Solved Examples

1. Calculate the first and fifth energy levels for an electron in a potential well 0.2 mm wide.

Solution:

The energy of a particle inside in an infinite potential well is,

$$E_n = \frac{n^2h^2}{8ml^2}$$

For first energy level, $E_1 = \frac{1^2h^2}{8ml^2} = \frac{h^2}{8ml^2}$

$$= \frac{(6.62 \times 10^{-34})^2}{8 \times 9.1 \times 10^{-31} \times (0.2 \times 10^{-3})^2} = 1.5 \times 10^{-30} J$$

For fifth energy level, n = 5

$$E_5 = \frac{5^2h^2}{8ml^2} = 25 \times E_1 = 3.75 \times 10^{-29} J$$

5. **Find the temperature at which the probability of occupation of the energy state 0.75 eV above the Fermi level is 30 percentages.**

Solution:

Here, F (E) = 30% = 0.3

$$E = 0.75eV + E_F$$

We have, $F(E) = \dfrac{1}{\exp\left(\dfrac{E - E_F}{KT}\right) + 1} \Rightarrow 30\% = \dfrac{1}{\exp\left(\dfrac{0.75eV}{KT}\right) + 1}$

$$\exp\left(\frac{0.75eV}{KT}\right) + 1 = \frac{1}{0.3}$$

$$\exp\left(\frac{0.75eV}{KT}\right) = \frac{1}{0.3} - 1$$

$$\exp\left(\frac{0.75eV}{KT}\right) = 2.33$$

$$\frac{0.75eV}{KT} = ln\,(2.33)$$

$$T = \frac{0.75eV}{K \times ln\,(2.33)} = \frac{0.75 \times 1.6 \times 10^{-19}}{1.3 \times 10^{-23} \times ln\,(2.33)}$$

$$= 10280.15K$$

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10. **Find the temperature at which there is 98% probability that a state 0.3eV below the Fermi energy level will be occupied by an electron**

Solution:

Here, $F(E) = 98\% = 0.98$

$E = E_f - 0.3eV$

$$\text{We have, } F(E) = \frac{1}{\exp\left(\frac{E - E_F}{KT}\right) + 1}$$

$$0.98 = \frac{1}{\exp\left(\frac{E_F - 0.3eV - E_F}{KT}\right) + 1}$$

$$0.98 = \frac{1}{\exp\left(\frac{-0.3eV}{KT}\right) + 1}$$

$$\exp\left(\frac{-0.3eV}{KT}\right) + 1 = \frac{1}{0.98}$$

$$\exp\left(\frac{-0.3eV}{KT}\right) = 0.02$$

$$\exp\left(\frac{0.3eV}{KT}\right) = \frac{1}{0.02} \Rightarrow \exp\left(\frac{0.3eV}{KT}\right) = 50$$

$$\left(\frac{0.3eV}{KT}\right) = ln\ (50)$$

$$T = \frac{0.3eV}{K \times ln\ (50)} = \frac{0.3 \times 1.6 \times 10^{-19}}{1.38 \times 10^{-23} \times ln(50)} = 889.12\ K$$

17. **Evaluate the probability of finding electron 1.5 KT above the Fermi level.**

Solution:

Here, $E = E_F + 1.5\ KT$

We have,

$$F(E) = \frac{1}{\exp\left(\frac{E - E_F}{KT}\right) + 1} = \frac{1}{\exp\left(\frac{E_F + 1.5\ KT - E_F}{KT}\right) + 1}$$

$$F(E) = \frac{1}{e^{1.5} + 1} = 0.18$$

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23. The conductivity and drift mobility of copper conductor is 5.9×10^5 sm/cm and 43.4 cm^2/V.S. Calculate Fermi level for copper conductor.

→ no. of electrons per unit volume,

Solution:

Here, $\sigma = 5.9 \times 10^5$ Sm/cm $= \frac{5.9\times10^5}{10^{-2}}$ Siemens/ m

$= 5.9 \times 10^7\ \Omega^{-1}m^{-1}\ [S \Rightarrow \Omega^{-1}]$

And, $\mu = 43.4\ cm^2/V.S.$

$= 43.4 \times 10^{-4}\ m^2\ V^{-1}S^{-1}$

Since, $\sigma = ne\mu$

$$n = \frac{\sigma}{e\mu} = \frac{5.9 \times 10^7}{1.6 \times 10^{-19} \times 43.4 \times 10^{-4}}$$

$n = 8.5 \times 10^{28}/m^3$

Now, the Fermi energy is given by,

$$E_F = \frac{\hbar^2}{2m}(3\pi^2 n)^{2/3}$$

$$= \frac{(1.054 \times 10^{-34})^2}{2 \times 9.1 \times 10^{-31}}(3 \times 3.14^2 \times 8.5 \times 10^{28})^{2/3}$$

$$= 1.1286 \times 10^{-18} \text{ Joule}$$

$$= 7.05 \text{ eV}$$

$= 0.033 eV.$

27. Calculate the kinetic energy of a neutron having de-Broglie wave length 1A°, (mass of neutron = 1.67×10^{-27} kg)

Solution:

Here, $\lambda = 1A^{o} = 10^{-10}$m, $m = 1.67 \times 10^{-27}$ kg

Since, $\lambda = \frac{h}{mv} \Rightarrow v = \frac{h}{m\lambda}$

$$v = \frac{6.624 \times 10^{-34}}{1.67 \times 10^{-27} \times 10^{-10}} = 4 \times 10^{3} \text{m/sec}$$

The kinetic energy of neutron is given by,

$$E = \frac{1}{2}\, mv^{2} = \frac{1}{2}\, (1.67 \times 10^{-27}) \times (4 \times 10^{3})^{2}$$

$= 1.336 \times 10^{-20}$ Joule

$= 0.083$ eV

Find the

electrons in copper. What is transmission probability for conduction electrons in copper, which have kinetic energy of about 7eV?

39. An electron is confined in an infinite potential well. The length of confinement is 0.01 nm. Find the energy and wave function of electron at third energy level.

40. Find the wave length of an electron accelerated by 100V.

41. Given E_F is the Fermi level. Show that the probability of emptying $E_F - \Delta E$ energy level is equal to probability of occupying $E_F + \Delta E$ energy level.

42. Calculate the wave length and energy of a proton of mass 1.67×10^{-27} kg while traveling with a velocity of 2200 ms^{-1}.

43. An electron is confined to a box of length 10^{-8} meter; calculate the minimum uncertainty in its velocity. Given $M = 9\times10^{-31}$ kg, $\hbar = 1.05\times10^{-34}$ JS

44. An electron is bounded by a potential which closely approaches an infinite square well of width 2.5×10^{-10} m. Calculate the lowest three permissible quantum energies the electron can have.

45. Calculate the Fermi energy for silver assuming 6×10^{22} free electrons per cubic centimeter. Take $m = 0.97\ m_o$ for silver, rest mass of electron $(m_o) = 9.1\times10^{-31}$ kg

46. At what temperature we can expect a 10% probability that electrons in silver have energy, which is 1% above the Fermi level. ($E_F = 5.5$eV)

47. Calculate the wave length of an electron accelerated by 50 V.

48. Consider an electron in an infinite potential well of size 0.12 nm. What is the energy required to put this electron from ground level to third energy level? What is the wave length of photon required to do this.

49. Find the temperature at which there is a 1% probability that a state 0.08 eV above Fermi level will be occupied by an electron.

50. A vacuum is required to have a cathode operating at 800°C and providing a saturation current of 10A. What should be the surface area of cathode if Thoriated Tungsten is used as cathode material having work function $\phi = 2.6$ eV and Richardson's constant is $3\times10^{4}\ Am^{-2}K^{-2}$.

51. Find momentum and energy of an electron having wave length 450 nm.

52. Consider silver in the metallic state with one free electron per atom. Calculate the Fermi energy. Given, density of silver is 10.5 gm cm^{-3} and atomic weight 108.

53. Evaluate the probability that an energy state KT above the Fermi level will be occupied by an electron.

$= 3.6 \times 10^{...} cm^2 S$

3. Calculate the drift mobility and the mean scattering time of conduction electrons in copper at room temperature, given that the conductivity of copper is $5.9 \times 10^5 \Omega^{-1} cm^{-1}$. The density of copper is 8.96 gcm^{-3} and its atomic mass is 63.5 $gmol^{-1}$. (Assume one free electron per atom)

Solution:

Here, conductivity, $\sigma = 5.9 \times 10^5\ \Omega^{-1}\ cm^{-1}$, density, $d = 8.96\ g\ cm^{-3}$ atomic mass, $M_{at} = 63.5$ g mol^{-1}.

We have, number of copper atoms per unit volume $n = \dfrac{dN_A}{M_{at}}$

$$= \frac{8.96 \times 6.02 \times 10^{23}}{63.5} = 8.5 \times 10^{22}\ cm^{-3}$$

Since, $\sigma = ne\mu$

$$\Rightarrow \mu = \frac{\sigma}{ne} = \frac{5.9 \times 10^5}{1.6 \times 10^{-19} \times 8.5 \times 10^{22}} = 43.4\ cm^2\ V^{-1} S^{-1}$$

Again, $\mu = \dfrac{e\tau}{m}$

$$\Rightarrow \tau = \frac{\mu m}{e} = \frac{43.4 \times 10^{-4} \times 9.1 \times 10^{-31}}{1.6 \times 10^{-19}} = 2.5 \times 10^{-14}\ S$$

4. The resistivity of copper at 20 degree centigrade is 0.69×10^{-8} Ω-m and density of free electron is 8.5×10^{28} m^{-3}. Calculate the mean free time of electron in copper lattice, Assume $m^* = 1.01$ m, where $m = 9.1 \times 10^{-31}$ kg.

Solution:

Here Temperature (T) = 20°C = 293 K.

Resistivity, $(\rho) = 0.69 \times 10^{-8}\Omega$-m, density of free electron,

$n = 8.5 \times 10^{28} m^{-3}$, $m = 1.01 \times 9.1 \times 10^{-31} = 9.191 \times 10^{-31}$ kg.

We have conductivity, $\sigma = \dfrac{ne^2\tau}{m} \Rightarrow \tau = \dfrac{m\sigma}{ne^2} = \dfrac{m}{ne^2\rho}$

$$\therefore \tau = \frac{9.191 \times 10^{-31}}{8.5 \times 10^{28} \times (1.6 \times 10^{-19})^2 \times 0.69 \times 10^{-8}}$$

$= 6.12 \times 10^{-14}$ sec.

Solved Examples

1. **The electronic polarizibility of the Ar atom is 1.7×10^{-40} Fm^2. What is the static dielectric constant of solid Ar if it's density is 1.8 gcm^{-3}? Given $N_A = 6.02 \times 10^{23}$ mol^{-1}, Atomic mass of Ar = 39.95 g mol^{-1}.**

Solution:

Here, $\alpha_e = 1.7 \times 10^{-40}$ Fm^2, density d = 1.8 gcm^{-3}

Number of atoms per unit volume, $N = \dfrac{dN_A}{Mat}$

$$= \frac{6.02 \times 10^{23} \times 1.8}{39.95} = 2.71 \times 10^{22}\ \text{cm}^3 = 2.71 \times 10^{28}\ \text{m}^{-3}$$

From Calusius-Massotti equation,

$$\frac{N\alpha_e}{3\epsilon_o} = \frac{\epsilon_r - 1}{\epsilon_r + 2} \Rightarrow \frac{N\alpha_e \epsilon_r}{3\epsilon_o} + \frac{2N\alpha_e}{3\epsilon_o} = \epsilon_r - 1$$

$$\epsilon_r\left(\frac{N\alpha_e}{3\epsilon_o} - 1\right) = -\left[1 + \frac{2N\alpha_e}{3\epsilon_o}\right]$$

$$\epsilon_r = \frac{1 + \dfrac{2N\alpha_e}{3\epsilon_o}}{1 - \dfrac{N\alpha_e}{3\epsilon_o}} = 1.63$$

8. The optical index of refraction and the dielectric constant for glass are 1.45 and 6.5 respectively. Calculate the percentage of ionic polarizibility.

Solution:

Here, optical index of refraction, $n = 1.45$

Dielectric constant, $\epsilon_r = 6.5$

We have from Clausius - Massotti equation

$$\frac{\epsilon_r - 1}{\epsilon_r + 2} = \frac{N(\alpha_e + \alpha_i)}{3\epsilon_o} \qquad \text{...(1)}$$

At optical frequencies, ϵ_r in Clausius-Massotti relation for electronic polarization is replaced by n^2

$$\frac{n^2 - 1}{n^2 + 2} = \frac{N\alpha_e}{3\epsilon_o} \qquad \text{...(2)}$$

Now, dividing equation (2) by (1)

$$\frac{n^2 - 1}{n^2 + 2} \times \frac{\epsilon_r + 2}{\epsilon_r - 1} = \frac{\alpha_e}{\alpha_e + \alpha_i}$$

So, percentage of ionic polarizibility is

$$\frac{\alpha_i}{\alpha_e + \alpha_i} \times 100 = \left[1 - \frac{\alpha_e}{\alpha_e + \alpha_i}\right] \times 100$$

$$= \left[1 - \left(\frac{n^2 - 1}{n^2 + 2}\right) \times \left(\frac{\epsilon_r + 2}{\epsilon_r - 1}\right)\right] \times 100$$

$$= \left[1 - \left(\frac{1.45^2 - 1}{1.45^2 + 2}\right) \times \left(\frac{6.5 + 2}{6.5 - 1}\right)\right] \times 100$$

$= 58.47\%$

17. The water has static dielectric constant of 8.1 and optical index of refraction 1.33. Calculate the percentage contribution of ionic polarizibility.

Solution:

Here optical index of refraction n = 1.33, Dielectric constant, ϵ_r = 8.1 we have from Clausius Massotti equation.

$$\frac{\epsilon_r - 1}{\epsilon_r + 2} = \frac{N(\alpha_e + \alpha_i)}{3\epsilon_o}$$

At optical frequencies, ϵ_r in Clausius - Massotti relation for electronic polarization is replaced by n^2

$$\text{i.e.} \quad \frac{n^2 - 1}{n^2 + 2} = \frac{N\alpha_e}{3\epsilon_o} \qquad \text{...(2)}$$

[For optical frequency the ionic polarizibility is negligible)

Dividing equation (2) by (1)

$$\frac{n^2-1}{n^2+2} \times \frac{\epsilon_r+2}{\epsilon_r-1} = \frac{\alpha_e}{\alpha_e+\alpha_i}$$

The percentage of ionic polarizibility is

$$\frac{\alpha_i}{\alpha_e+\alpha_i} \times 100\% = \left[1 - \frac{\alpha_e}{\alpha_e+\alpha_i}\right] \times 100\%$$

$$= \left[1 - \left(\frac{n^2-1}{n^2+2} \times \frac{\epsilon_r+2}{\epsilon_r-1}\right)\right] \times 100\%$$

$$= \left[1 - \left(\frac{(1.33^2-1)}{(1.33^2+2)} \times \frac{(8.1+2)}{(8.1-1)}\right)\right] \times 100\%$$

$$= 70.98\%$$

Solved Examples

Calculate the permeability and susceptibility of an iron bar of cross sectional area 0.2 cm^2 when a magnetizing field of 1200 Am^{-1} produces magnetic field of 24 micro-Weber.

Solution:

Here, $\phi = 24 \times 10^{-6}$ Wb $= 2.4 \times 10^{-5}$ Wb

$A = 0.2\ cm^2 = 0.2 \times 10^{-4}\ m^2$

$H = 1200\ Am^{-1}$

Using the relation, $\phi = B.A$

$$\Rightarrow B = \frac{\phi}{A} = \frac{2.4 \times 10^{-5}}{0.2 \times 10^{-4}} = 1.2\ T$$

The permeability is given by, $B = \mu H$

$$\Rightarrow \mu = \frac{B}{H} = \frac{1.2}{1200} = 1 \times 10^{-3}\ H/m$$

The susceptibility is given by,

Imp

$$\chi = \mu_r - 1 = \frac{\mu}{\mu_o} - 1 = \left(\frac{1 \times 10^{-3}}{4\pi \times 10^{-7}} - 1\right) = 795.2$$

2. Calculate the magnetization and flux density in a diamagnetic sample having susceptibility -0.3 × 10^{-5} and magnetic field strength 1000 A/m.

Solution:

Here, $\chi = -0.3 \times 10^{-5}$, $H = 1000$ A/m

We have, $M = \chi H = -0.3 \times 10^{-5} \times 1000 = -3 \times 10^{-3}$ A/m

Now, the magnetic flux density is given by

$$B = \mu_o (H + M)$$
$$= 4\pi \times 10^{-7} (1000 - 3 \times 10^{-3})$$
$$= 1.256 \times 10^{-3}\ T$$

Imp

3. Determine the permeability and relative permeability of a diamagnetic sample having susceptibility - 9.5 × 10^{-9}

Solution:

Here, $\chi = -9.5 \times 10^{-9}$

$\mu_r - 1 = -9.5 \times 10^{-9}$

$\mu_r = 1 - (9.5 \times 10^{-9}) = 0.999$

$$\Rightarrow \frac{\mu}{\mu_o} = 0.999 \Rightarrow \mu = \mu_o \times 0.999 = 1.256 \times 10^{-6}$$

5. The magnetic field strength in a piece of Fe_2O_3 is 10^6 Am^{-2}. Given that the susceptibility at room temperature is 1.4×10^{-3}, find the flux density and magnetization in the material.

Solution:

Here, $H = 10^6\ Am^{-2}$, $\chi = 1.4 \times 10^{-3}$, $B = ?$, $M = ?$

We have, $\chi = \dfrac{M}{H} \Rightarrow M = \chi H$

$M = 1.4 \times 10^{-3} \times 10^6 = 1.4 \times 10^3\ Am^{-1}$

Again $B = \mu_o (H + M)$

$B = 4\pi \times 10^{-7} (10^6 + 1.4 \times 10^3)$

$B = 1.257\ T$

7. Calculate the field intensity of a magnetic field and the intensity of magnetization 0.2A current is passed through a winding of 20 turns/cm over an iron anchor ri[illegible] having magnetic field 1.26 T.

Solution:

Here, $I = 0.2$ A, $n = 20$ turns/cm $= 2000$ turns/m, $B = 1.26$ T

We have, $B = \mu I n \Rightarrow \mu = \frac{B}{I.n} = \frac{1.26}{0.2 \times 2000}$

$\mu = 3.15 \times 10^{-3}$ H/m

Again $B = \mu H \Rightarrow H = \frac{B}{\mu} = \frac{1.26}{(3.15 \times 10^{-3})}$

$H = 400\ \text{Am}^{-1}$

Again, $B = \mu_o (H + M) \Rightarrow (M + H) = \frac{B}{\mu_o}$

$M = \frac{B}{\mu_o} - H$

$M = \frac{1.26}{(4\pi \times 10^{-7})} - 400$

$M = 1 \times 10^{6}\ \text{Am}^{-1}$

6. Classify magnetic material and explain each of them briefly.
7. What are ferrimagnetic material? Explain how does its property differ with anti ferromagnetic material?
8. Classify magnetic materials based on their magnetic susceptibilities. What is the basic difference between ferromagnetic and ferrimagnetic materials? Mention their field of application. Why ferrites are used in high frequency applications.
9. Explain different types of magnetic material and give two examples of each.
10. Distinguish between ferromagnetic and antiferromagnetics materials. Give an example for each class of material. Discuss the various uses of ferrites.
11. What are magnetic domains? Explain the behaviour of magnetic domains in presence of external magnetic field.
12. Explain the domain structure of ferromagnetic material for both the magnetized and unmagnetized specimen.
13. What are magnetic domains? Explain domain wall motion in a ferromagnetic material
14. Explain the domain structure and domain wall of ferromagnetic materials.
15. What is the significance of hysteresis loop
16. How hysteresis loop plays an important role in classifying magnetic materials?Explain.
17. Explain the hysteresis loss and eddy current loss in magnetic materials?
18. Explain different types of losses in magnetic materials.
19. Why hard magnetic material is prefered for making permanent magnet while soft magnetic material is used for high frequency application. Explain with B-H Curve.
20. Differentiate soft and hard magnetic material taking help of hysteresis loop.
21. What are the properties of soft magnetic materials and give the examples of the uses of soft magnetic material.
22. Differentiate between hard and soft magnetic materials suggest which type of magnetic material to use for the manufacture of power transformer cores and why?
23. What do you mean by hard and soft magnetic material? Explain the requirement of the magnetic material to be used for transformer core.
24. What are ferromagnetic materials? With the help of hysleresis loop, classify hard and soft magnetic material?
25. What do you mean by hysterisis loop? Describe the types of magnetic material based on it.
26. A magnetic field strength in copper is 10^6 ampere/ meter. If the magnetic susceptibility of copper is -0.8×10^{-5}, calculate the flux density and magnetization in copper.
27. A magnetic material has magnetization of 3300 ampere per meter and flux density of 0.0044 weber/meter^2. Calculate magnetizing field and the relative permeability of the material.
28. Consider bismath $\chi_m = -16.6 \times 10^{-5}$ and aluminium with $\chi_m = 2.3 \times 10^{-5}$. Suppose that we subject each sample to an applied field of 1T. What is the magnetization M in each sample.

16. A pn junction Semiconductor has resistivity of 5Ω-cm. If mobility of hole is 450 $cm^2V^{-1}S^{-1}$ and electron mobility is three times the mobility of hole. At room temperature, find (i) Built in potential (ii) depletion width that lies in n-region and p-region and (iii) built in electric field at x = 0 (Given, $n_i = 1.45 \times 10^{10}$ cm^{-3} at T = 300 K, ϵ_r =11.9 for Si)

Solution:

Here, $\rho = 5\Omega cm = 5 \times 10^{-2}\ \Omega\text{-m}$

Therefore $\sigma = \dfrac{1}{\rho} = \dfrac{1}{5 \times 10^{-2}} = 20\ \Omega^{-1}m^{-1}$

$\mu_h = 450\ cm^2V^{-1}S^{-1} = 450 \times 10^{-4}\ m^2V^{-1}S^{1}$

$\mu_c e = 3 \times 450 = 1350\ cm^2V^{-1}S^{-1} = 1350 \times 10^{-4}\ m^2V^{-1}S^{-1}$

T = 300 K

For n-side, $\sigma = N_d e\ \mu_e$

$$\Rightarrow N_d = \frac{\sigma}{e\mu_e} = \frac{20}{1.6 \times 10^{-19} \times 1350 \times 10^{-4}} = 9.26 \times 10^{20}\ m^{-3}$$

For p - side, $\sigma = N_a e\mu_h$

$$N_a = \frac{\sigma}{e\,\mu_h} = \frac{20}{1.6 \times 10^{-19} \times 450 \times 10^{-4}} = 2.78 \times 10^{21}\ m^3$$

1) **The built in potential is given by**

$$V_o = \frac{KT}{e}\, ln\left(\frac{N_a N_d}{n_i^2}\right)$$

$$V_o = \left(\frac{1.38 \times 10^{-23} \times 300}{1.6 \times 10^{-19}}\right) ln\left[\frac{2.78 \times 10^{21} \times 9.26 \times 10^{20}}{(1.45 \times 10^{16})^2}\right] = 0.6 \text{ Volts}$$

2) **The total depletion width is given by**

$$w = \sqrt{\frac{2\epsilon V_o}{e}\left(\frac{1}{N_a} + \frac{1}{N_d}\right)}$$

$$= \sqrt{\frac{2\epsilon_r \epsilon_o V_o}{e}\left(\frac{N_a + N_d}{N_a . N_d}\right)}$$

$$= \sqrt{\frac{2 \times 11.9 \times 8.85 \times 10^{-12} \times 0.6}{1.6 \times 10^{-19}}\left(\frac{2.78 \times 10^{21} + 9.26 \times 10^{20}}{2.78 \times 10^{21} \times 9.26 \times 10^{20}}\right)}$$

$$= 1.07 \times 10^{-6}\ m = 1.07\ \mu m$$

Now the depletion width in n -region is

$$x_n = \left[\frac{2\epsilon V_o}{eN_d\left[1 + \frac{N_d}{N_a}\right]}\right]^{1/2} \left[\frac{2\epsilon_r\epsilon_o V_o}{eN_d}\left(\frac{N_a}{N_a + N_d}\right)\right]^{1/2}$$

$$x_n = \left[\frac{2 \times 11.9 \times 8.85 \times 10^{-12} \times 0.6 \times 2.78 \times 10^{21}}{1.6 \times 10^{-19} \times 9.26 \times 10^{20}\,(2.78 \times 10^{21} + 9.26 \times 10^{20})}\right]^{1/2}$$

$$= 0.8 \times 10^{-6} m = 0.8\ \mu m$$

Therefore, depletion width in p-region is,

$$x_p = w - x_n = 1.07 - 0.8 = 0.27\ \mu m$$

3) **The built in electric field is given by**

$$E_o = \frac{V_o}{w} = \frac{0.6}{1.07 \times 10^{-6}} = 5.6 \times 10^5\ V/m$$

51. What is PN junction? Find the necessary mathematical expression to find out the potential difference across the junction.

52. Derive the expression for contact potential in a PN junction.

53. Explain ideal pn junction mechanism. Explain with diagrams the forward biased and reverse biased pn junction.

54. Explain No bias, Forward bias and Reverse bias in ideal PN junction.

55. Define diffusion capacitance and depletion layer capacitance.

56. How band bending occurs in semiconductors? Derive Einstein relationship.

57. A metal and n-type semiconductor with different Fermi energy level (assume metal has higher Fermi energy than n-type semiconductor) are brought into contact. Explain the band bending phenomena near the junction with necessary sketch.

58. List out the condition for formation of Ohmic junction between semiconductor and metal.

59. Explain about the metal semiconductor junction in semiconductor.

60. Describe the phenomena of formation of Schottky junction between a metal and a n type semiconductor. What changes occur during forward biasing of such junction?

61. Explain Schottky junction.

62. Calculate the intrinsic concentration of charge carrier at 300 K. E_g for Germanium is 0.67 eV. Gien $m^*_e = 01.2\ m_e$ and $m^*_h = 0.28$ me. Where m_e is the rest mass of electron.

63. The following data are given for intrinsic Germanium at 300 K. $n_i = 2.4 \times 10^{19}/m^3$, $\mu_e = 0.39\ m^2V^{-1}S^{-1}$, $\mu_h = 0.19\ m^2V^{-1}S^{-1}$. Calculate the conductivity of sample.

64. Find the resistance of an intrinsic germanium rod, 1 cm long, 1mm wide and 1mm thick at 300K. For Germanium, $n_i = 2.5 \times 10^{19}/m^3$, $\mu_e = 0.39\ m^2V^{-1}S^{-1}$ and $\mu_h = 0.19\ m^2V^{-1}S^{-1}$ at 300 K.

65. In an intrinsic semiconductor the effective mass of the electron is $0.07m_e$ and that of the hole is $0.4m_e$ where m_e is the rest mass of the electron. Calculate the intrinsic concentration of charge carriers at 300 K. Given $E_g = 0.7$ eV.

66. In a p-type semiconductor, the Fermi level lies 0.4 eV above the valence band. If the concentration of acceptor atoms is tripled, find the new position of the Fermi level. Assume KT = 0.03eV.

67. Calculate the density of donor atoms which have to be added to intrinsic Germanium to produce n - type material of resistivity $0.19 \times 10^{-2}\ \Omega m$. It is given that the mobility of electron in the n-type semi conductor is $0.325\ m^2V^{-1}S^{-1}$.

68. Crystalline pure Germanium has 4.5×10^{28} atoms/m^3. At 300 K, one atom in 2×10^9 is ionized. The mobilities of electrons and holes at 300 K are 0.4 and 0.2 $m^2V^{-1}S^{-1}$ respectively. Determine the conductivity of pure Germanium. Also estimate the conductivity of Germanium doped by one trivalent impurity in 10^{17} Germanium atoms at 300K.

69. Find the diffusion coefficients of electrons and holes of a silicon single crystal at 27°C if the mobilities of electrons and holes are 0.17 and 0.025 $m^2V^{-1}S^{-1}$ respectively at 27°C.