

# HindPhotostat



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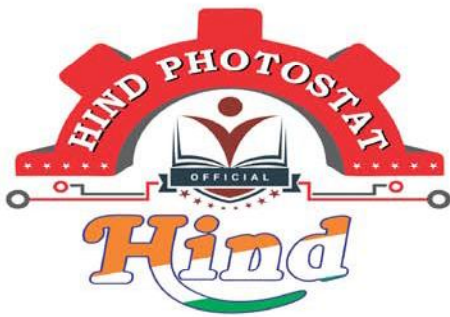
### MADE EASY ELECTRICAL ENGINEERING

Basic Electronics  
By.Rajender Sir

- Theory
- Explanation
- Derivation
- Example
- Shortcuts
- Previous Years Question With Solution

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## **PUBLICATIONS BOOKS -**

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## Books:-

1) Semiconductor Physics and Devices  
— DONALD NEAMEN.

2) GATE

↳ Basics } Solved Examples  
↳ Diode } of Donald Neamen.  
↳ \*\* FET }

## \* CLASSIFICATION OF TEMPERATURE (T):

\* Divided into three parts:

1) ABSOLUTE TEMPERATURE ( $0\text{K} = -273^\circ\text{C}$ )

2) ROOM TEMPERATURE ( $300\text{K} = 27^\circ\text{C}$ )

3) AMBIENT TEMPERATURE ( $T_A$ ) ( $290\text{K} = 17^\circ\text{C}$ )

old Notation  
\*  $^0\text{K} = \text{K}$   
New Notation

\* Absolute Temperature is Practically not Possible. It is only the Reference Temperature, and never used in Reality.

\* Absolute Temperature is just a Reference temperature

\* At Room temperature, all properties of Semiconductor Devices are max<sup>m</sup> at Room temperature.

\* All Properties of Comm<sup>n</sup> systems are taken at the Ambient Temp. ie  $290\text{K}$  or  $17^\circ\text{C}$ .

\* \*\*  $\boxed{\text{TEMPERATURE in KELVIN} = \text{TEMPERATURE in } ^\circ\text{C} + 273}$

## \* THERMAL VOLTAGE ( $V_T$ ):

\* Also called as the "VOLT EQUIVALENT OF TEMPERATURE".

\* Most of S.C devices properties changes with temperature.

\* Mathematically,

\*  $\boxed{V_T = \frac{\bar{K} T}{q} \text{ Volts}}$

Where,  $T$  = Temperature in Kelvin  
 $q$  = Magnitude of charge ( $1.6 \times 10^{-19} \text{C}$ )  
 $\bar{K} = 1.381 \times 10^{-23} \text{ J/}^\circ\text{K}$

Also,

$$V_T = \frac{T}{11600} \text{ volts}$$

Hence,

i) At  $T = 0\text{K} \Rightarrow V_T = 0 \text{ volts}$

ii) At  $T = 300\text{K} \Rightarrow V_T = \frac{300}{11600}$

\*\*  
 $V_T = 0.02568 \text{ volts}$   
 $= 26 \text{ mV.}$

Note :

i) For a large variation in Temperature, the variation in the Thermal voltage is negligible.

\* BOLTZMANN CONSTANT :

$$\bar{K} = 1.381 \times 10^{-23} \text{ J/}^\circ\text{K}$$

$$K = 8.62 \times 10^{-5} \text{ eV/}^\circ\text{K}$$

Hence,

\*\*  
 $\bar{K} = 1.6 \times 10^{-19} \text{ K}$

Hence,

$$V_T = \frac{\bar{K}T}{q} = \frac{qKT}{q}$$

\*\*

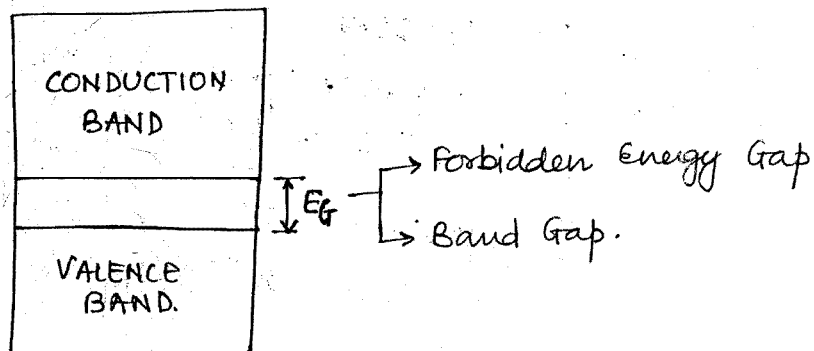
$$V_T = KT = \frac{\bar{K}T}{q}$$

↳ Numerically equal values.

\* ENERGY GAP ( $E_G$  or  $E_g$ ) :

\* Gap between Valence Band and Conduction Band is called as Energy Gap.

\* Band diagram of Semiconductor (SC) is given as:



	$E_{G0}$	$E_{G300}$
Ge	0.782 eV	0.72 eV
Si	1.21 eV	1.1 eV

\*\* Energy Gap decreases with Temperature in a semiconductor.  
Mathematically,

$$E_G \propto \frac{1}{\text{Temp}}$$

\* To calculate  $E_G$  at different temp we can use:

$$E_G(T) = E_{G0} - \beta_0 T \text{ (eV)}$$

$\beta_0$  = material constant (eV/°K)

\* For Germanium:

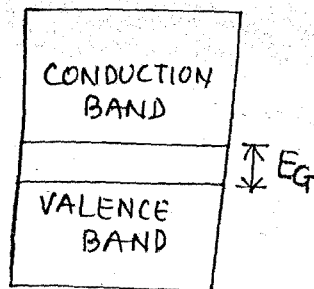
$$E_G(T) = 0.782 - 2.33 \times 10^{-4} T \text{ (eV)}$$

\* For Silicon:

$$E_G(T) = 1.21 - 3.6 \times 10^{-4} T \text{ (eV)}$$

\* For a semiconductor, Energy Gap is small

$$E_G \leq 1.5 \text{ eV}$$



Note:

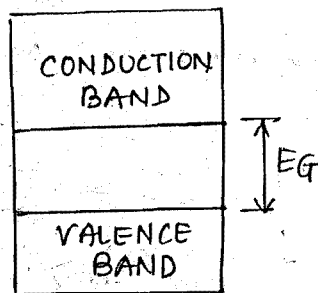
- 1) Semiconductors are BIPOLAR
- 2) Semiconductor can contribute DIFFUSION CURRENT.
- 3) Semiconductor has NTC of RESISTANCE

$$T \uparrow \quad R \downarrow$$

\*Note:

\* For Insulators, the Energy Gap is large

\*\*\*  $E_g \gg 5\text{eV}$



\* Insulators are Bad conductors of current, and their Conductivity is negligible.

\* For Ideal Insulator, Conductivity is Zero.

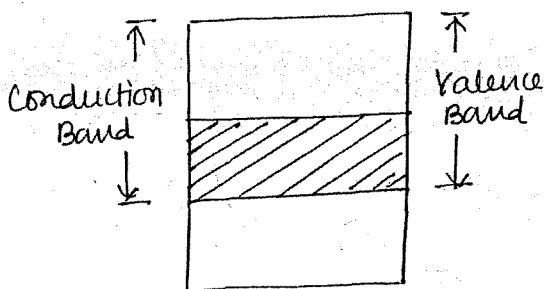
Note:

1) If Energy Gap is small, less amount of additional energy is required for the  $e^-$  to jump from "VALENCE BAND" to "CONDUCTION BAND"

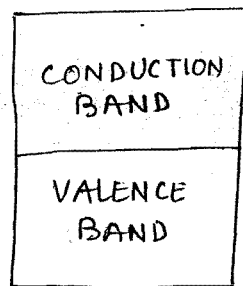
\* For Metals (conductors)

$E_g = 0\text{eV}$  + Practically negligible value.

(Non Zero Energy Gap)



(at  $T = 300\text{K}$ )



(at  $T = 0\text{K}$ )

\* For metals, the conductors ~~and~~ the Conduction Band and Valence Band overlap each other and the overlapping increases with Temp.

\* Conductivity is very large in conductors

\* Only DRIFT CURRENT flows in conductor

\* Conductors are unipolar, current carried only by  $e^-$ .

\* PTC of Resistance: \*\*\*  $T \uparrow R \uparrow$  ← Exclusive Property of Metals.

## \* Definition of Semiconductor:-

\* Semiconductors are the elements whose conductivity lies in between in the conductivity of an insulators and the conductivity of a metal.

## \* ELECTRON VOLT (eV):-

\* Electron volt is a unit of ENERGY

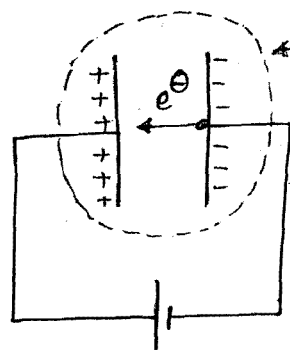
\* Very small unit of Energy (almost fraction of unit of Energy ie Joule).

\* Electron volt is the unit of ENERGY in Electronics

\* 1 eV is defined as the energy gained by the electron ( $e^-$ ) in moving through a potential difference of 1V.

Note:-

\* Air is a perfect insulator, the Best insulator.



Vacuumised Glass Tube

Note:-

\*  $e^-$  cannot move through air, hence air in the glass has been removed.

\*  $e^-$  can move through Vacuum

↳ for eg → Vacuum Tubes

Mathematically,

$$1 \text{ eV} = |q| \times \text{Potential difference}$$

$$= 1.6 \times 10^{-19} \text{ C} \times 1 \text{ V}$$

$$= 1.6 \times 10^{-19} \text{ C.V}$$

$$\text{Or } 1 \text{ eV} = 1.6 \times 10^{-19} \text{ Joules}$$
$$= 1.6 \times 10^{-19} \text{ Coulomb-Volt}$$

Note:-

\* Electron volt is the Kinetic Energy Gained by the  $e^-$  or the Potential energy lost by the  $e^-$ .

Mathematically,

\*\* Kinetic Energy =  $\frac{1}{2} m v^2$   
 $m = \text{mass of } e^-$   
 $= 9.1 \times 10^{-31} \text{ Kg}$

\*\* Potential Energy =  $q \times V$   
 $V = \text{Potential difference}$

By definition:-

KE gained = PE lost

$\frac{1}{2} m v^2 = q V$

\*\* Velocity of  $e^-$ ,  $v = \sqrt{\frac{2qV}{m}} \text{ m/s}$

\* ELECTRIC FIELD INTENSITY ( $\epsilon$  or  $E$ ) :-

\* Also called Field Intensity

\* Also called as Field Gradient

\* Also called as Field.

\* Mathematically,

\*\*  $\epsilon = - \frac{dV}{dx} \text{ Volt/metre}$

Also, \*\*

$|\epsilon| = \frac{\text{magnitude of voltage existing}}{\text{distance or space}}$

Note :-

