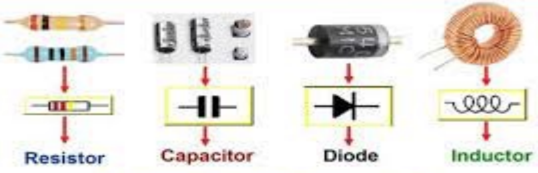
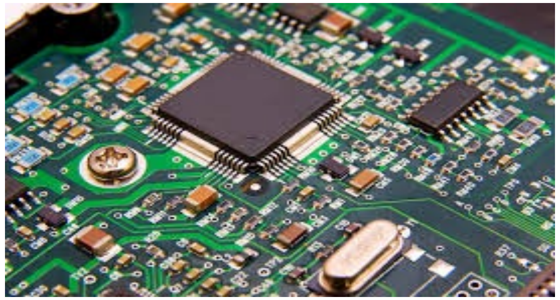




Electronics 1

BSC 113

Fall 2022-2023

Lecture 10

Sinusoidal Steady State Analysis
Introduction to Semiconductors

INSTRUCTOR

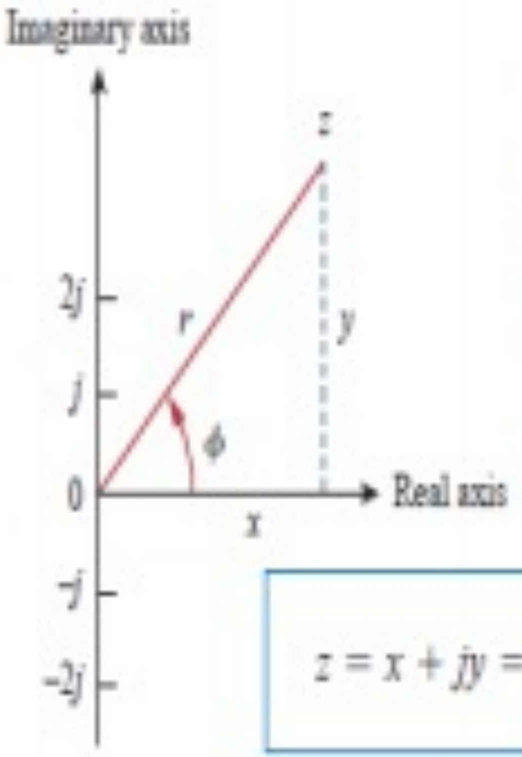
DR / AYMAN SOLIMAN

➢ Contents

1) Phasors and sin wave
2) Electrical circuit analysis
3) Average and RMS
4) Definitions of atom
5) Basic of materials
6) Semiconductor concepts
7) doping process
8) N-type material & P-type material

1- Phasors and sin wave

- A phasor is a complex number that represents the amplitude and phase of a sinusoid.



$z = x + jy$ Rectangular form

$z = r\angle\phi$ Polar form

$z = re^{j\phi}$ Exponential form

$r = \sqrt{x^2 + y^2}, \quad \phi = \tan^{-1}\frac{y}{x}$

$x = r\cos\phi, \quad y = r\sin\phi$

$$z = x + jy = r\angle\phi = r(\cos\phi + j\sin\phi)$$

Subtraction: $z_1 - z_2 = (x_1 - x_2) + j(y_1 - y_2)$

Multiplication: $z_1 z_2 = r_1 r_2 \angle\phi_1 + \phi_2$

Division: $\frac{z_1}{z_2} = \frac{r_1}{r_2}\angle\phi_1 - \phi_2$

Reciprocal: $\frac{1}{z} = \frac{1}{r}\angle-\phi$

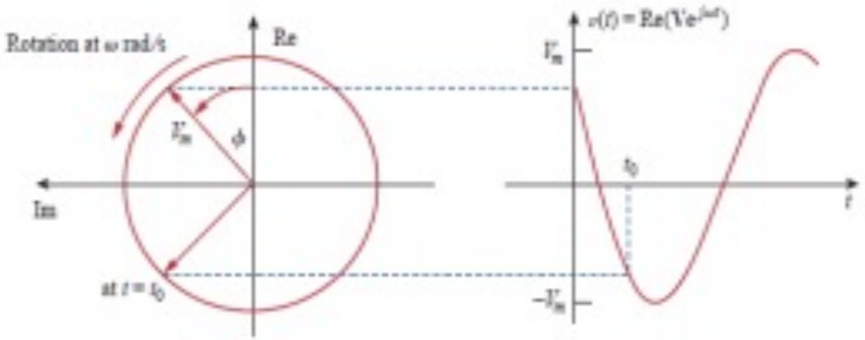
Square Root: $\sqrt{z} = \sqrt{r}\angle\phi/2$

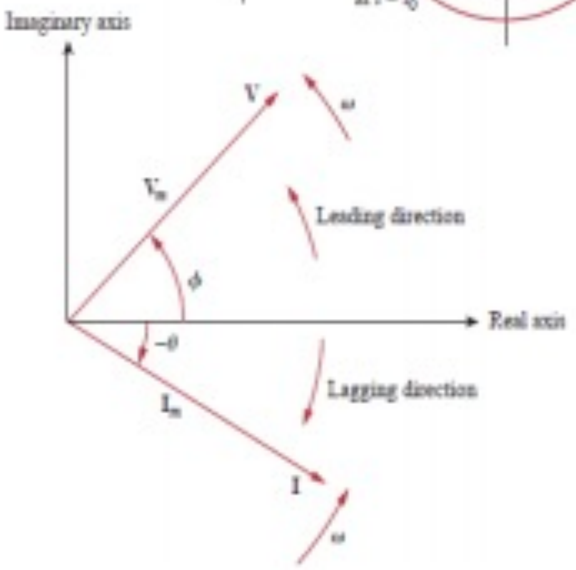
Complex Conjugate:

$z^* = x - jy = r\angle-\phi = re^{-j\phi}$

1- Phasors and sin wave

- A phasor is a complex number that represents the amplitude and phase of a sinusoid.



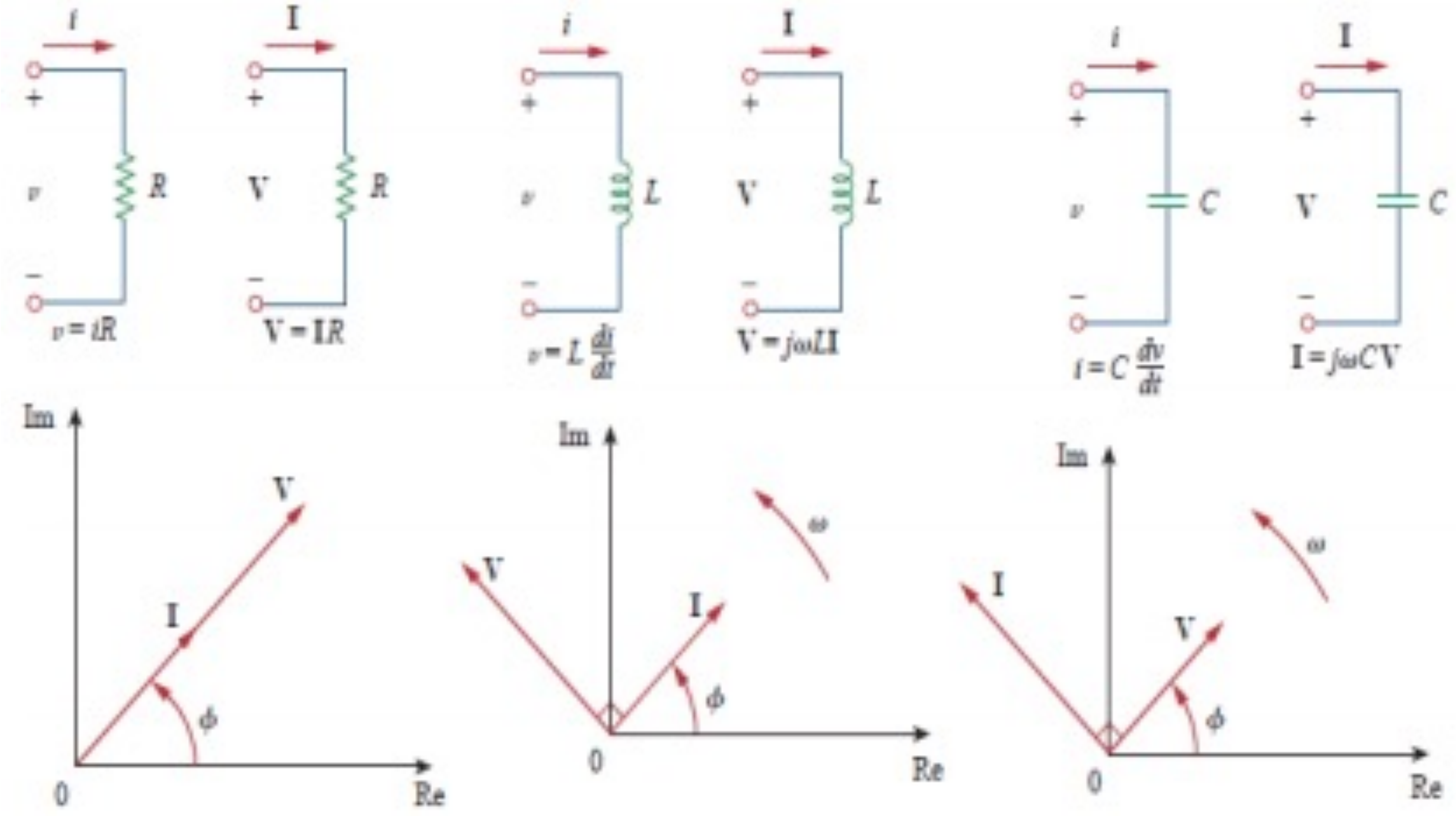


Sinusoid-phasor transformation.

Time domain representation	Phasor domain representation
$V_m \cos(\omega t + \phi)$	$V_m \angle \phi$
$V_m \sin(\omega t + \phi)$	$V_m \angle \phi - 90°$
$I_m \cos(\omega t + \theta)$	$I_m \angle \theta$
$I_m \sin(\omega t + \theta)$	$I_m \angle \theta - 90°$

2- Electrical circuit analysis

➢ Phasor relationships of circuit elements



2- Electrical circuit analysis

- Summary of voltage-current relationships

Element	Time domain	Frequency domain
R	$v = Ri$	$\mathbf{V} = R\mathbf{I}$
L	$v = L\frac{di}{dt}$	$\mathbf{V} = j\omega L\mathbf{I}$
C	$i = C\frac{dv}{dt}$	$\mathbf{V} = \frac{\mathbf{I}}{j\omega C}$

3- Average and RMS

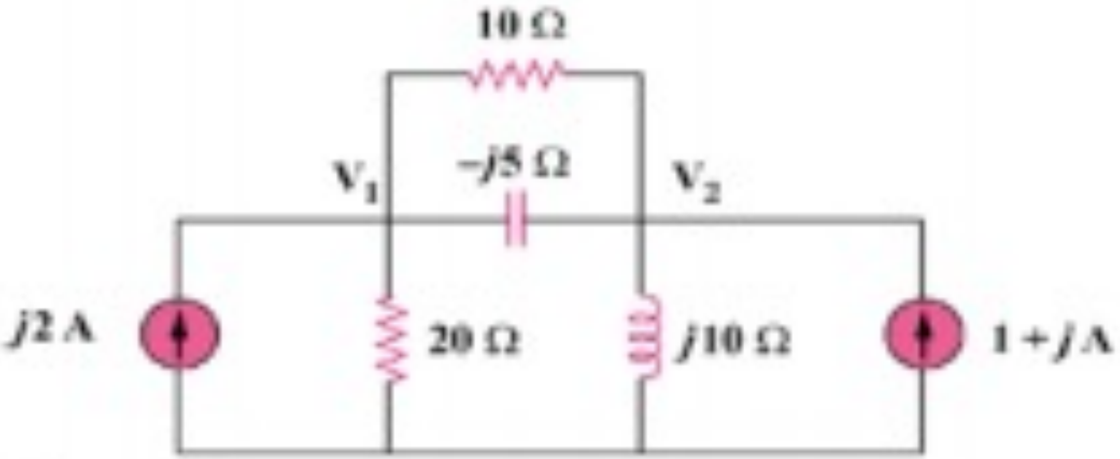
- The two important parameter in electronics calculations is average and root mean square value which are discussed here.

$$v_{avg} = \frac{1}{T}\int_0^T v(t)dt$$

- Given a periodic function , its rms value (or the effective value) is given by

$$v_{rms} = \sqrt{\frac{1}{T}\int_0^T v^2(t)dt}$$

Example



At node 1,

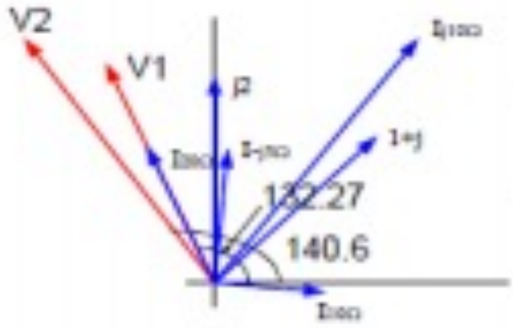
$$j2 = \frac{V_1}{20} + \frac{V_1 - V_2}{10} + \frac{V_1 - V_2}{-j5}$$

$$j40 = (3 + j4)V_1 - (2 + j4)V_2$$

At node 2,

$$\frac{V_1 - V_2}{10} + \frac{V_1 - V_2}{-j5} + 1 + j = \frac{V_2}{j10}$$

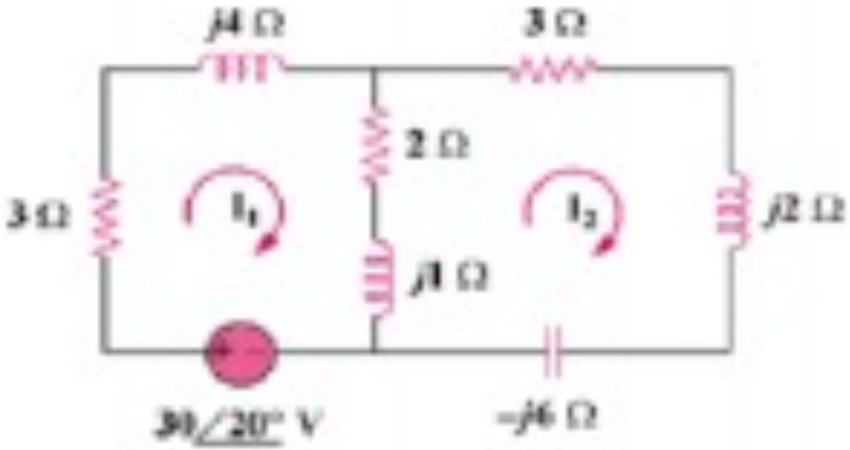
$$10(1 + j) = -(1 + j2)V_1 + (1 + j)V_2$$



$V_1 = \underline{22.87\angle 132.27^\circ}$ V

$V_2 = \underline{27.87\angle 140.6^\circ}$ V

Example



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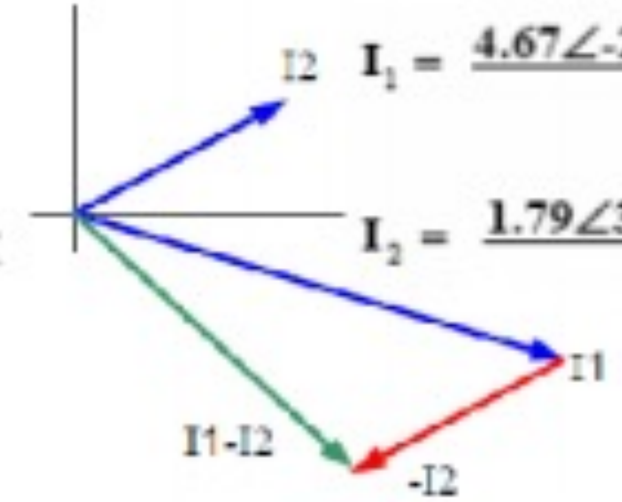


$\mathbf{I}_1 = \underline{4.67\angle -20.17° \text{ A}}$

$\mathbf{I}_2 = \underline{1.79\angle 37.35° \text{ A}}$

For mesh 1,

$$(5 + j5)\mathbf{I}_1 - (2 + j)\mathbf{I}_2 - 30\angle 20° = 0$$
$$30\angle 20° = (5 + j5)\mathbf{I}_1 - (2 + j)\mathbf{I}_2$$
(1)

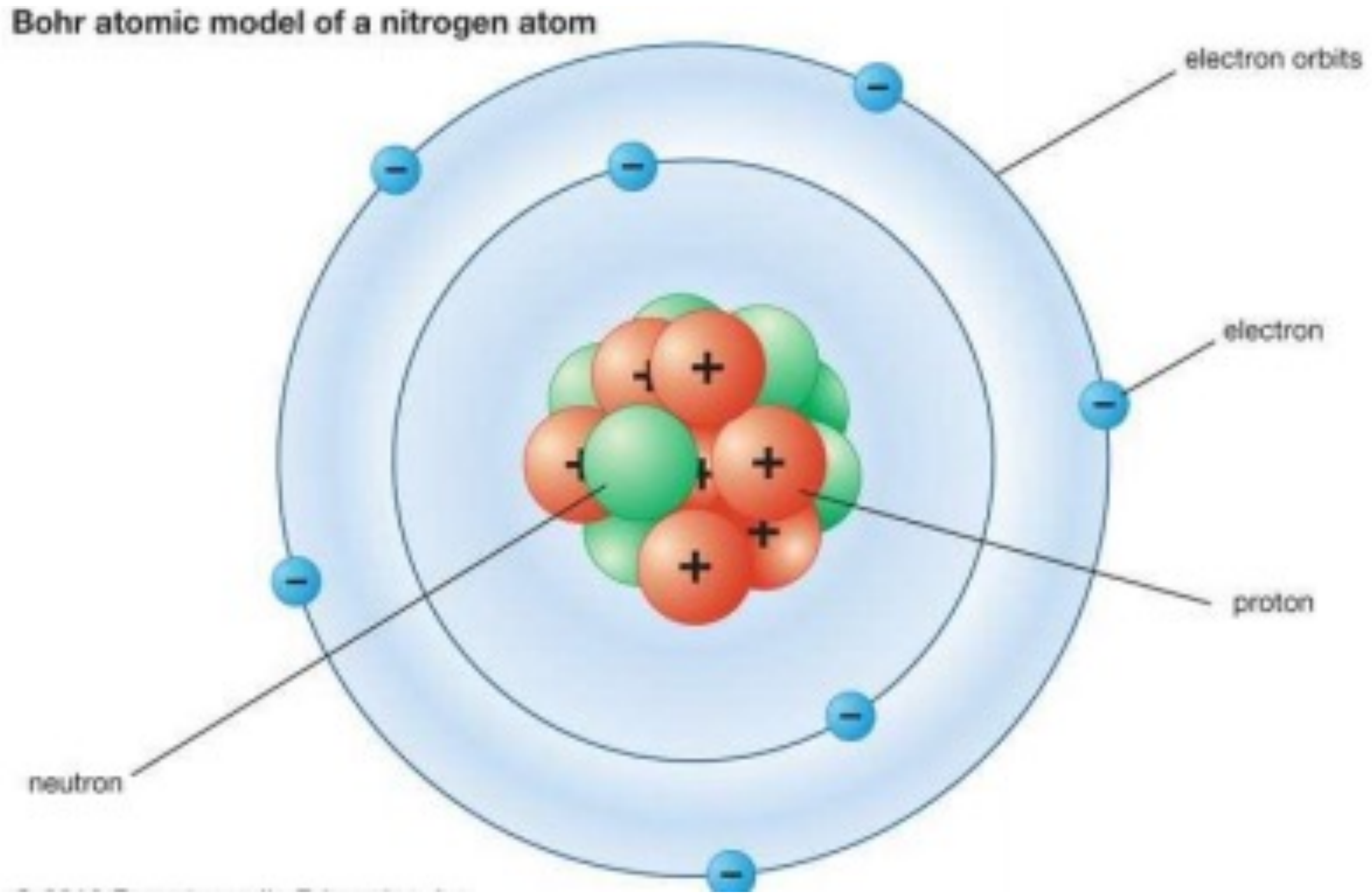
For mesh 2,

$$(5 + j3 - j6)\mathbf{I}_2 - (2 + j)\mathbf{I}_1 = 0$$
$$0 = -(2 + j)\mathbf{I}_1 + (5 - j3)\mathbf{I}_2$$
(2)

Semiconductor

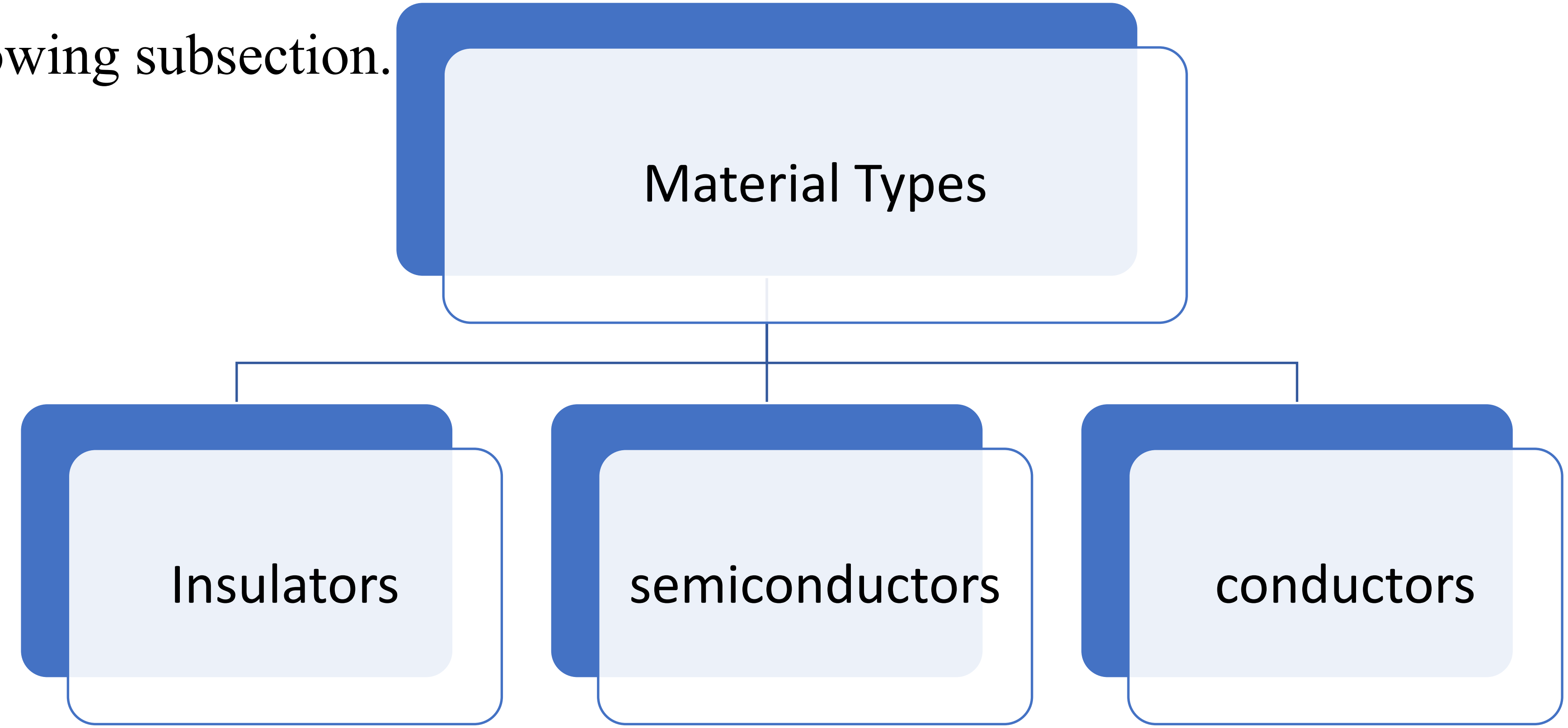
❑ 1. Definitions of atom

- The atom is considered the smallest particle of the element.

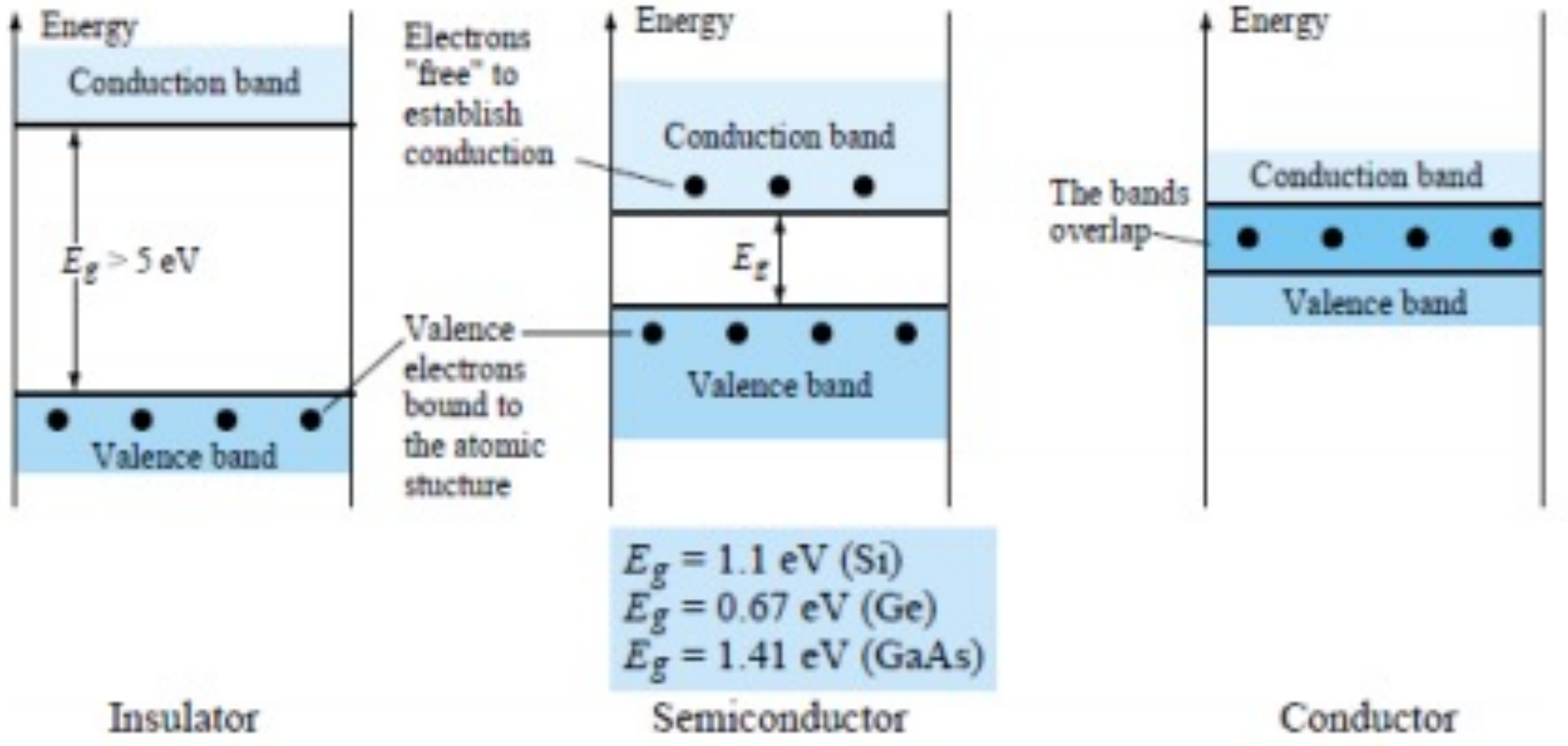


❑ 2. Basic of materials

➢ 2.1 Resistivity: We can define the resistivity as resistance of matter against flow the electrical current. Now the differences between materials will be stated in the following subsection.

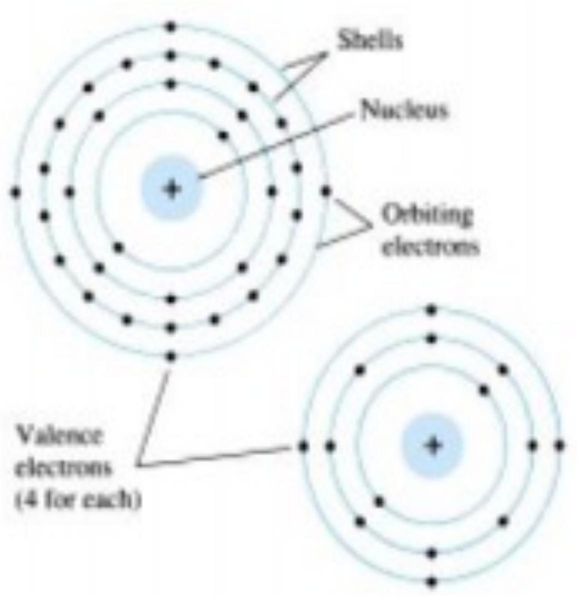


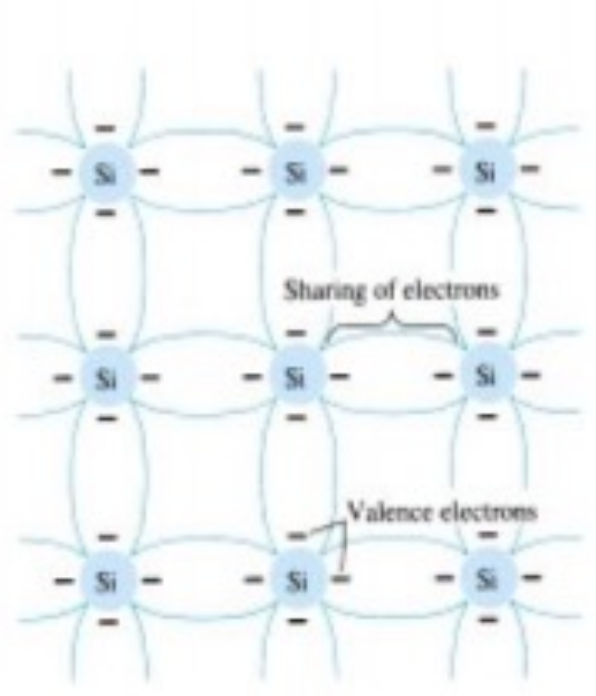
❑ Material Types



❑ Semiconductor concepts

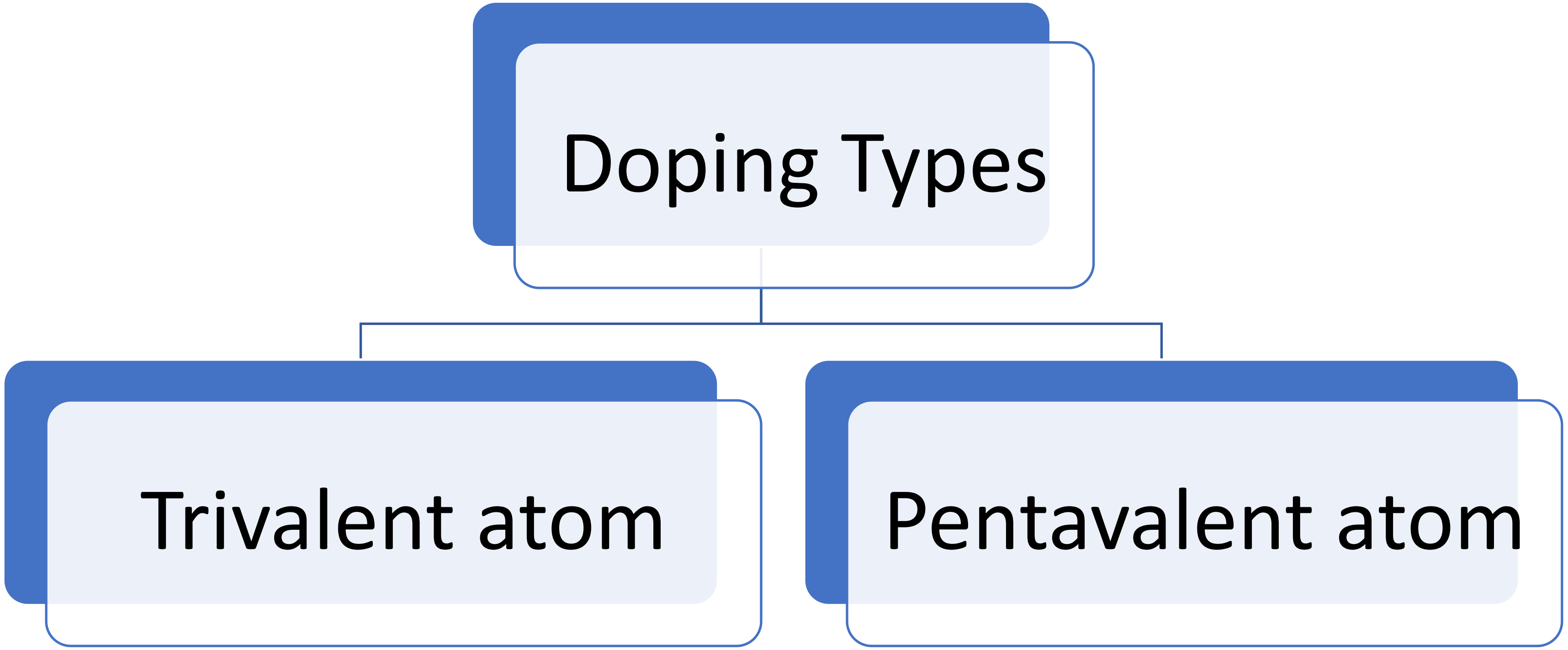
- The more popular semiconductor materials are Silicon (Si) which has 14 electrons and germanium (Ge) which has 32 electrons. All semiconductors have 4 electrons at the Fermi level.





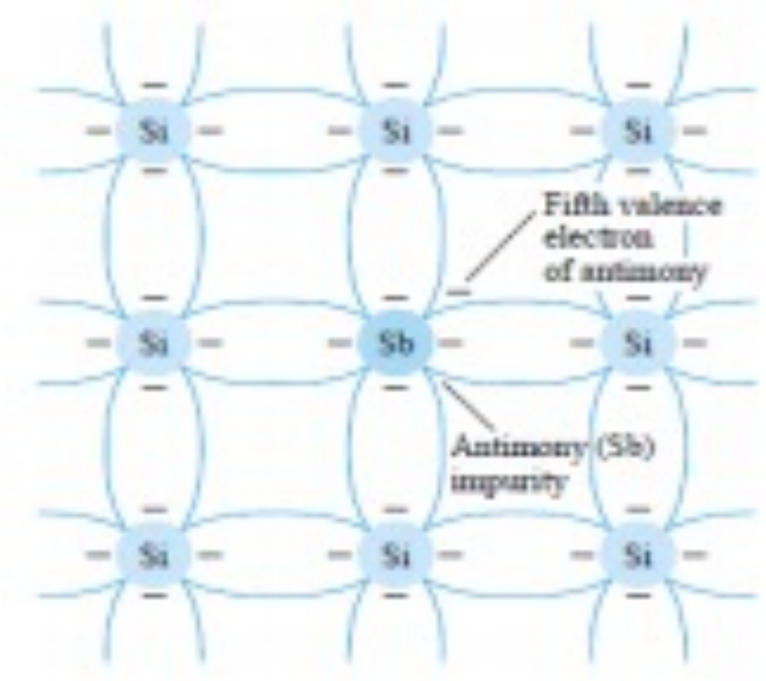
❑ doping process

➢ The doping is control process by adding impurities to pure semiconductors to enhance its conductivity to electrical current.



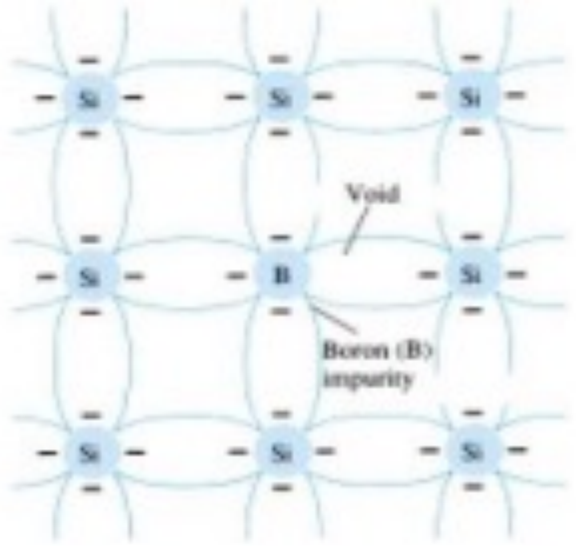
❑ N-type material

➢ This type is negative type with majority of electrons and minority of holes. The doping in this type is happened by pentavalent atom which has five electrons in the Fermi level. Four of them complete covalent bonds and still one free electron to conduct electrical current



P-type material

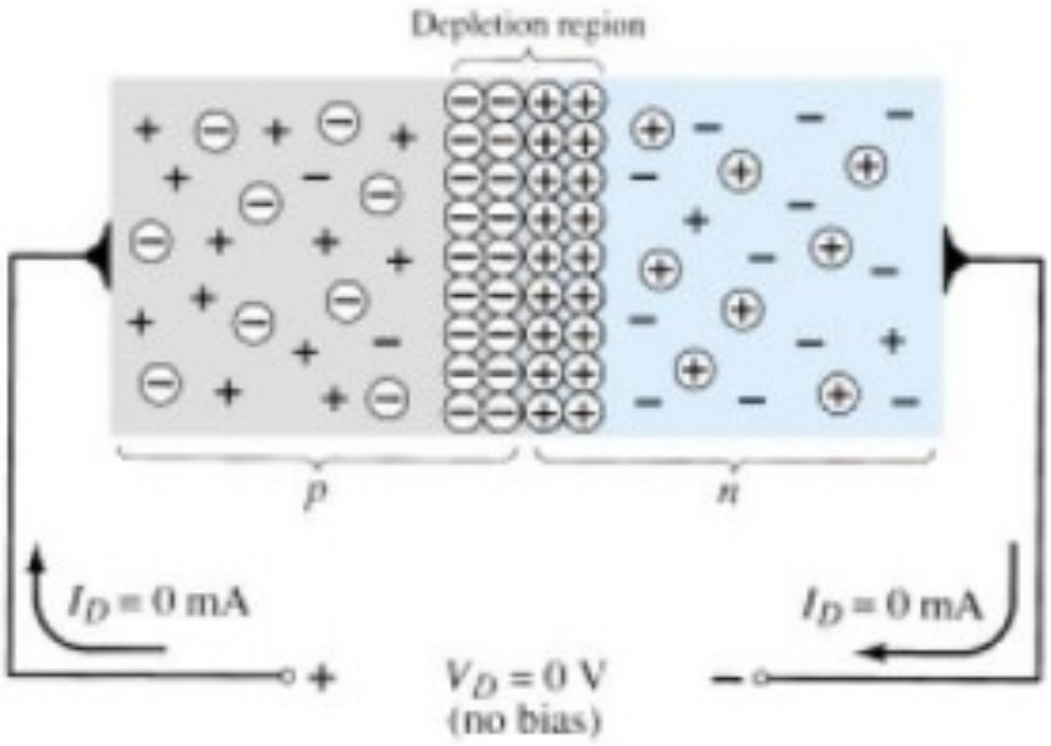
- This type is positive type with majority of holes and minority of electrons. The doping in this type is happened by trivalent atom which has three electrons in the Fermi level. all of them complete covalent bonds and still one hole needs one free electron to conduct electrical current



❑ Depletion layer

- First, we will put N-type material beside P-type material. The diffusion of electrons will be happened from N-type to P-type.
- The second step is the recombination between electrons and holes to complete electron and hole pairs.
- The third step is the ionization which makes the N-type change from neutral state to positive ions (Donor's atoms) and the P-type change from neutral state to negative ions (Acceptors atoms). At the equilibrium between the attraction force between positive ions and electrons and the repulsion force between negative ions and electrons complete the depletion layer

❑ **Depletion layer**



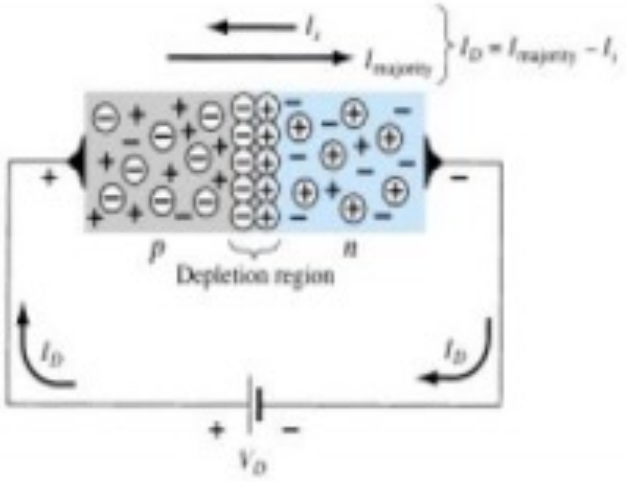
❑ Forward bias

- Forward bias (F.B): the connection is positive DC battery with P-type and negative DC battery with N-type generate two repulsion force between them then depletion region width is reduced then flow the electrical current I_D.

$$I_D = I_s\left(e^{\frac{kV_d}{T_k}} - 1\right) \qquad (5\text{-}1)$$

where:

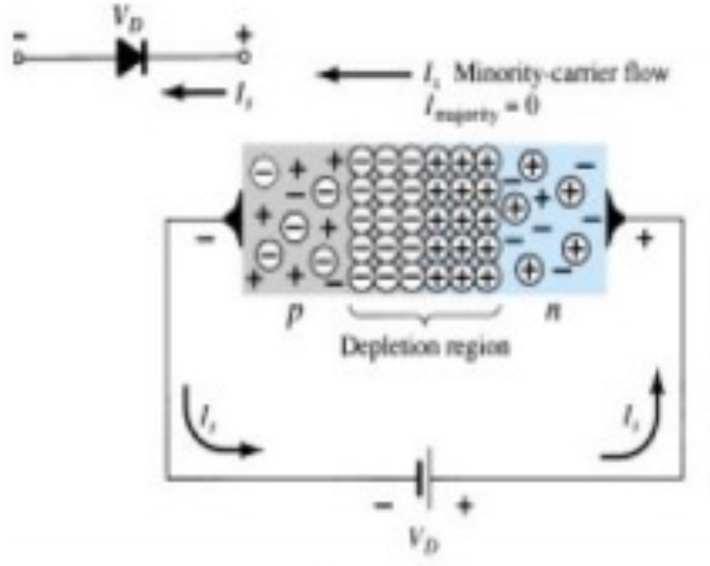
V_d: Voltage on diode.
k: 11,600/η with $\eta = 1$ for Ge and $\eta = 2$ for Si.
T_k: $T_C + 273$.



(b) F.B

❑ Reverse bias

- Reverse bias (R.B): the connection is positive DC battery with N-type and negative DC battery with P-type generate two attraction force between them then depletion region width is increased then no flow the electrical current or flow small reverse saturation current I_s.



(a) R.B


Thank you