MADE EASY

ELECTRICAL ENGINEERING

Basic Electronics

By.Rajender Sir

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

Books :-

1) Semiconductor Physics and Devices
— DONALD NEAMEN.

2) GATE
↳ Basics
↳ Diode
↳ ** FET

} Solved Examples of Donald Neamen.

* CLASSIFICATION OF TEMPERATURE (T) :-

* Divided into three parts :-

1) ABSOLUTE TEMPERATURE (0K = −273°c)
2) ROOM TEMPERATURE (300K = 27°c)
3) AMBIENT TEMPERATURE (T_A) (290 K = 17°c)

** $^{o}K = K$ (old Notation: ^{o}K; New Notation: K)

* 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^m at Room temperature.
* All Properties of Common systems are taken at the Ambient Temp. ie 290K or 17°c.

** * TEMPERATURE in KELVIN = TEMPERATURE in °c + 273

* THERMAL VOLTAGE (V_T) :-

* Also called as the "VOLT EQUIVALENT OF TEMPERATURE".
* Most of s.c devices properties changes with temperature.
* Mathematically,

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

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

Also, $V_T = \frac{T}{11600}$ volts

Hence,

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

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

** $V_T = 0.02568$ volts $= 26$ mV.

Note :

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

* BOLTZMANN CONSTANT :

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

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

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

Hence, $V_T = \frac{\bar{K}T}{q} = \frac{q \times K T}{q}$

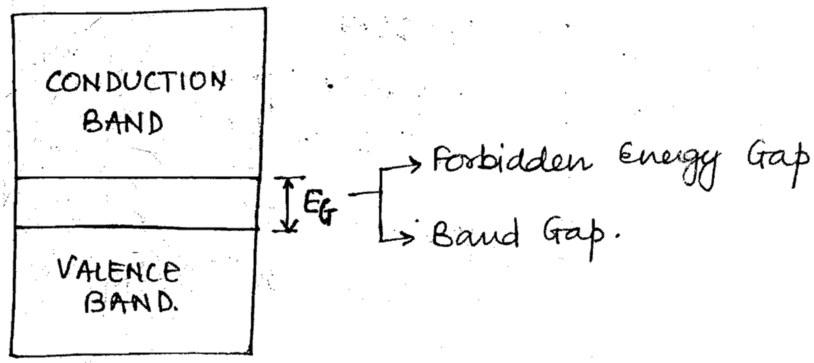
** $V_T = KT = \frac{\bar{K}T}{q}$

↳ 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,

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

* To calculate E_G at different temp we can use:-

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

β_0 = material constant (eV/°K)

* <u>For Germanium</u>:-

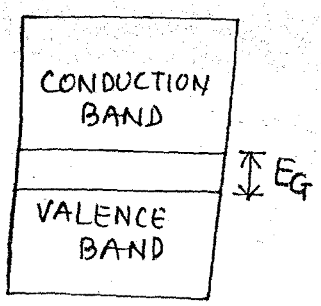
$$E_G(T) = 0.782 - 2.33\times10^{-4}\,T \text{ (eV)}$$

* For Silicon:-

$$E_G(T) = 1.21 - 3.6\times10^{-4}\,T \text{ (eV)}$$

* For a semiconductor, Energy Gap is small

↳** $E_G \leq 1.5\,eV$



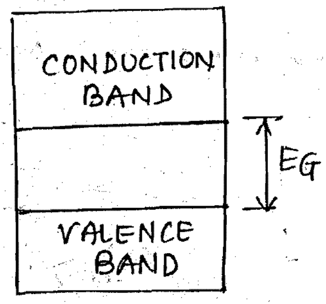
<u>Note</u>:-
1) Semi Conductors are BIPOLAR
2) Semi Conductor can contribute DIFFUSION CURRENT.
3) Semi Conductor has NTC of RESISTANCE

** T↑ R↓

*Note:·

* For Insulators, the Energy Gap is large

└** $E_G \geq 5eV$



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

* For Ideal Insulator, Conductivity is zero.

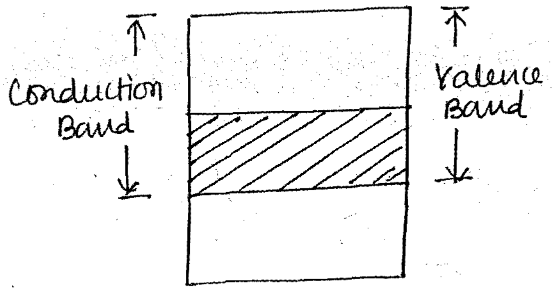
Note:

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

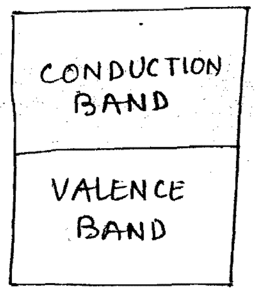
* For Metals (Conductors):

└ $E_G = 0\,eV$ ← Practically negligible value.

└ (Non Zero Energy Gap)



(at T= 300K)



(at T=0K)

* 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 ~~in~~ by $e^{\ominus}$.
* PTC of Resistance :** $T\uparrow R\uparrow$ ← Exclusive Property of Metals.

* Definition of Semiconductor :-

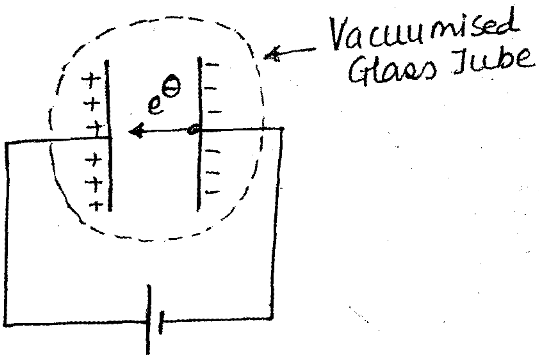
* Semiconductors are the elements whose conductivity lies in between in the conductivity of an insulators and the conductivity of a metal.

* 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
** * 1eV 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.



Note :-
* $e^{\ominus}$ cannot move through air, hence air in the glass has been removed.
* $e^{\ominus}$ can move through vacuum
  ↳ for eg → Vacuum Tubes

Mathematically,

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

$$= 1.6\times10^{-19}C \times 1V$$

** $$= 1.6\times10^{-19}C.V$$

or

$$1eV = 1.6\times10^{-19}\ \text{Joules}$$
$$= 1.6\times10^{-19}\ \text{Coulomb-Volt}$$

Note :-
* Electron Volt is the Kinetic Energy Gained by the $e^{\ominus}$ or the Potential energy lost by the $e^{\ominus}$.

Mathomatically,

** Kinetic Energy $= \frac{1}{2} m v^2$

m = mass of $e^{\ominus}$
$= 9.1 \times 10^{-31}$ Kg

** Potential Energy $= q \times V$

V = Potential difference

By definition:

KE gained = PE lost

$\frac{1}{2} m v^2 = qV$.

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

* ELECTRIC FIELD INTENSITY ($\mathcal{E}$ or E) :-

* Also called Field Intensity
* Also called as Field Gradient
* Also called as Field.

* Mathematically,

** $\mathcal{E} = -\frac{dV}{dx}$ Volts/metre

Also, **

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

Note :-