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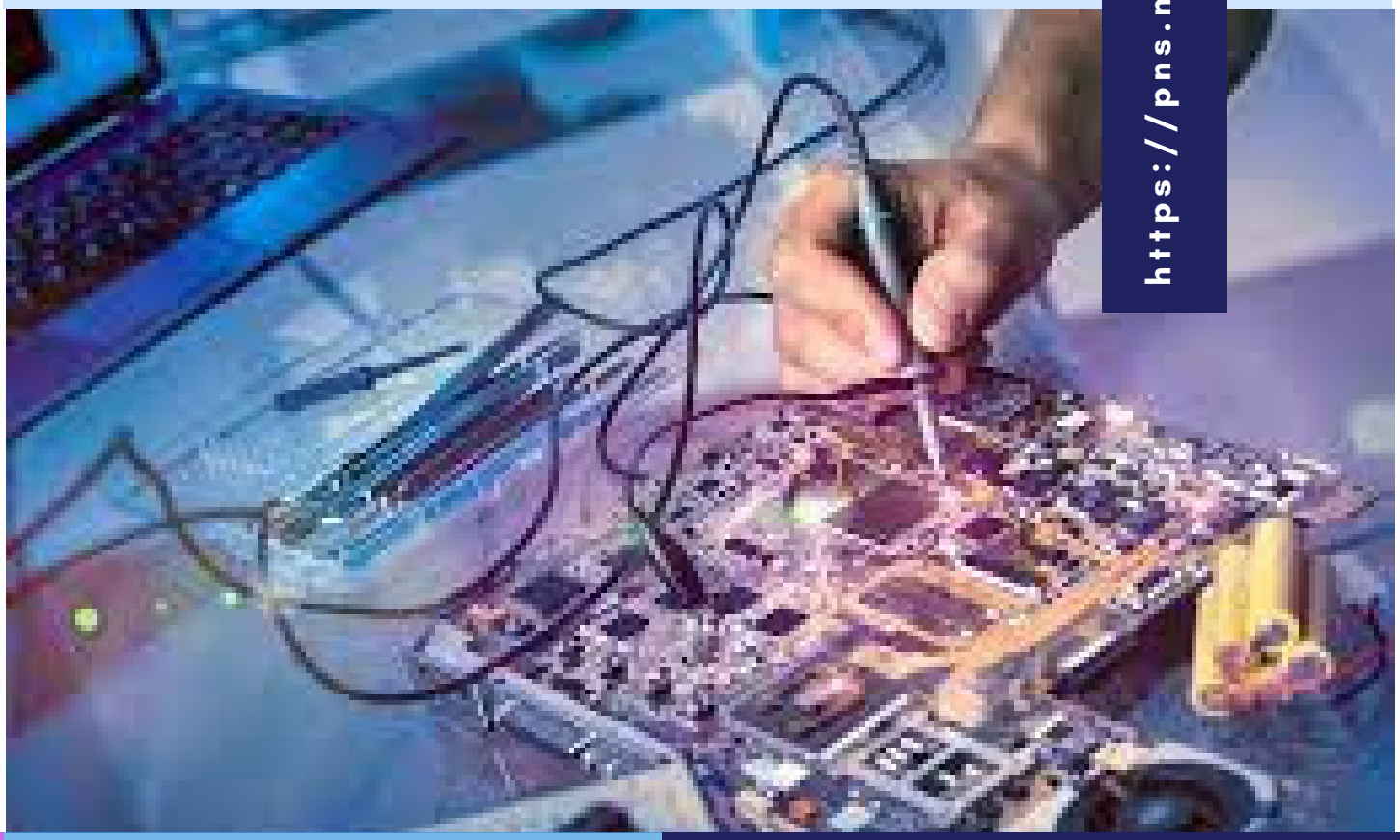

ELECTRONIC SYSTEM

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ELECTRONIC SYSTEM

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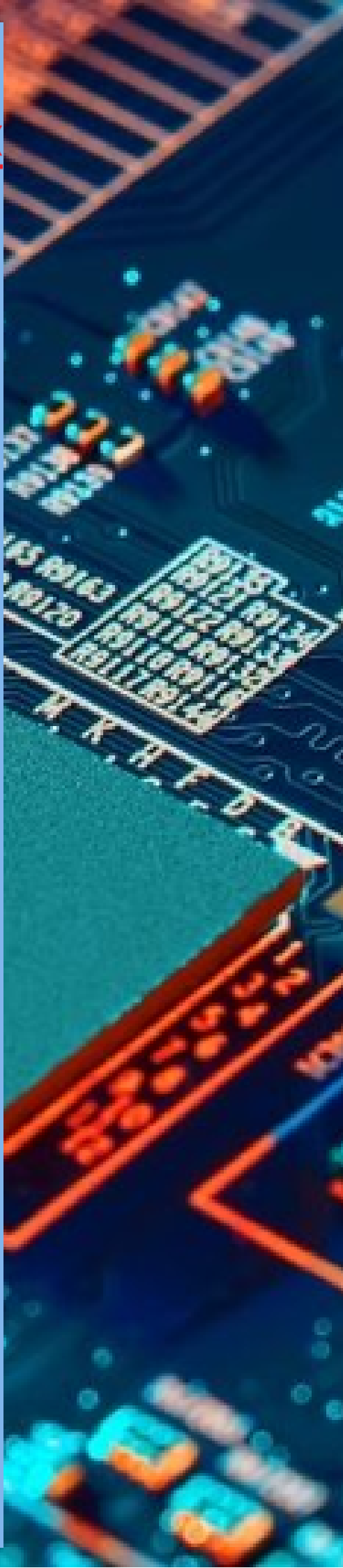

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P R E F A C E

The Electronic System eBook was produced to give students an understanding of the basic concepts related to the electronic system focus on Semiconductor topic. It is produced digitally to make it easier for students to access and to reduce the use of paper for printing. In this topic, there had been explain about the Conductor, Insulator, Semiconductor and also type of Semiconductor

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THANKS ALLAH S.W.T FOR HIS GUIDANCE AND MERCY. THE COMPLETION OF THIS EBOOK COULD NOT HAVE POSSIBLE WITHOUT THE PARTICIPATION TEAM MEMBERS AND SUPPORT FROM OUR MANAGEMENT OF THE POLYTECHNIC AND THE ACADEMIC DEPARTMENT, ESPECIALLY THE MECHANICAL ENGINEERING DEPARTMENT. THEIR CONTRIBUTION ARE SINCERELY APPRECIATED AND GRATEFULLY ACKNOWLEDGED. TO OUR PRARENTS, RELATIVE, FRIENDS, STUDENTS AND OTHERS WHO SHARED THEIR SUPPORT, EITHER MORALLY OR PHYSICALLY, THANK YOU VERY MUCH.

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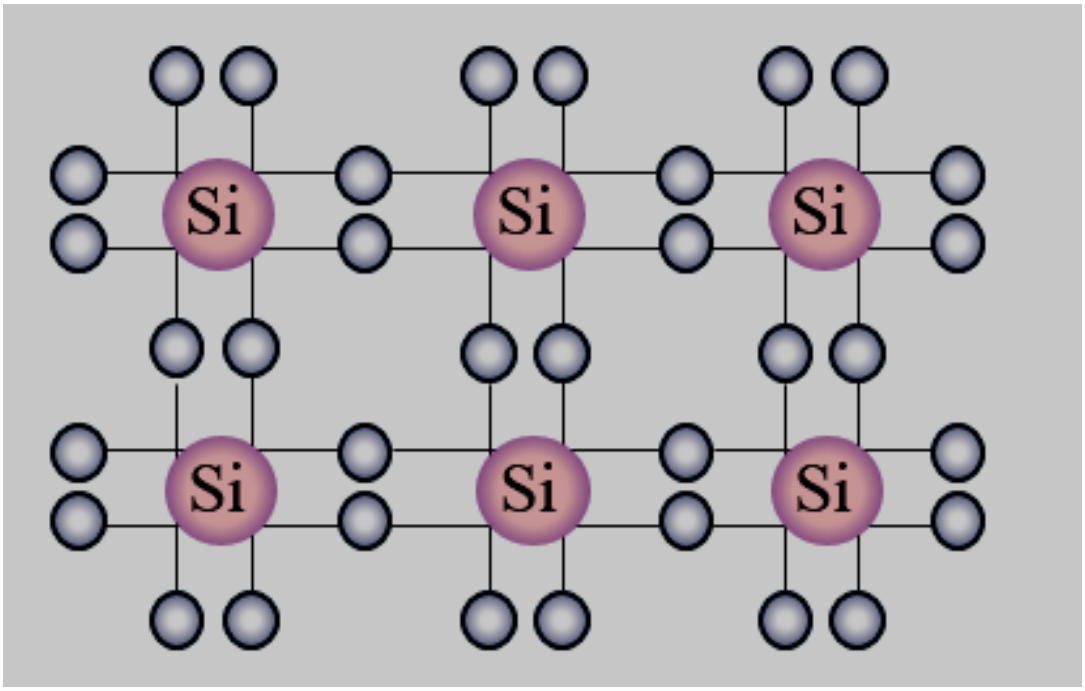

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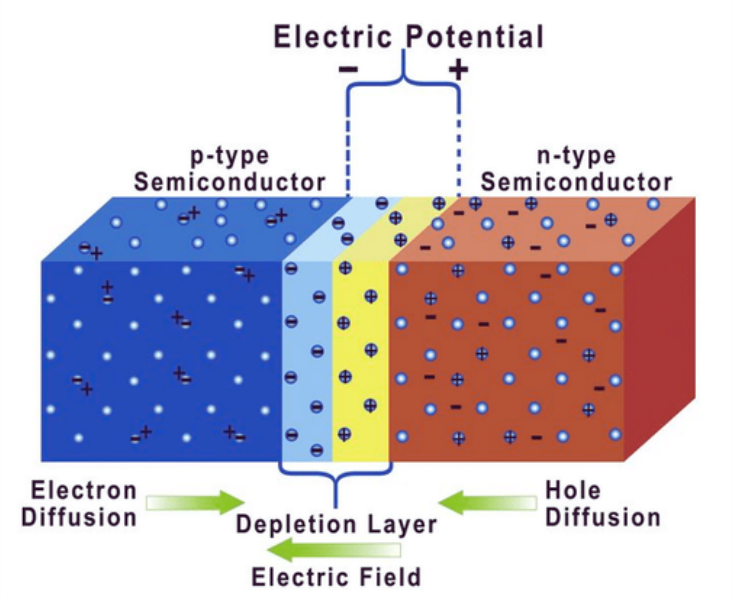


ELECTRONIC System

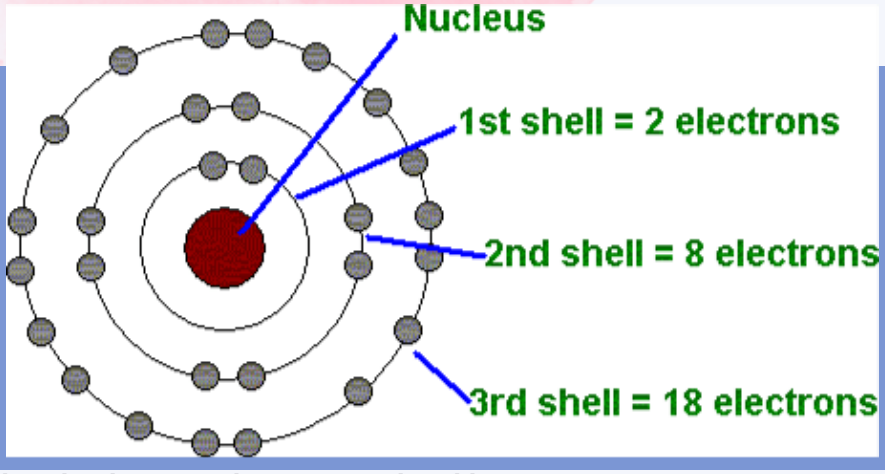
CHAPTER

01

SEMICONDUCTOR

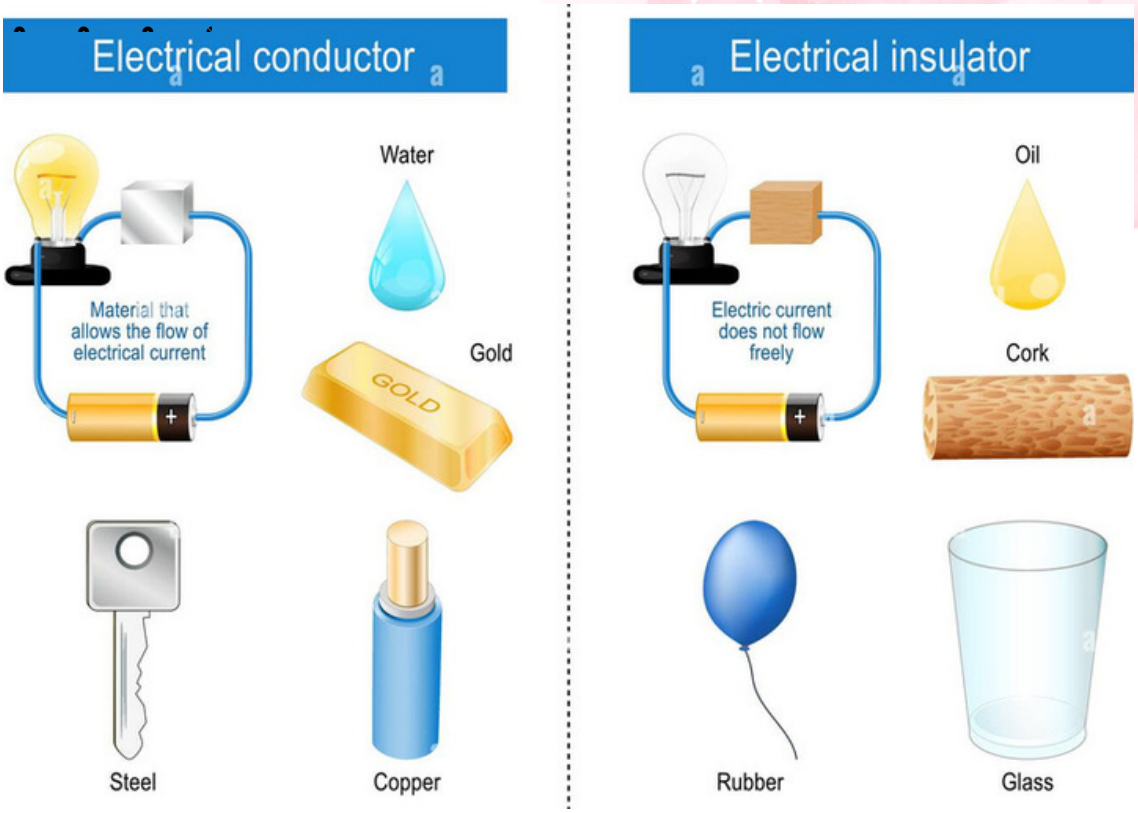
CONDUCTOR, INSULATOR & SEMICONDUCTOR

- The ability of a material to conduct current is based on its atomic structure.
- The orbit paths of the electrons surrounding the nucleus are called shells
- Each shell has a defined number of electrons it will hold. Ex: Copper:2.8.18.1
  (1 electron valence)



- The outer shell is called the valence shell
- The less complete a shell is filled to capacity the more conductive the material is

CONDUCTOR



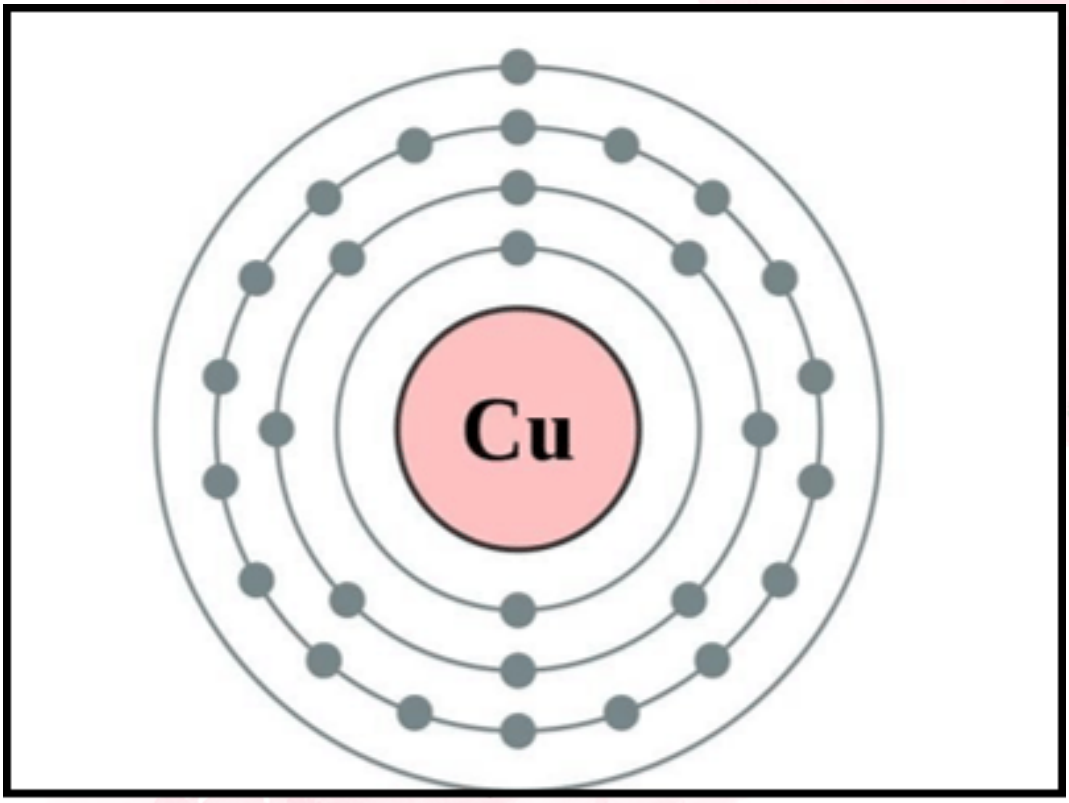
The material that contain electrical charges which can move when an electric potential difference (measured in volts) is applied across separate point.

The atom tends to release its electron valence to become free electrons which will move from one atom to another atom

Contains 1-3 electron valence and has the electrical conductivity.

Examples : silver, gold, copper, aluminum, mercury, steel, iron, mercury etc

Example: A copper atom has only 1 electron in its valence ring. This makes it a good conductor



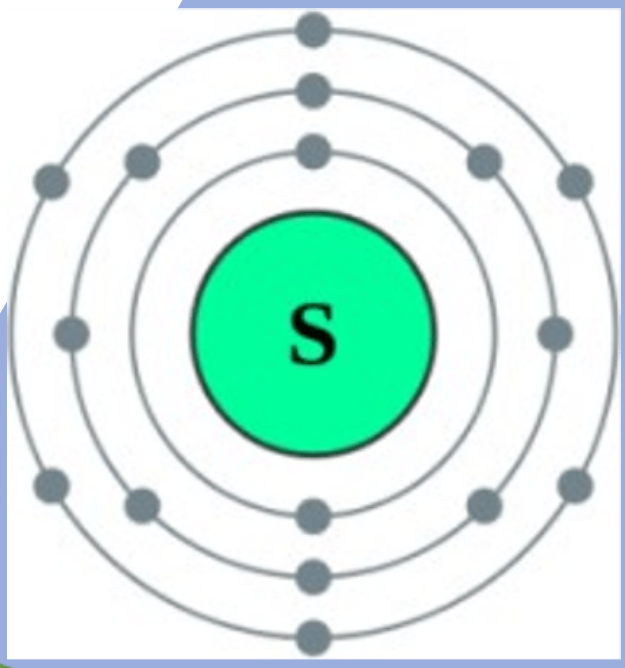
Copper : 29

2,8,18,1

Electron valence

INSULATOR

- The material has a high potential difference and cannot conduct electricity
- The atoms tend to gain electron valence from another atom to fulfill their outer valence to become stable and avoid any electrical or chemical activities
- Full valence shell, examples: rubber, glass, oil, air, diamond, dry wood, plastic, porcelain, ceramic, quartz, etc
- Example: A sulfur atom is 16. It has 6 electrons in its valence ring. This makes it an insulator.

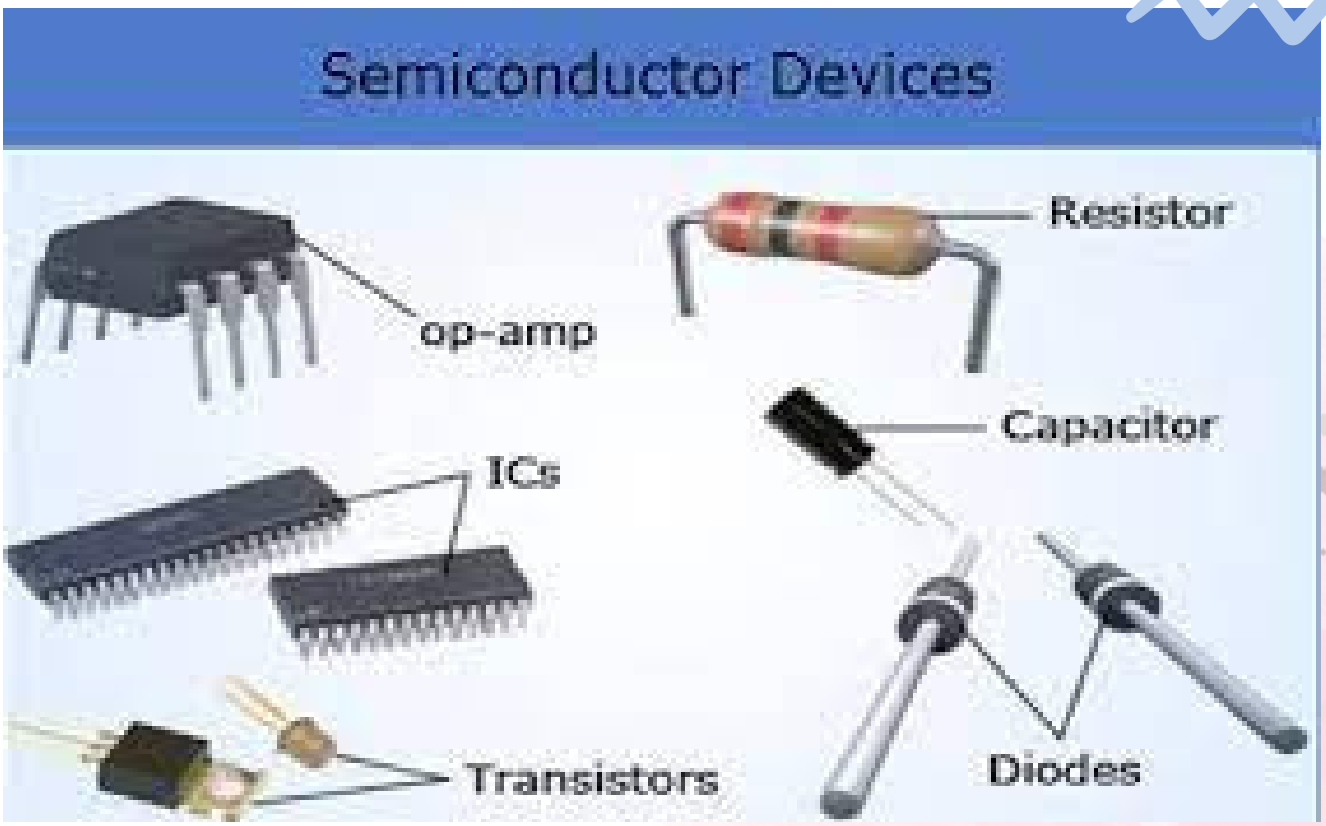


Sulfur : 16

2,8,6

Electron valence

SEMICONDUCTOR



The material that between conductors and insulators in its ability to conduct electrical current.

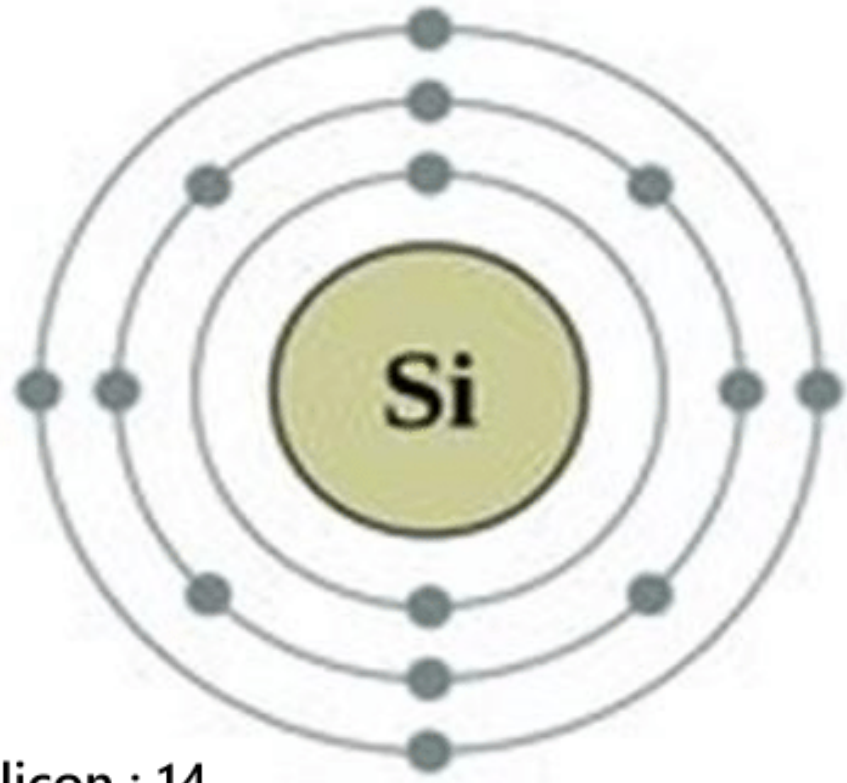
It not easily release electrons like conductor or gain electron like an insulator.

Contain 4 electron valence.

2 type of semiconductor

- Intrinsic semiconductor
- Extrinsic semiconductor

Example: A silicon atom has 4 electrons in its valence ring. This makes it a semiconductor.



Silicon : 14

2,8,4

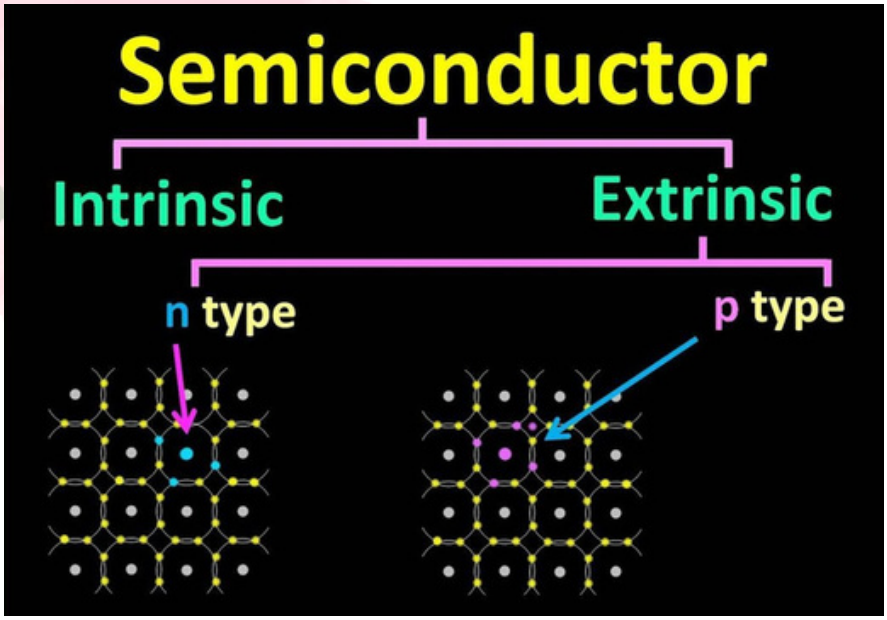
Electron valence

AS CONCLUSION.....

VALENCE ELECTRONS	CHARACTERISTIC	NOTE
1-3	Conductor	Acts as the current carrierIt has very low resistance.These electrons are only weakly attracted to the nucleus of the atoms. They are very easy to move.
5-8	Insulator	No current flows.It has very high resistance. The valence electrons are tightly bound to their parent atoms. They are not free to move but convenience to accept electrons from others atom to fulfill the valence orbit to make it stable.
4	Semiconductor	Can conduct so poorly that they behave as insulators .Difficult to accept/throe away valence electrons from another atom.

INTRINSIC SEMICONDUCTOR

These are pure semiconducting materials and no impurity atoms are added to them.

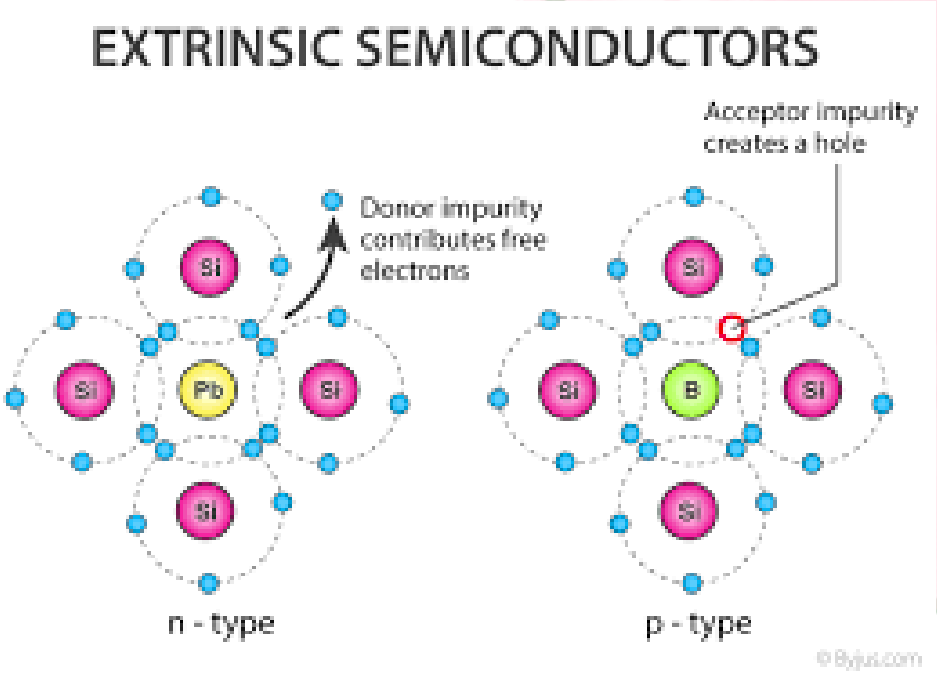


For example, crystals of pure elements like **germanium** and **silicon** are considered Intrinsic Semiconductors.

Properties:

- In an intrinsic semiconductor, the number density of electrons is equal to the number density of holes.
- The electrical conductivity is low
- The electrical conductivity of intrinsic semiconductors depends on their temperatures

EXTRINSIC SEMICONDUCTOR



When some impurity is added to an intrinsic semiconductor, extrinsic semiconductors can be produced.

There are 2 types of extrinsic semiconductors: **P-type semiconductors** and **N-type semiconductors**

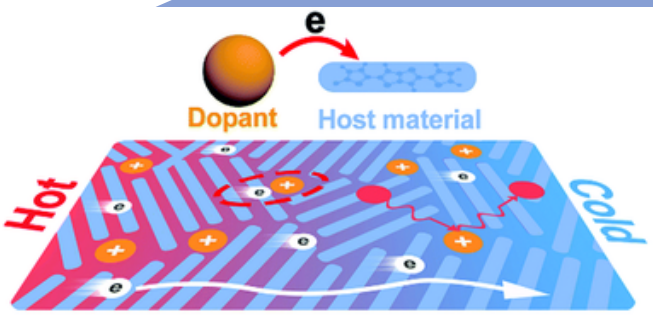
Properties:

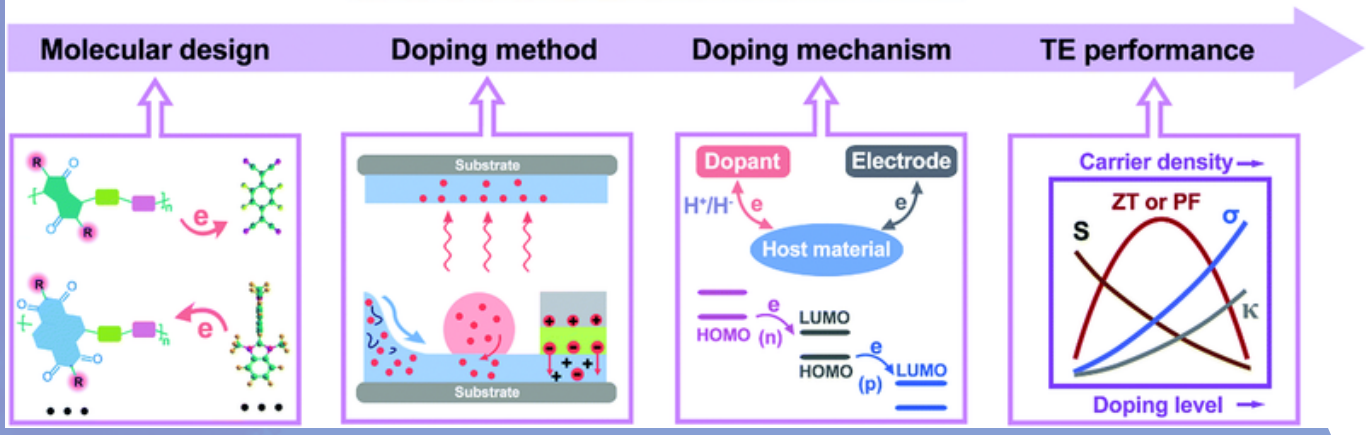
- In an extrinsic semiconductor, the number of electrons is not equal to the number density of holes
- The electrical conductivity is high
- The electrical conductivity depends on the temperature and the amount of an impurity added to them.

DOPING PROCESS

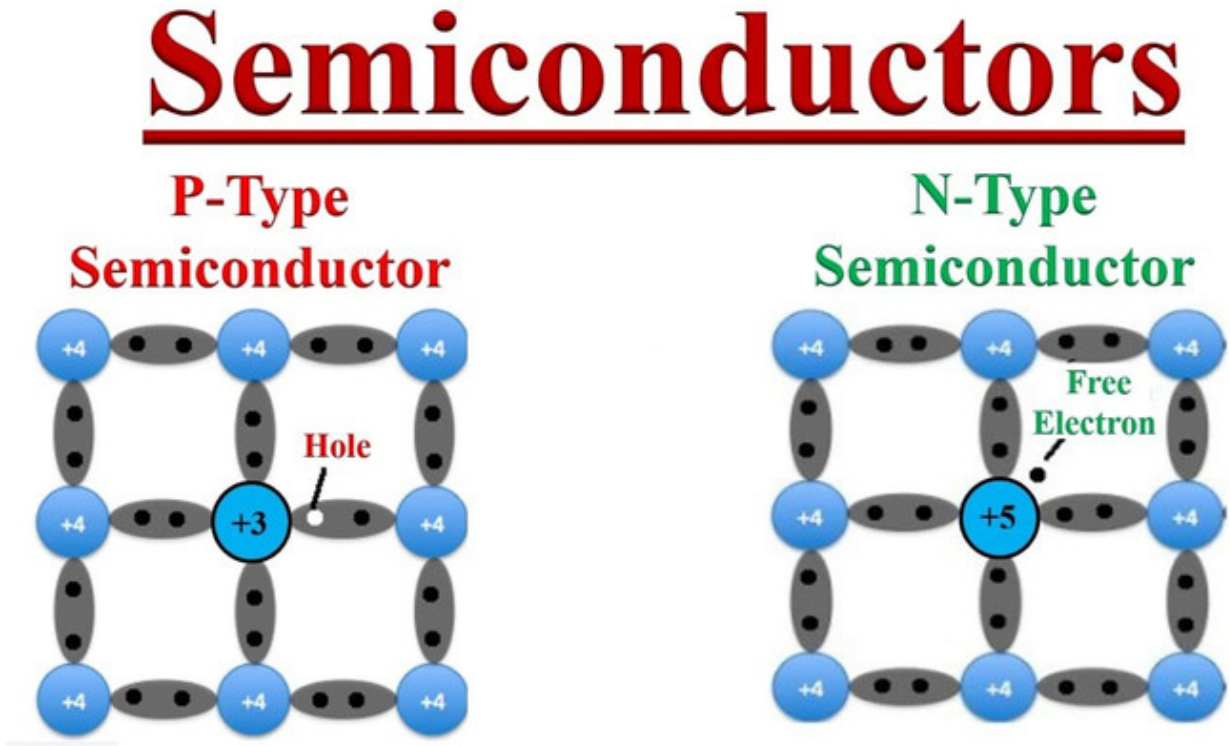
Doping is the process of adding impurities to intrinsic semiconductor (Silicon or germanium) to change their properties.

Mostly **Trivalent** and **Pentavalent** elements are used to dope these elements





SEMICONDUCTOR P-TYPE & N-TYPE



P-TYPE

When intrinsic semiconductor is doped with Trivalent impurity, it becomes a P- type semiconductor.

Example : Boron, Aluminum, Gallium

The P stands for positive, which means the semiconductor is rich in holes or positively charged ions

N-TYPE

When intrinsic materials are doped with pentavalent impurities, it becomes a N-type semiconductors, where N stands for negative.

Examples : Antimony, Arsenic, Phosphorus

N-type semiconductors have negatively charged ions or in other words they have excess electrons

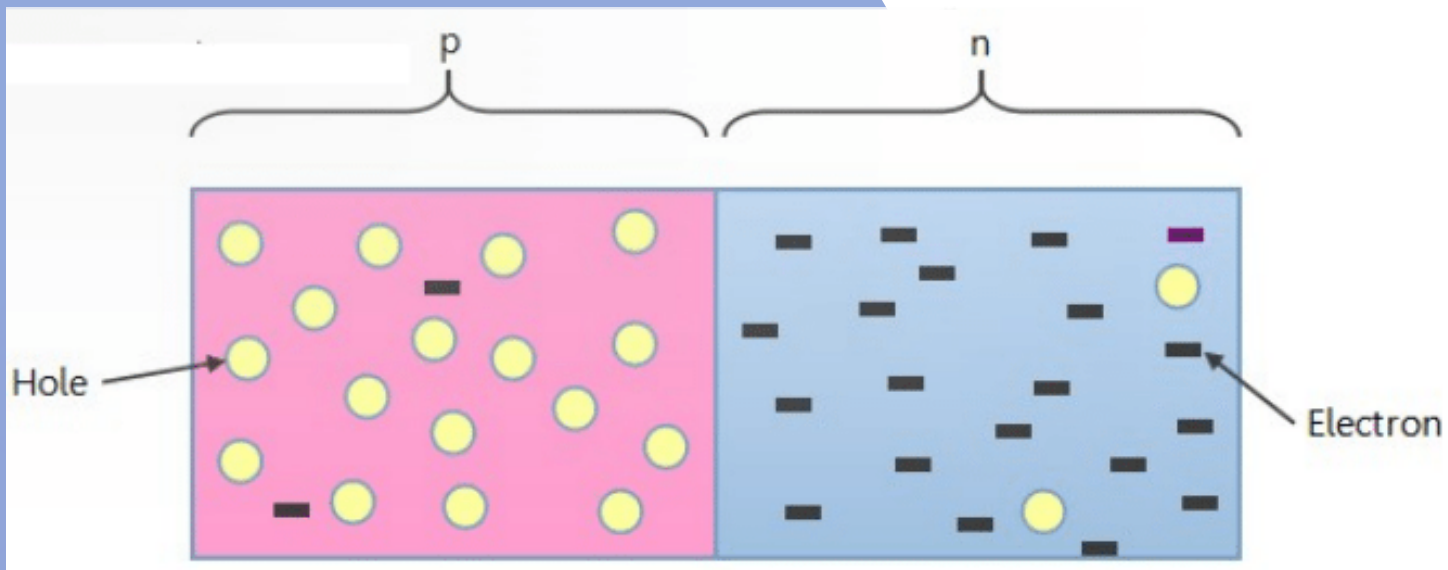
INTRODUCTION TO P-N JUNCTION

When P-type and N-type materials are placed in contact with each other

P-N JUNCTION

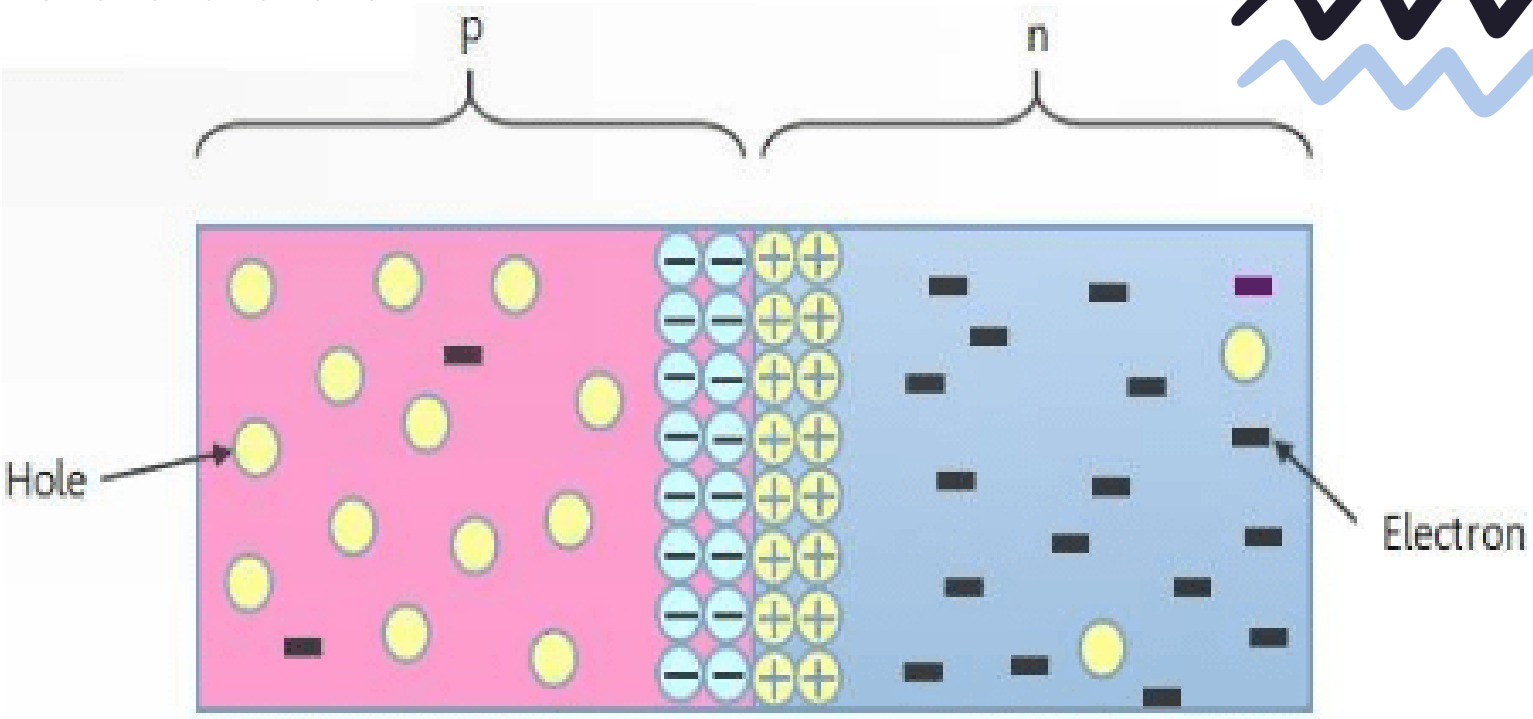
In an **N-type** semiconductor, the majority carriers are negative charge carriers or **electrons**.

In an **P-type** semiconductor, the majority carriers are **holes** or positive charges



Situation before formation of depletion region

HOW DIFFUSION OCCUR



When a junction is formed, this results in electrons moving from n-side to p-side and holes moving from p-side to n-side through the junction.

This is call as '**initial movement**'.

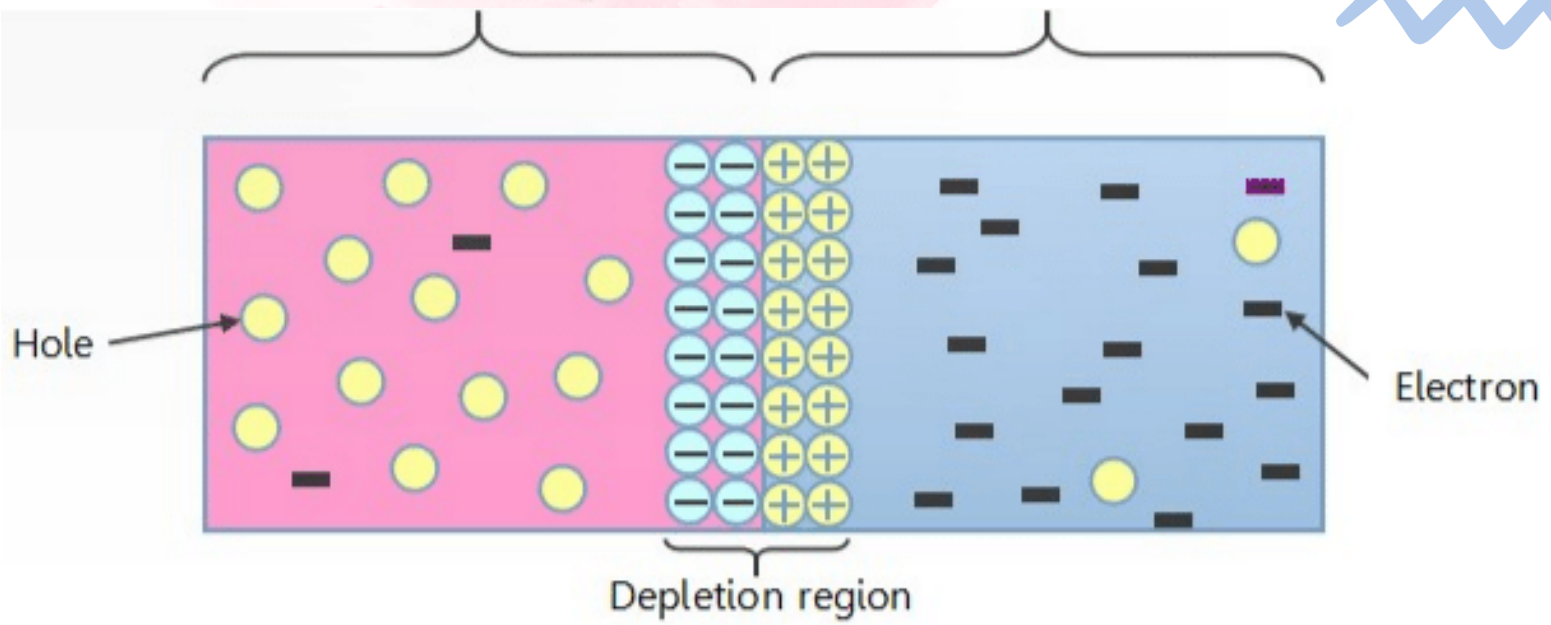
When an electron leaves n-side region, it leaves behind a positive charge at the n-side.

Similarly, when a hole is diffused to n-side, it leaves behind a negative charge at the p-side.

This **movement of electrons from n-side to p-side and the movement of holes from p-side to n-side is called diffusion** and it results in a current named diffusion current

DEPLETION REGION

When more and more electron leaves the n-region and more and more holes leave the p-region, a **region of positive and negative charges is formed at the junction.**



Positive charges get accumulated near the n-side junction and negative charges get accumulated near the p-side junction.

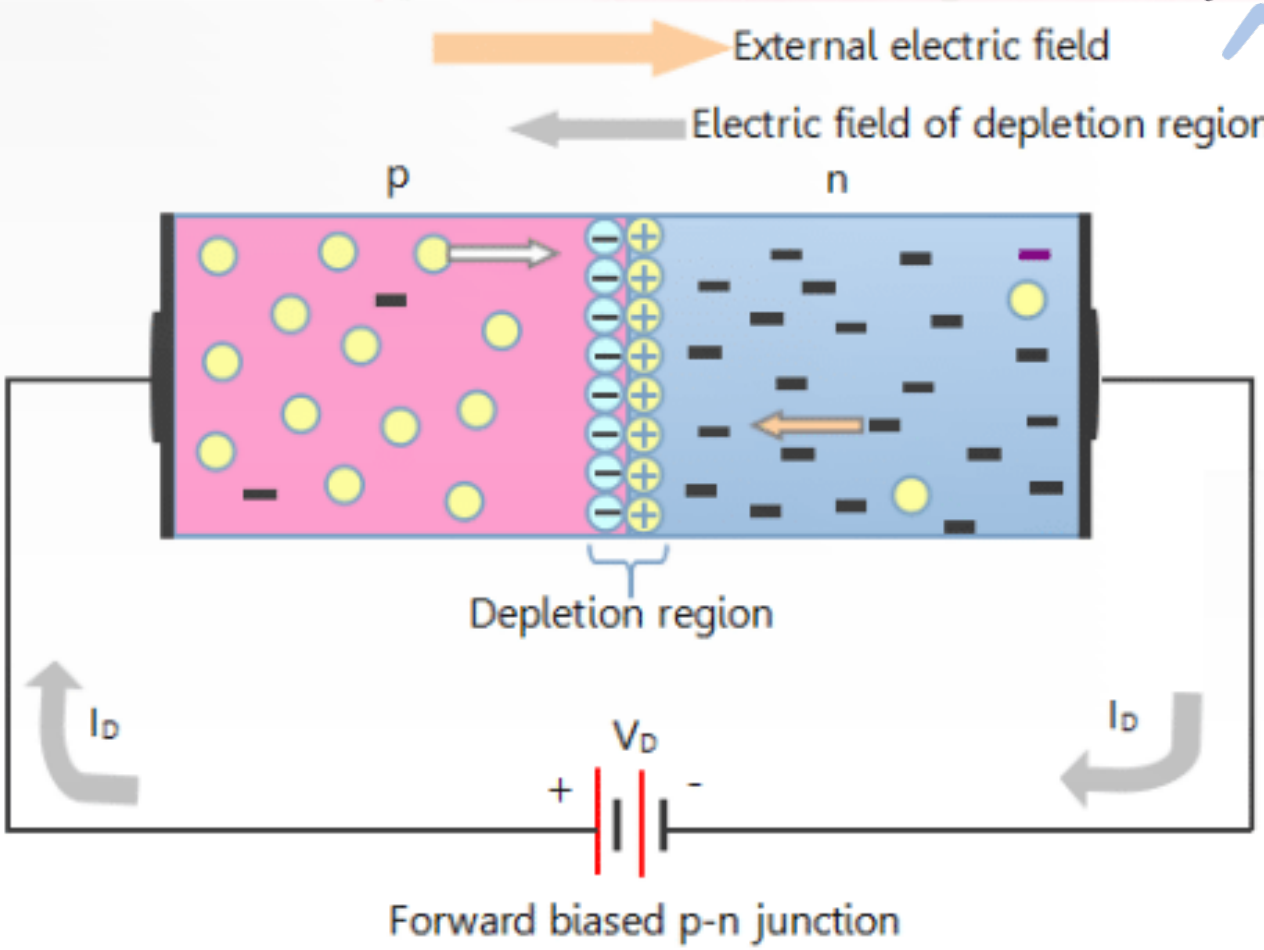
This region is known as **depletion region**.

Let's do some EXERCISE.....

What is the minority and majority current carrier for P-type material and N-type material?

State the purpose of 'Depletion Region'?

FORWARD BIAS

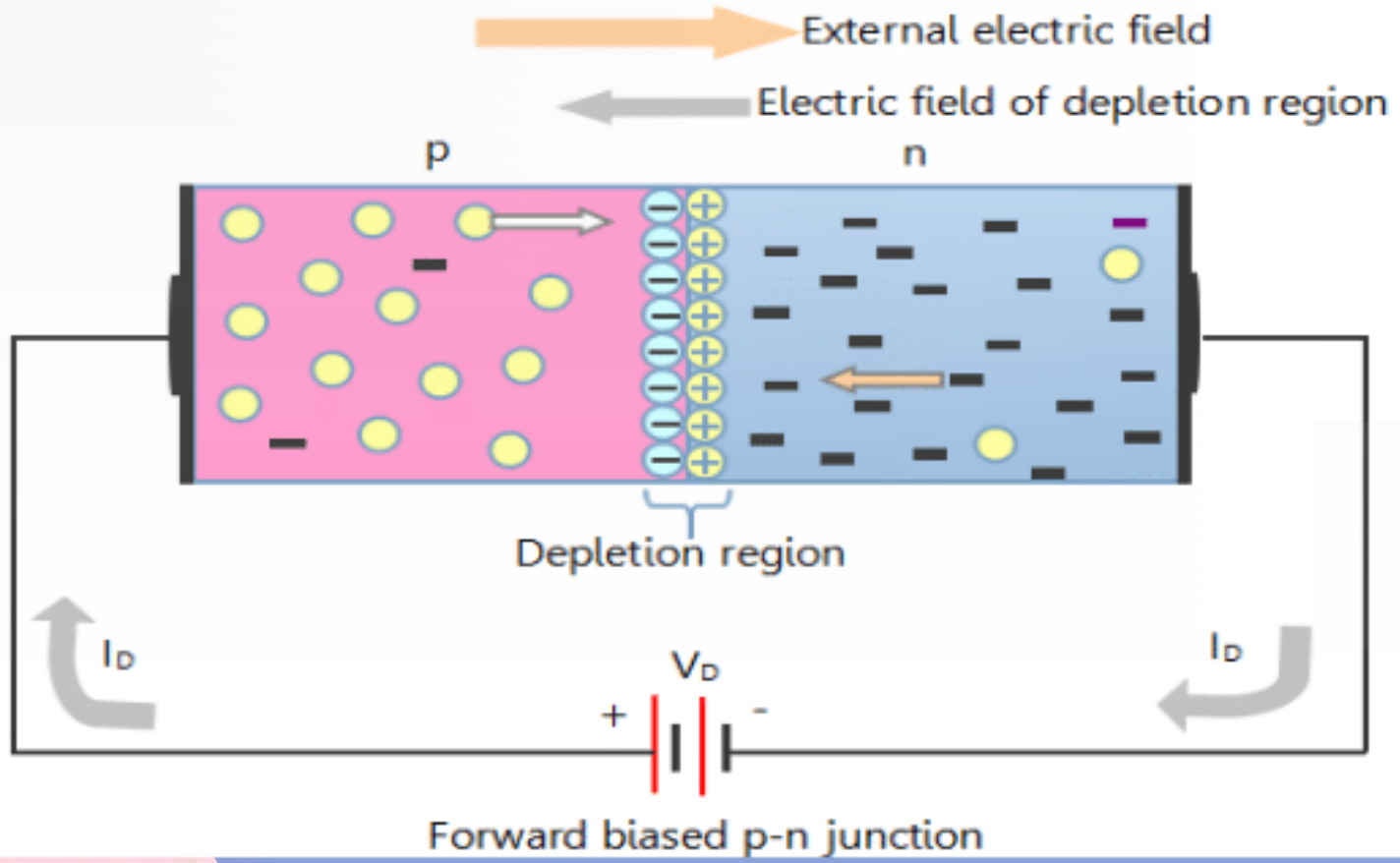


The **p region** is connected to **positive terminal** and **n region** is connected to the **negative terminal** of the DC voltage source.

If this external voltage becomes greater than the value of the potential barrier (0.7V / 0.3V), the potential barriers opposition will be overcome and current will start to flow.

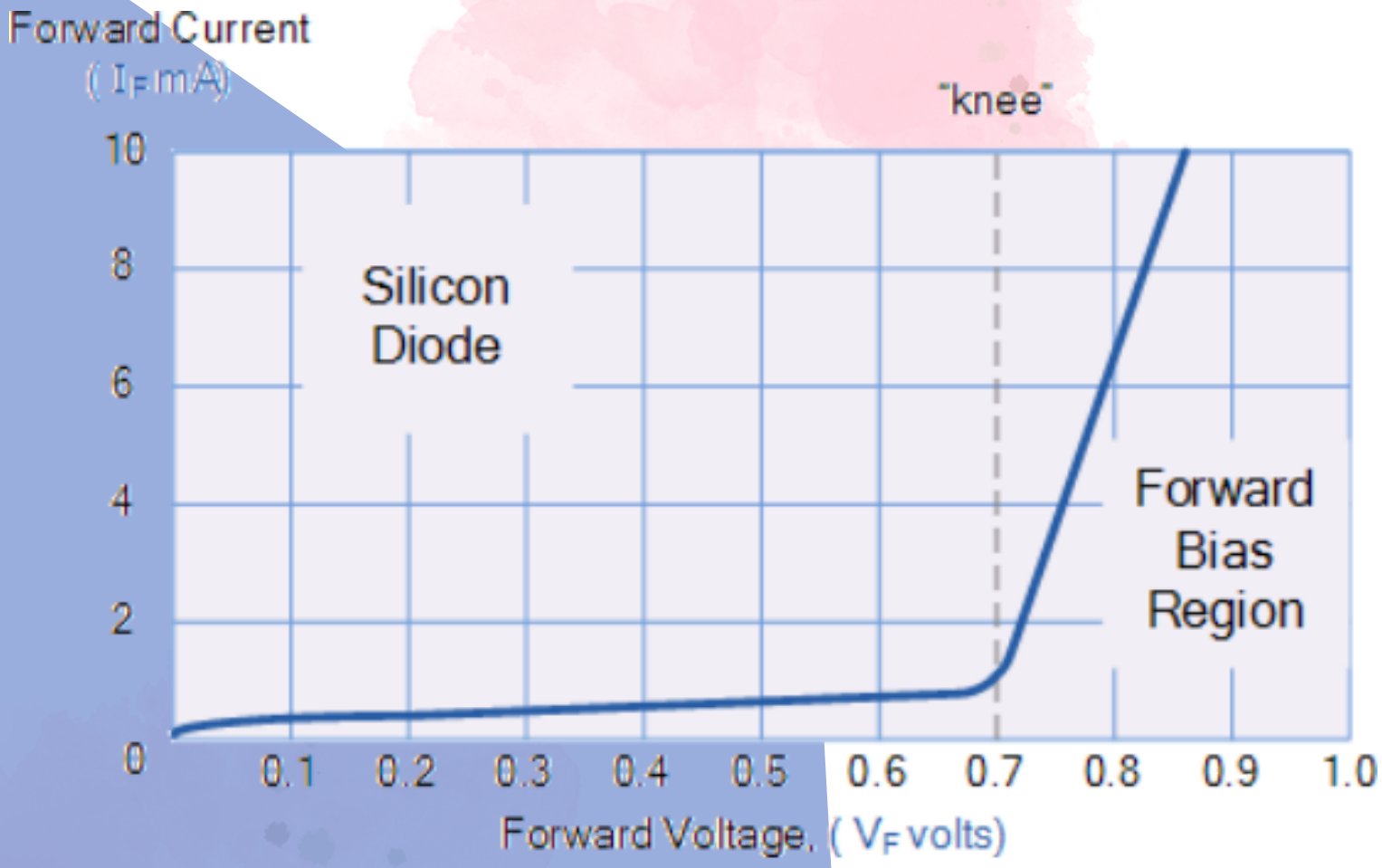
FORWARD BIAS (Cont.)

This is because the negative voltage pushes or repels electrons towards the junction giving them the energy to cross over and combine with the holes being pushed in the opposite direction towards the junction by the positive voltage.



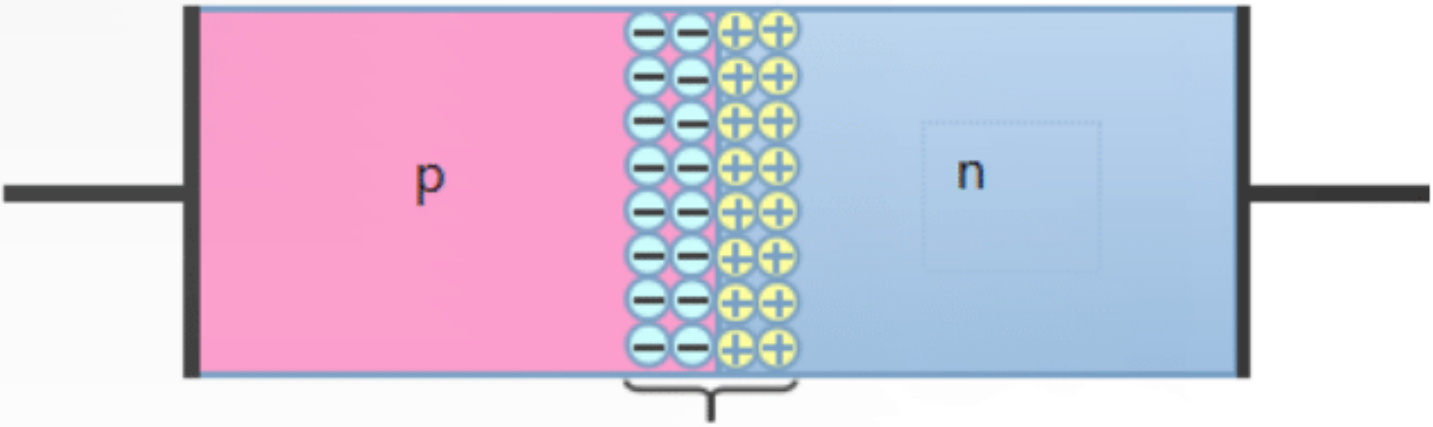
Forward biased p-n junction

FORWARD CHARACTERISTICS CURVE FOR A JUCTION DIODE

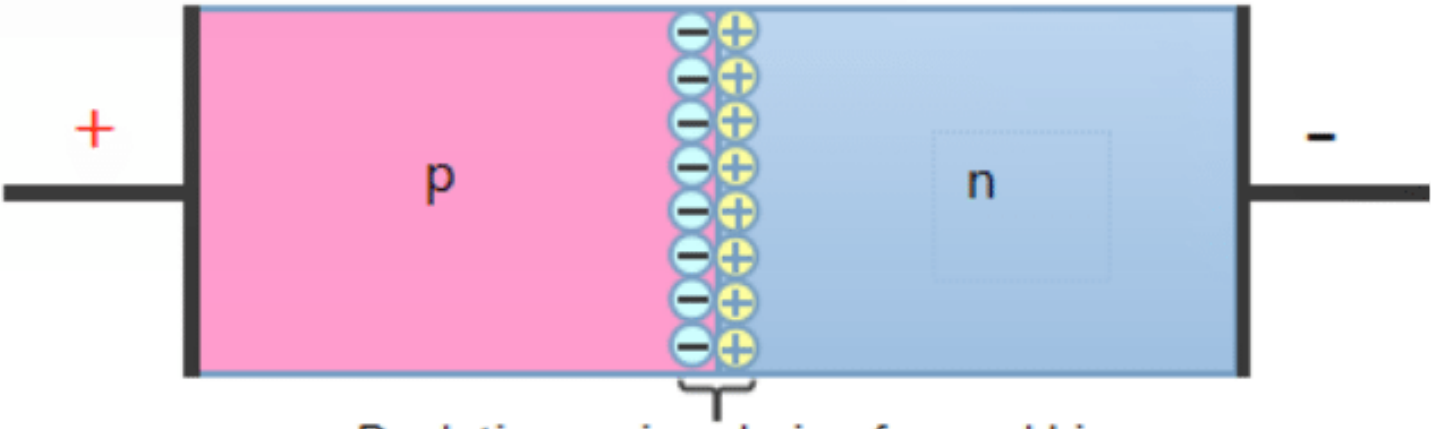


This results in a characteristics curve of **zero current flowing up to this voltage point**, called the "knee" on the static curves and then a high current flow through the diode with little increase in the external voltage as shown below.

EFFECT ON DEPLETION REGION DUE TO FORWARD BIAS



Depletion region during zero bias condition



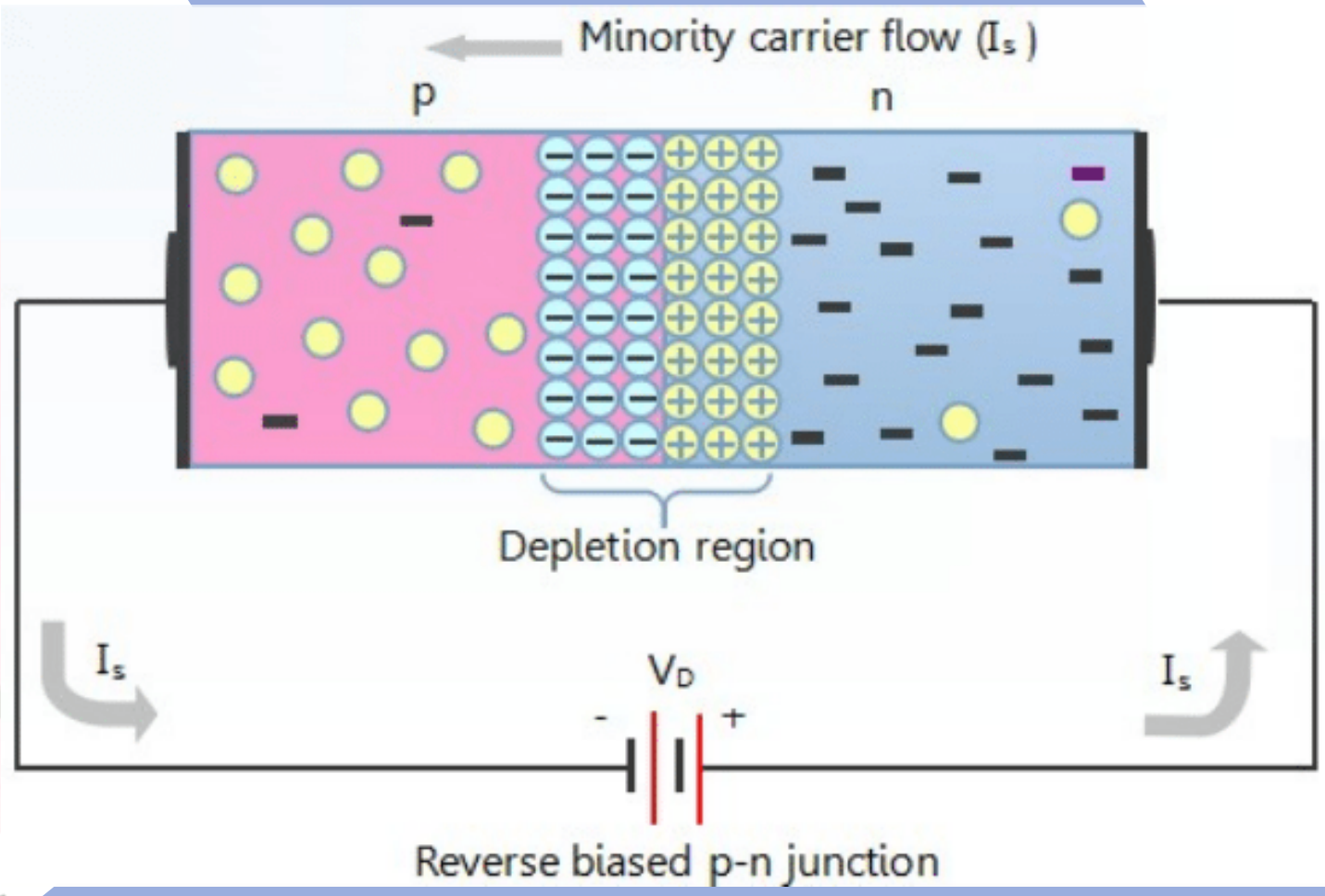
Depletion region during forward bias.

Depletion region narrows during forward bias.

REVERSE BIAS

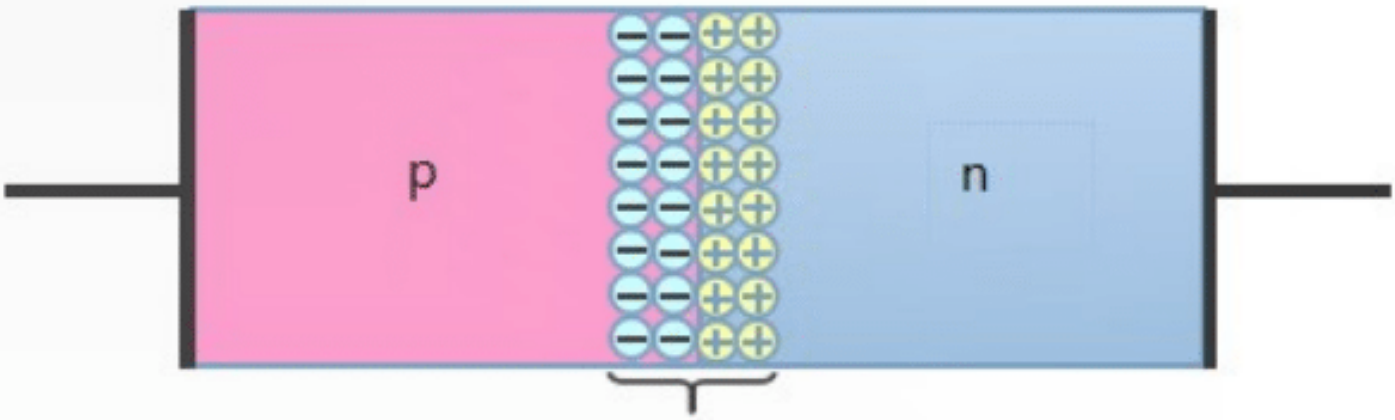
A positive voltage is applied to the **N-type** material and a **negative** voltage is applied to the **P-type** material.

The positive voltage applied to the N-type material **attracts** electrons towards the positive electrode and away from the junction, while the holes in the P-type end are also attracted away from the junction toward the negative electrode.

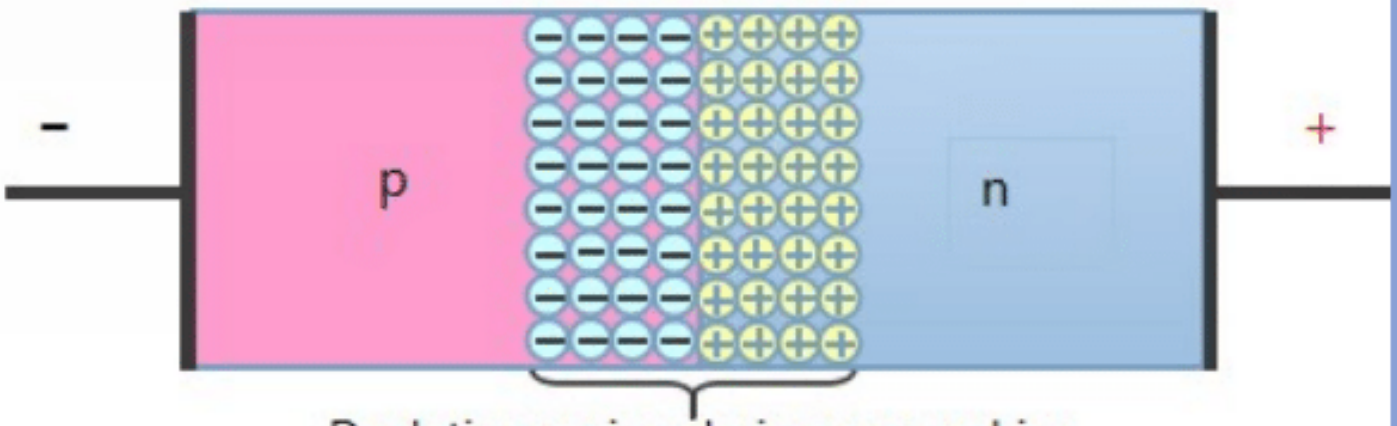


Reverse biased p-n junction

EFFECT OF REVERSE BIAS ON THE WIDTH OF DEPLETION REGION



Depletion region during zero bias condition



Depletion region during reverse bias.
The width of depletion region increases when reverse bias is applied.

EFFECT OF REVERSE BIAS ON THE WIDTH OF DEPLETION REGION (Cont..)

- The result is that the depletion layer grows wider due to a lack of electrons and holes and presents a **high impedance** path, almost an insulator.
- The result is that a **high potential barrier** is created thus **preventing current from flowing** through the semiconductor material.
- However, a very small **leakage current** does flow through the junction which can be measured in micro-amperes, (μA).
- One final point, if the reverse bias voltage Vr applied to the diode is increased to a sufficiently high enough value, it will cause the PN junction to **overheat and fail**. This may cause the diode to become shorted and will result in the flow of maximum circuit current

LET'S DO SOME EXERCISE.....

01.

A diode conducts when it is forward-biased, and the anode is connected to the _____ through a limiting resistor.

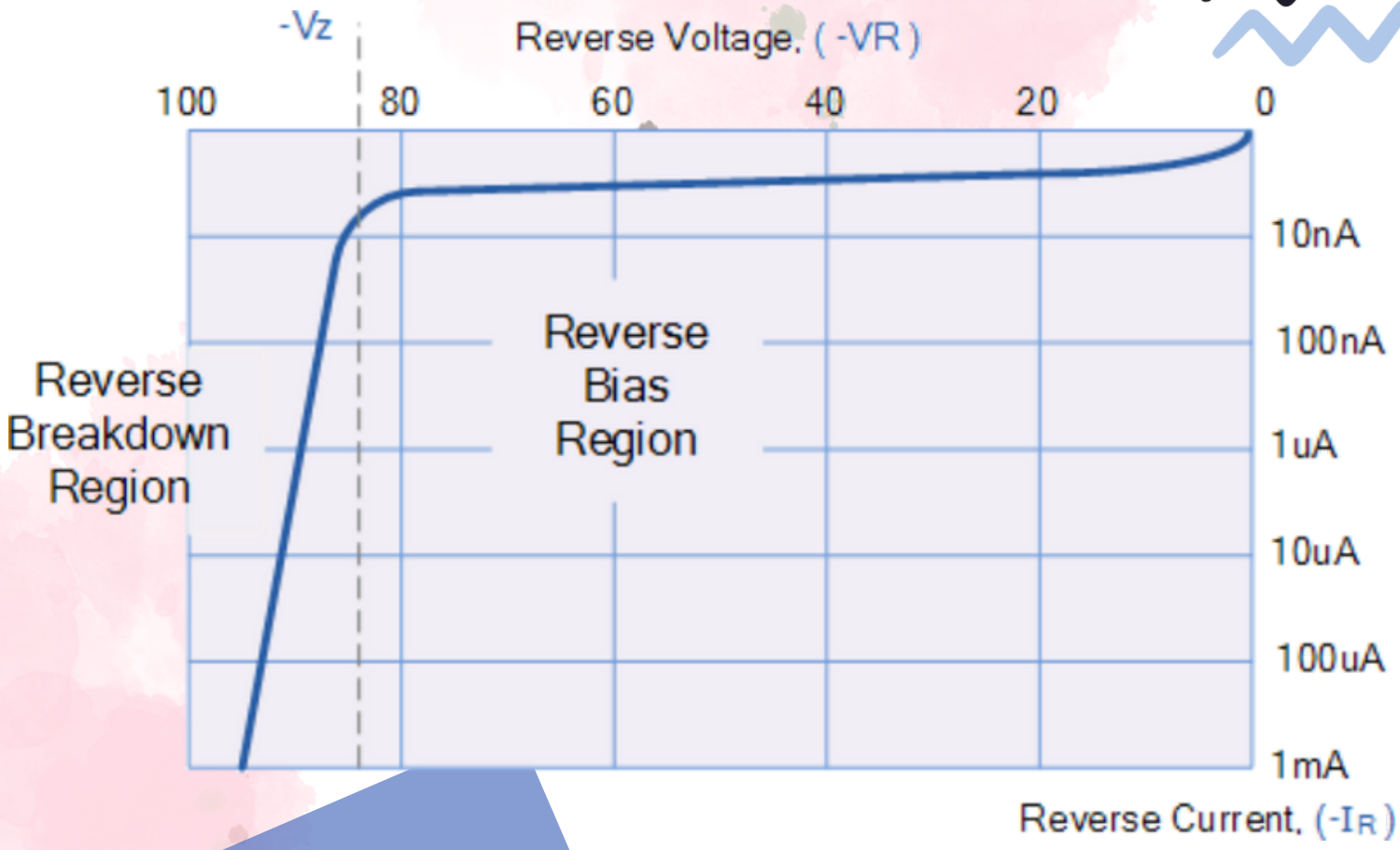
- ☐ **A-** positive supply
- ☐ **B-** negative supply
- ☐ **C-** cathode
- ☐ **D-** anode

02.

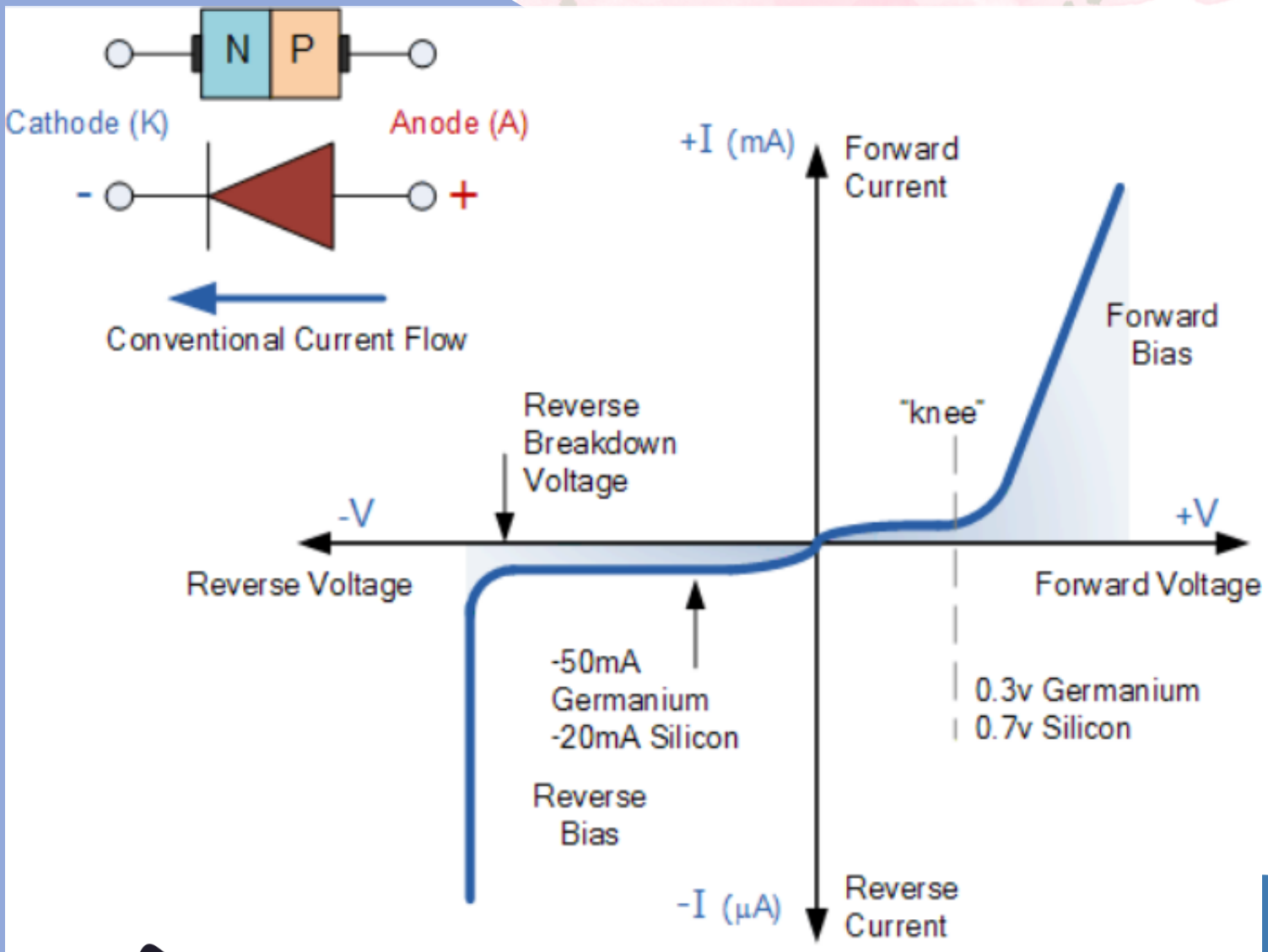
A reverse-biased diode has the _____ connected to the positive side of the source, and the _____ connected to the negative side of the source.

- ☐ **A-** cathode, anode
- ☐ **B-** cathode, base
- ☐ **C-** base, anode
- ☐ **D-** anode, cathode

REVERSE CHARACTERISTICS CURVE FOR A JUCTION DIODE



DIODE CHARACTERISTIC CURVE



LET'S DO SOME REVISION.....

01.

The most commonly used semiconductor is .....

- [ ] **A-** Germanium
- [ ] **B-** Silicon
- [ ] **C-** Carbon
- [ ] **D-** Sulphur

02.

A semiconductor has generally ..... valence electrons

- [ ] **A-** 2
- [ ] **B-** 3
- [ ] **C-** 6
- [ ] **D-** 4

LET'S DO SOME

REVISION (CONT)..

03.

The strength of a semiconductor crystal comes from ……..

- [ ] **A-** Forces between nuclei
- [ ] **B-** Forces between protons
- [ ] **C-** Electron-pair bonds
- [ ] **D-** None of the above

04.

When a pentavalent impurity is added to a pure semiconductor, it becomes ……..

- [ ] **A-** An insulator
- [ ] **B-** An intrinsic semiconductor
- [ ] **C-** p-type semiconductor
- [ ] **D-** n-type semiconductor

LET'S DO SOME

REVISION (CONT)..

05.

Addition of pentavalent impurity to a semiconductor creates many ……..

- ☐ **A-** Free electrons
- ☐ **B-** Holes
- ☐ **C-** Valence electrons
- ☐ **D-** Bound electrons

06.

A pentavalent impurity has ……. Valence electrons

- ☐ **A-** 3
- ☐ **B-** 5
- ☐ **C-** 4
- ☐ **D-** 6

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