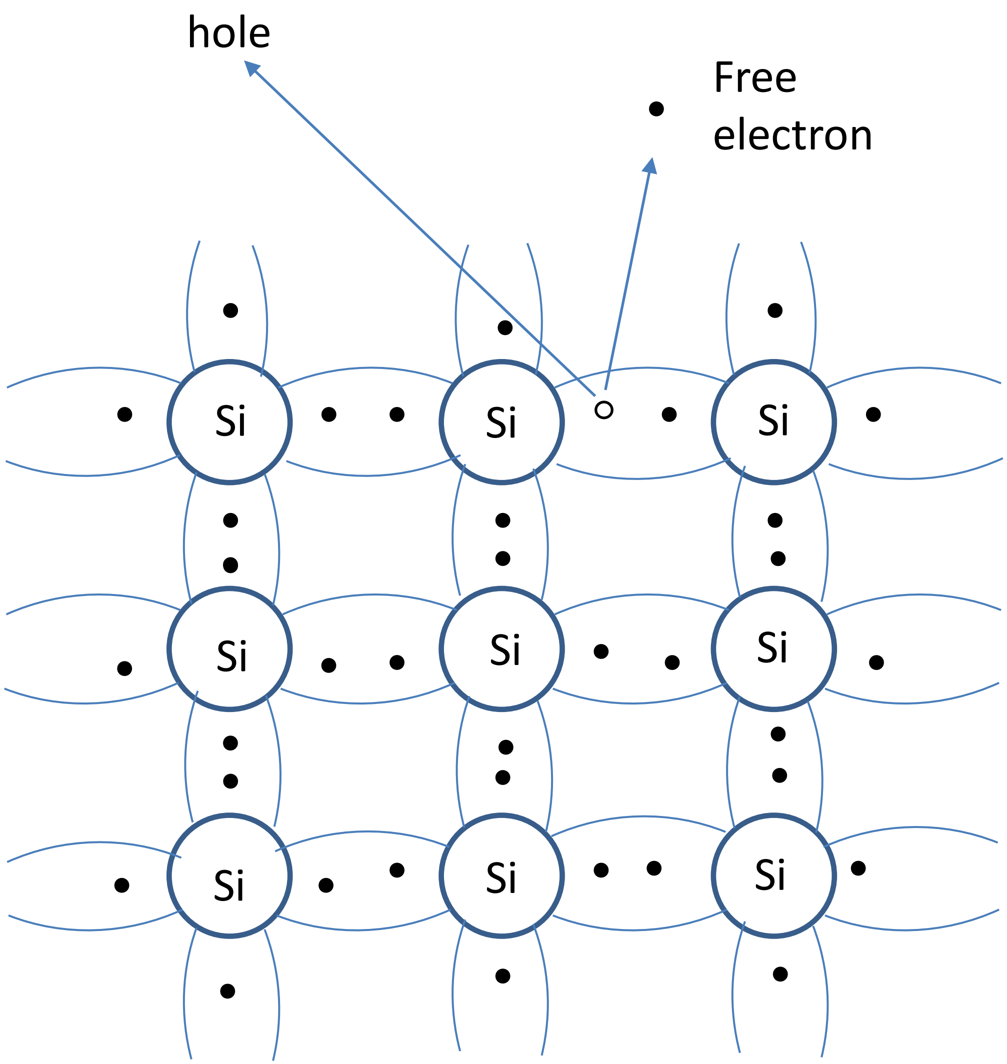
When a co-valent bond is broken a vacancy is created in the broken co valent bond. This vacancy is called as hole.

Because hole is generated by the moving away of an electron .

So hole is left with positive charge.



Thermal generation



Whenever a covalent bond is broken a free electron and a hole is generated simultaneously.

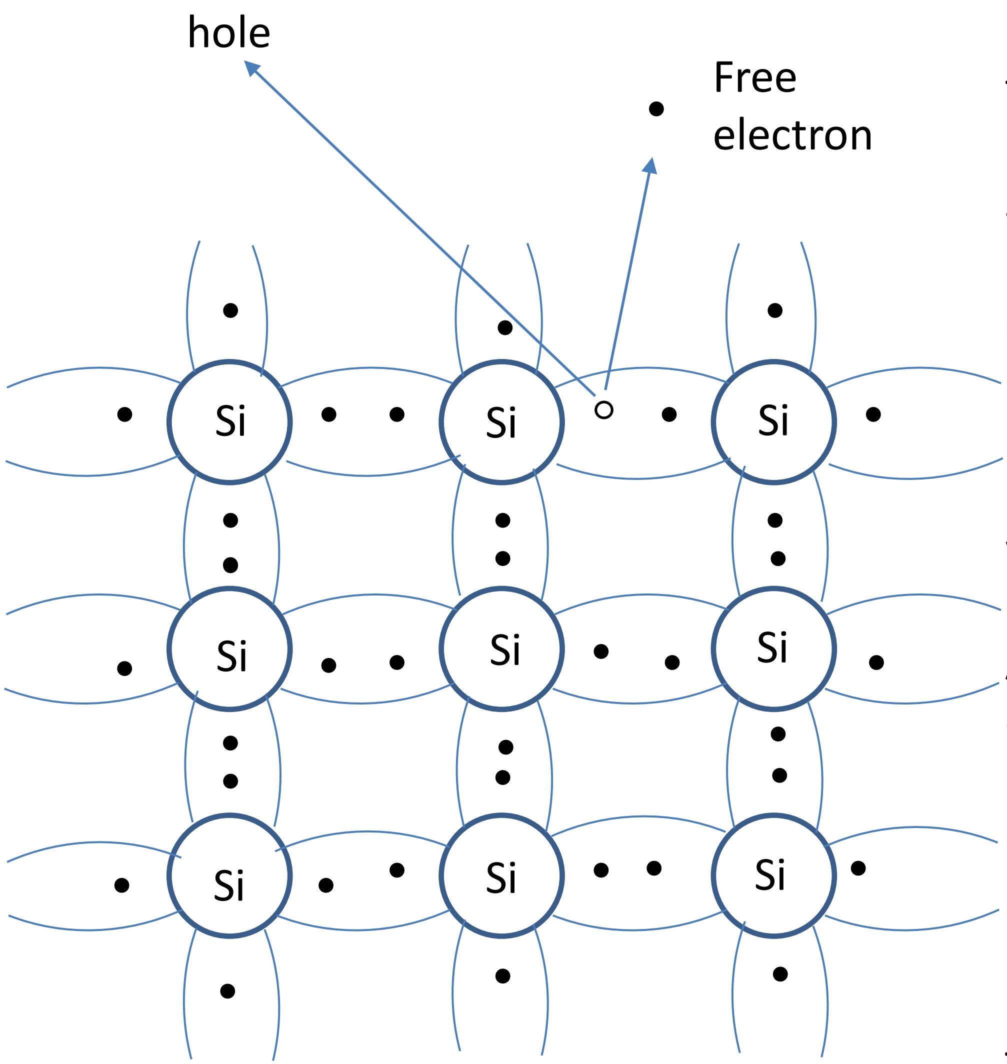
It means free electrons and holes are generated in pairs.

This type of generation of free electrons and holes is known as thermal generation.

Note: Because equal amount of free electrons and holes are produced so a very important result is concluded which is

Concentration of free electrons and holes will always be equal in an intrinsic semiconductor.

Effect of temperature



We know that covalent bond is broken because of heat. Heat is provided by temperature.

So if temperature is increased more number of covalent bonds will be broken and more number of free electrons and holes are produced.

It means higher the temperature higher will be the concentration of charge carrier.

As more charge careers are available the conductivity of intrinsic semiconductor increases with temperature .

In other words we can say resistivity decreases as temperature increases.

That is the semiconductors have **negative temperature coefficient of resistance**.

Extrinsic semiconductors

When small amount of impurity is added to the intrinsic semiconductor (pure semiconductor) then intrinsic semiconductor is converted into Extrinsic semiconductor .

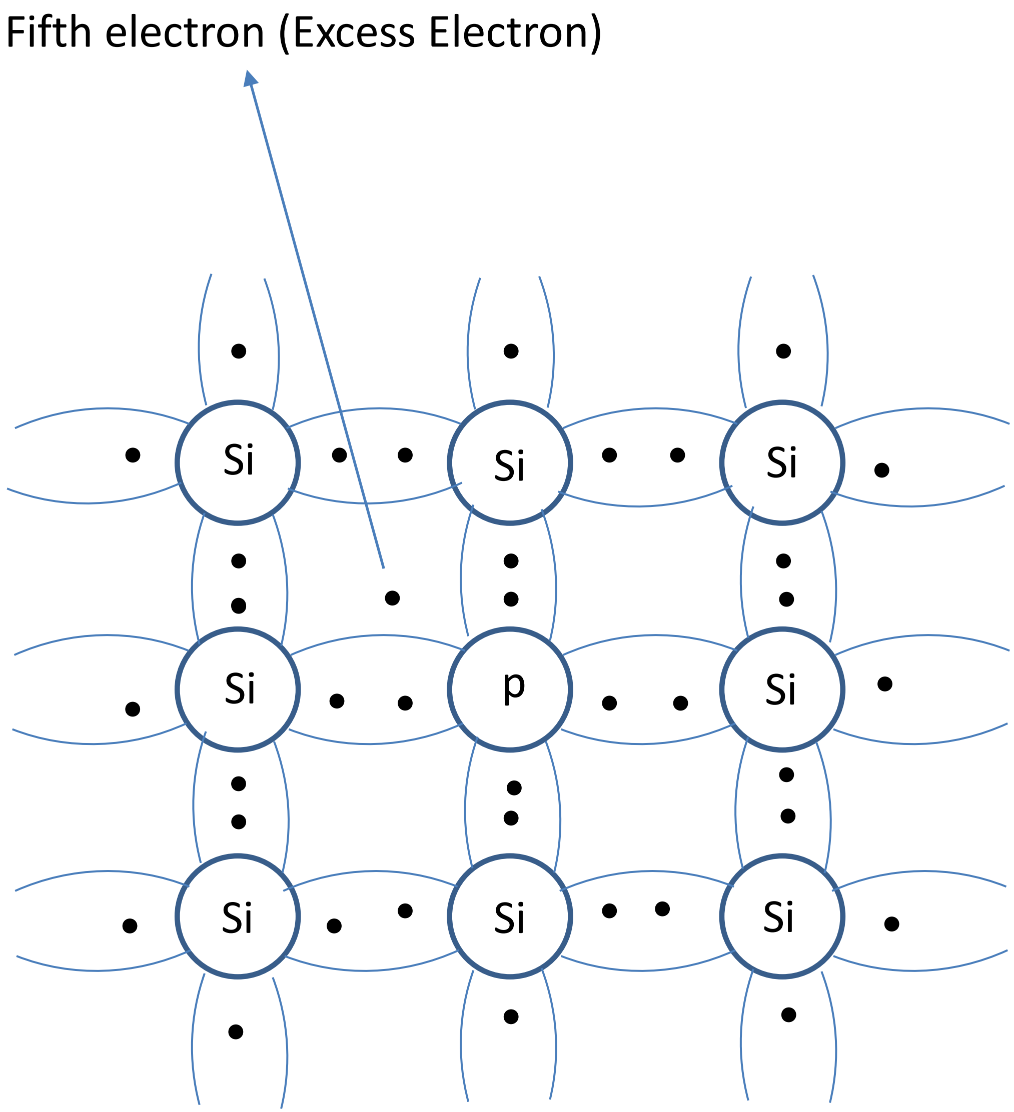
The process of adding impurities to an intrinsic semiconductor is called as **Doping**.

Extrinsic semiconductor are of two types

1. N type semiconductor

1. P Type semiconductor

N Type semiconductors



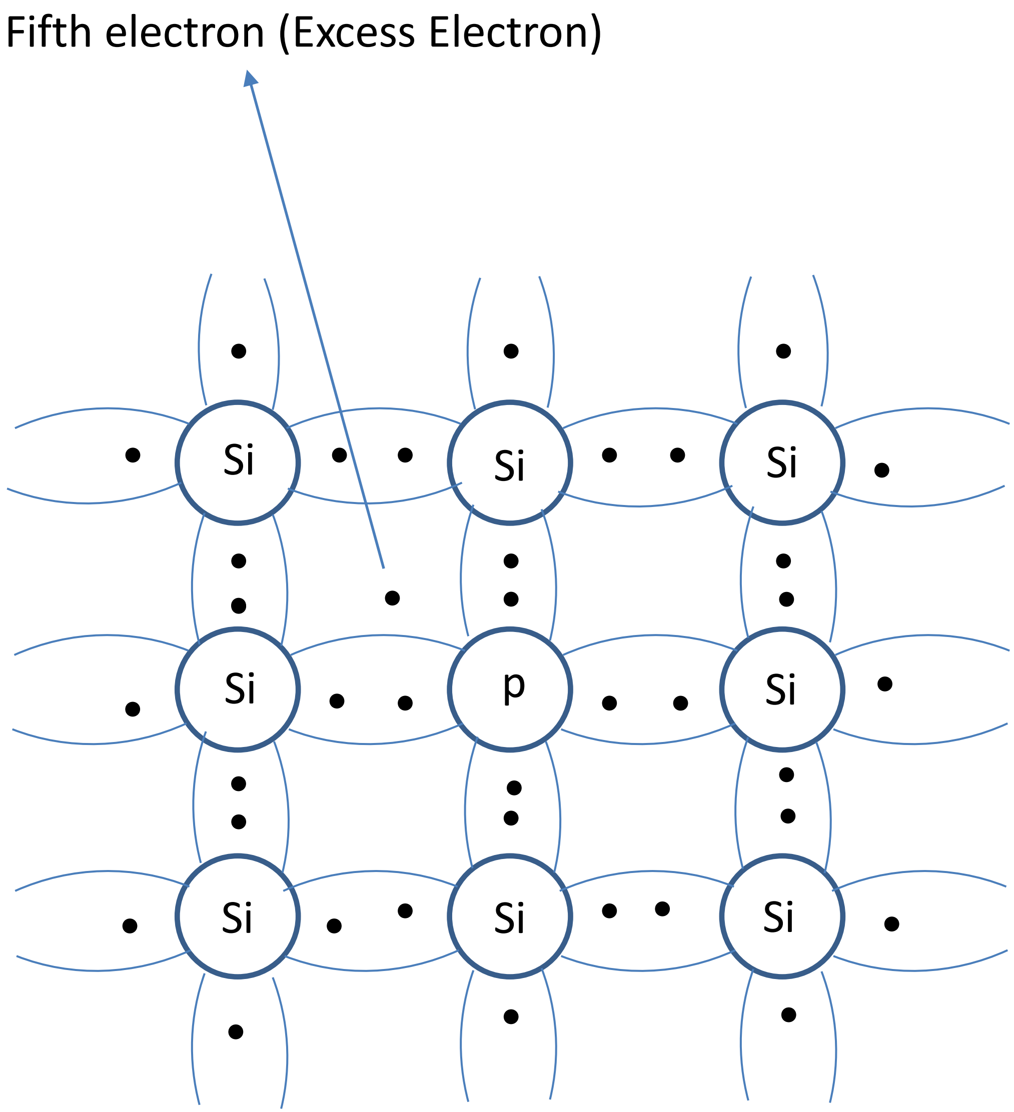
If we add small amount of pentavalent impurity such as phosphorus (P) to a sample of intrinsic Silicon structure.
Then it replaces one of the Si atom as shown in the figure.

Four of five valence electrons form covalent bonds with four neighbouring silicon atoms.
The fifth electron is in excess and is loosely bound to phosphorus atom.

This fifth electron requires very little energy to free itself from the phosphorus atom.

And this energy is so small that at room temperature **almost all such electrons become free.**

N Type semiconductors



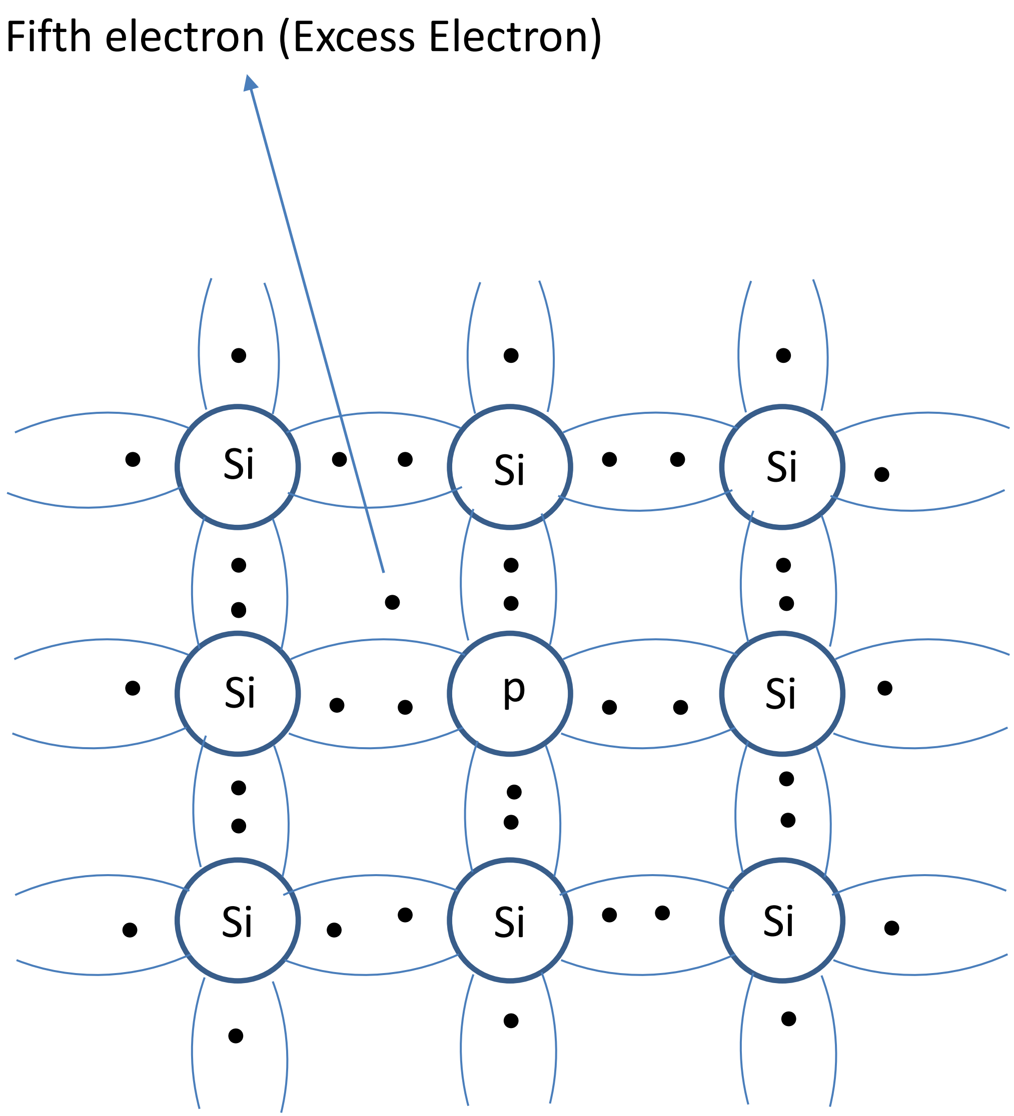
In other words we can say that at room temperature each impurity atom donates one electron to the conduction band.

This is the reason that pentavalent impurity is also called as **donor**.

The number of free electrons are far greater than the number of holes (which are generated by the breaking of covalent bonds at given temperature) and we say that semiconductor has become N type(negatively type).

It is clear that in N type semiconductor free electrons are **majority career** and holes are **minority career**.

N Type semiconductors



Now what will happen to impurity atom (P) when fifth electron leaves it.

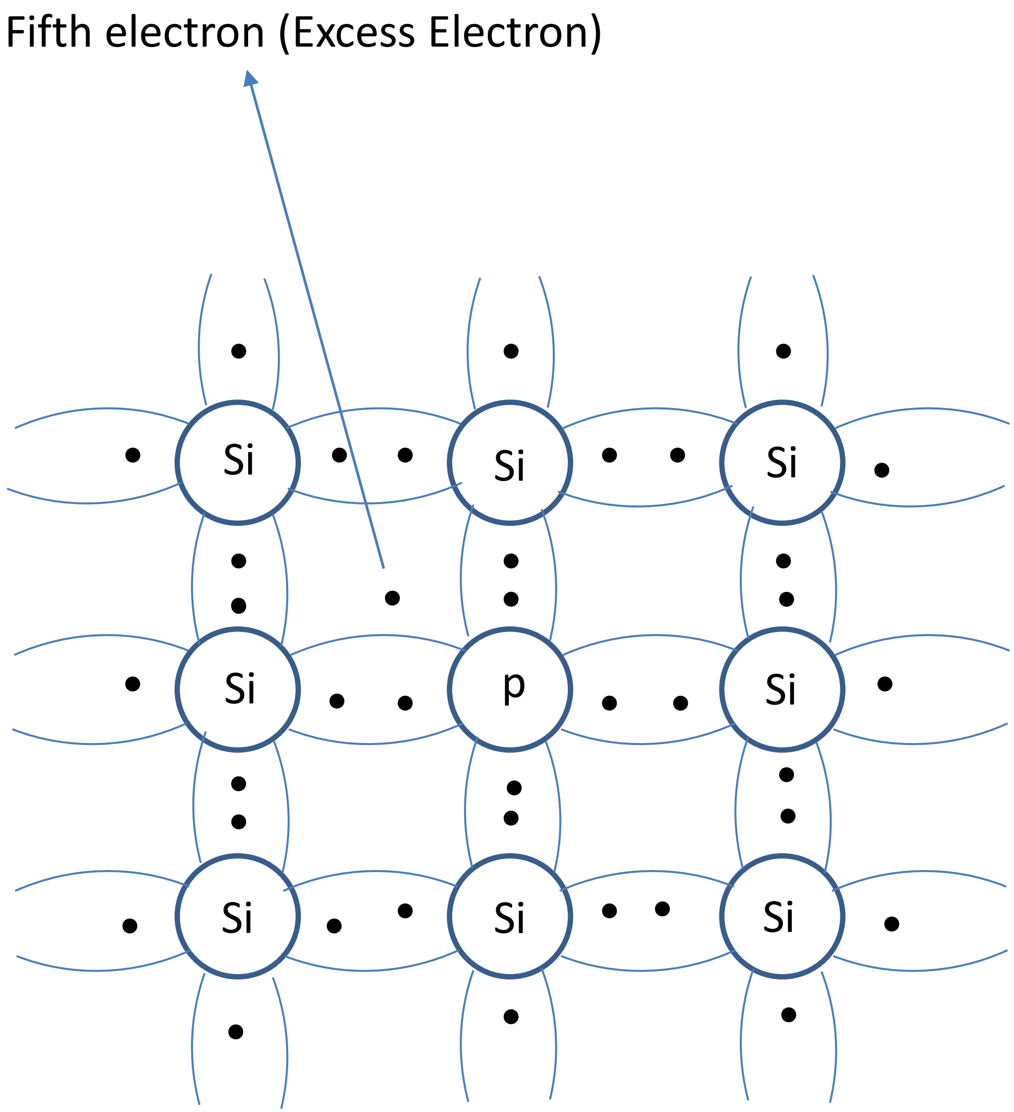
Before adding this impurity atom was neutral.

When fifth electron leave it , it gets +1 excess charge.

It means we get **positively** charged **immobile(fixed) ions**.

It means when N type semiconductor is formed by adding pentavalent impurities we get number of free electrons and immobile ion in e**qual** amount.

N Type semiconductors



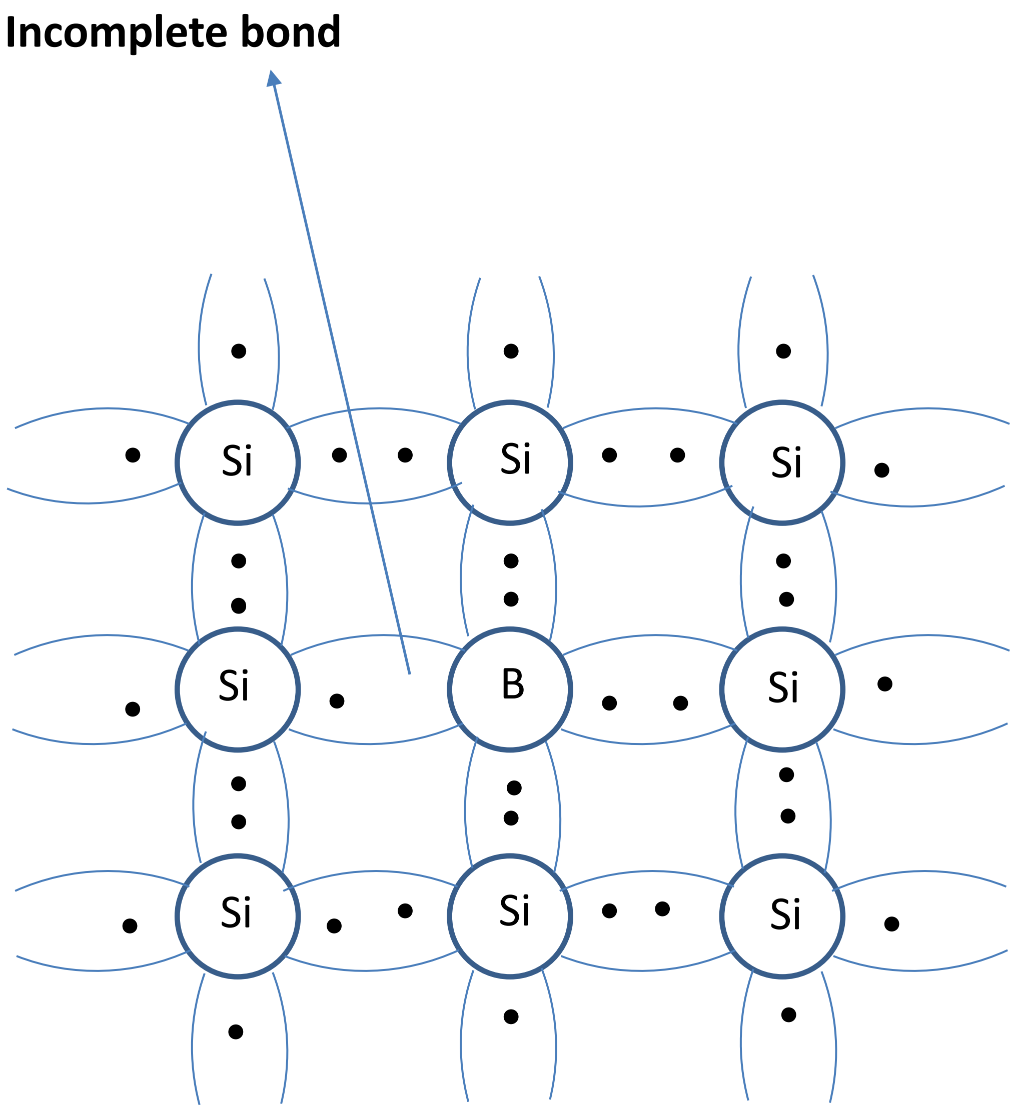
Now it is clear that when pentavalent impurity such as Phosphorus(P) is added to intrinsic semiconductor we get

- A free electron
- And a positively charged immobile ion.

Note: pentavalent impurity such as Phosphorus donates one electron that is why such type of impurity is also called as **Donor** impurity.

Note:- Other example of pentavalent impurities are
Antimony (Sb) , Arsenic (As)

P Type semiconductors



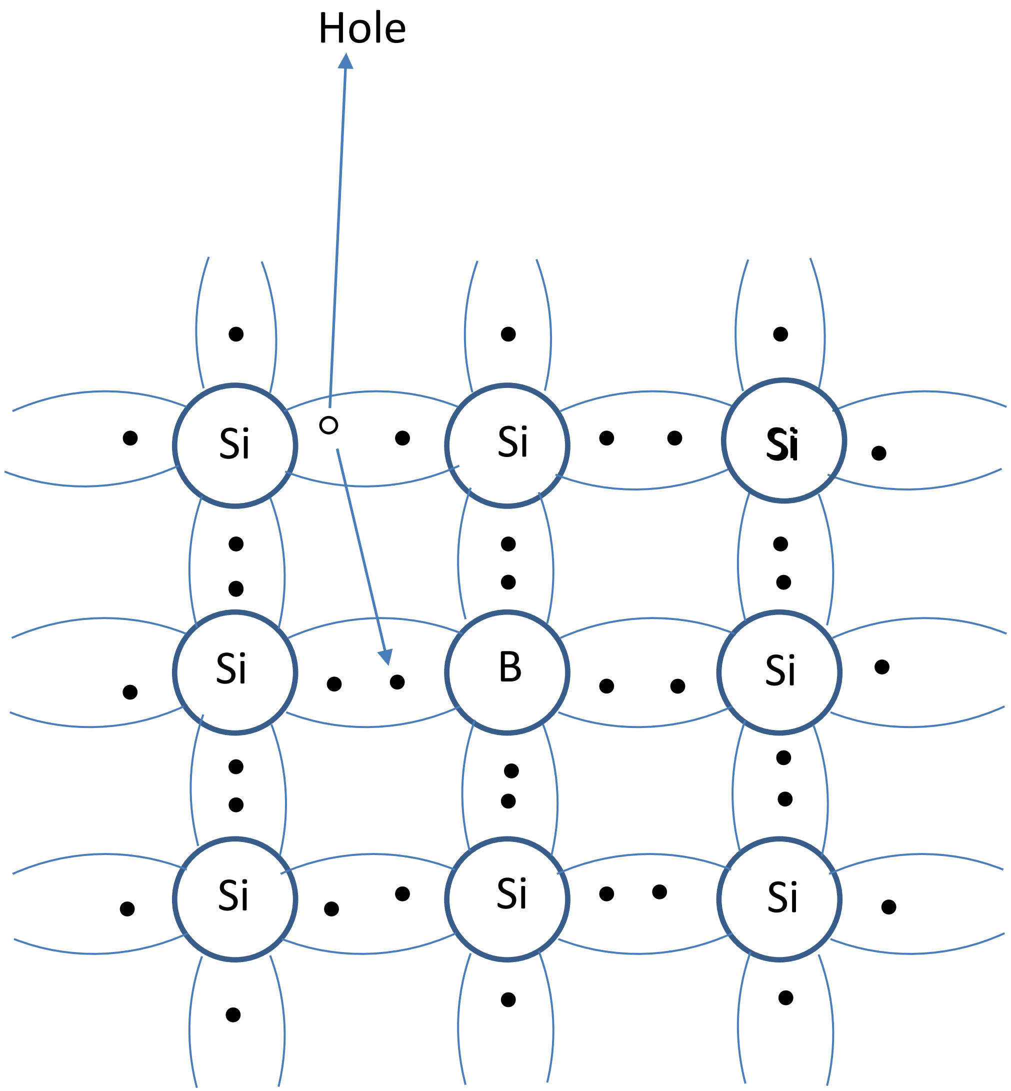
If we add small amount of trivalent impurity such as Boron(B) to a sample of intrinsic Silicon structure.
Then it replaces one of the Si atom as shown in the figure.

Boron atom has only three valence electrons .These three valence electrons form covalent bonds with three neighbouring silicon atoms.

Fourth neighbouring si atom is unable to form a covalent bond.

As shown in the figure.

P Type semiconductors



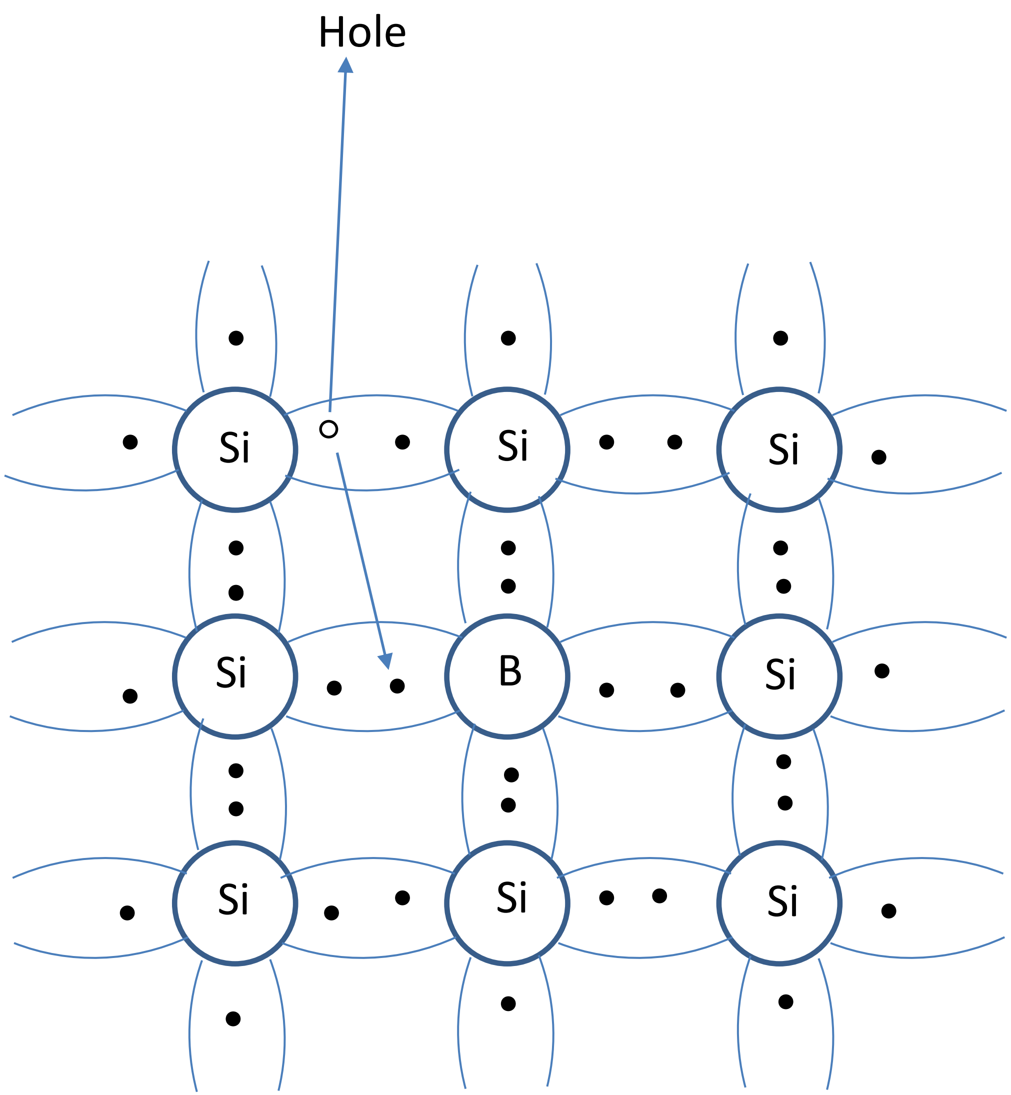
Then are chances that one covalent bond between two Si atom is broken and the electron jumps to occupy the vacancy around boron atom and hence a covalent bond is established between boron and silicon atom.

In the process two things happen
First a vacancy is created in the neighbouring Si atoms which is called as **hole**.

It is clear that hole will be **positively** charged.

Second, Boron with three valence electrons was earlier neutral but now because it has accepted one extra electron so this Boron atom is now negatively charged.

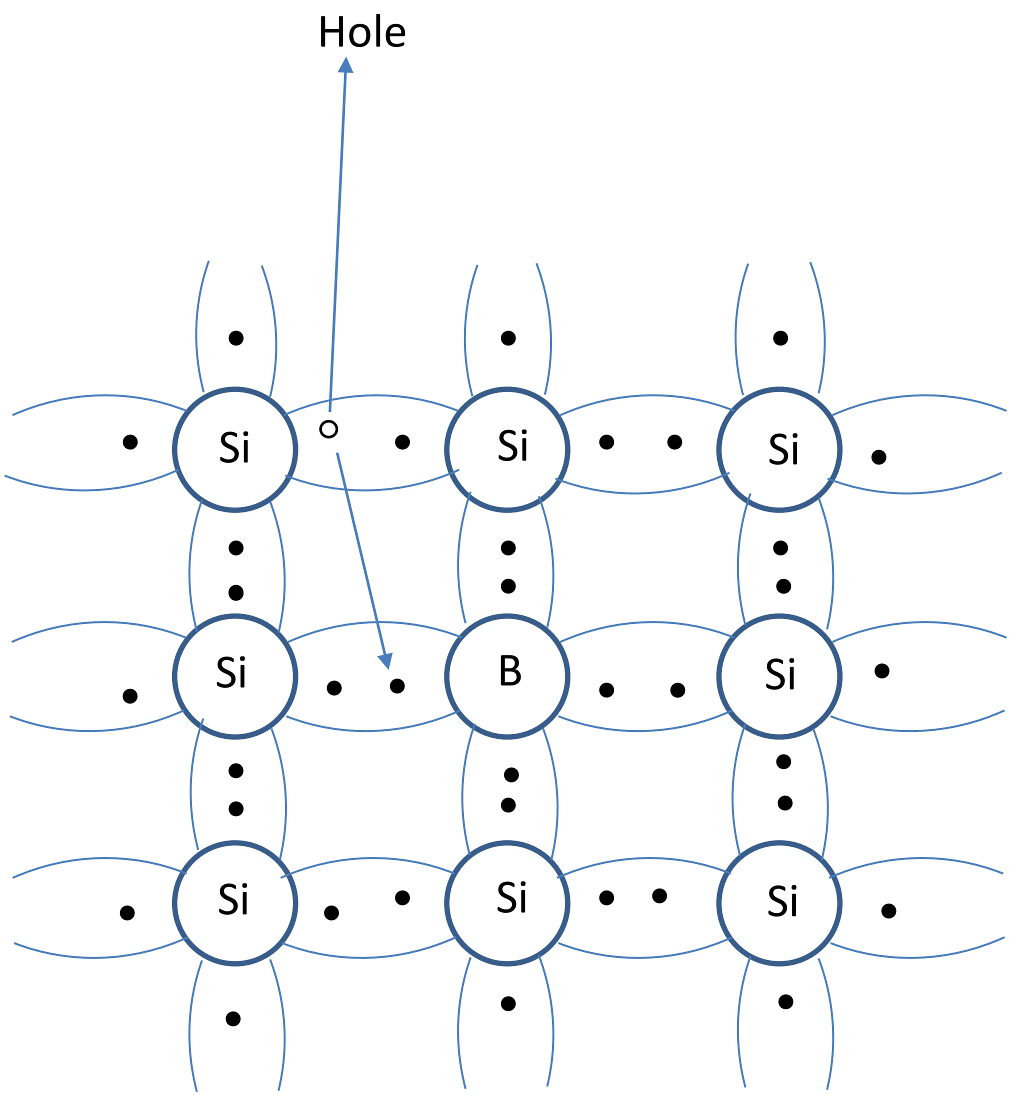
P Type semiconductors



The number of holes are far greater than the number of free electrons (which are generated by the breaking of covalent bonds at given temperature) and we say that semiconductor has become P type(**positively type)**.

It is clear that in P type semiconductor holes are **majority career** and free electrons are **minority career**.

P Type semiconductors



Now it is clear that when trivalent impurity such as boron (B) is added to intrinsic semiconductor we get

- A hole
- And a negatively charged immobile ion.

Note: Trivalent impurity such as boron accepts one electron that is why such type of impurity is also called as **Acceptor** impurity.

Note:- Other example of trivalent impurities are
Aluminium (Al),Gallium (Ga),Indium(In)

Thank you