Solved Examples

Solid State Physics

Ex. 1 (i) Calculate the energy gap of Si, given that it is transparent to radiation of wavelength greater than 11000 A^0

(ii) Calculate the energy band gap in germanium. Given that it is transparent radiation of wavelength greater than 17760 A^0

Soln :

The energy gap E_g is the minimum energy required to shift the electron from V.B. to C.

(i) Energy of the incident photon should at least be

For silicon $h\nu = E_g$

$E_g = h\nu =$

$E_g =$ J.

$E_g =$

$\mathbf{E_g = 1.129\ eV.}$

(ii) For Germanium $\lambda = 17760 \times 10^{-10}$ m.

So, energy gap of germanium

= J.

=

.

Ex. 2 Find the drift velocity for an electron in silver wire for radius 1 mm and carrying a current of 2 A. Density of silver is 10.5 gm/cc.

Avogadro number = 6.025×10^{23}/gm mole.

Soln :

Given :

Density of silver = 10.5 gm/cc.

At.wt. of silver = 108

Formula required :

$I = q \cdot n \cdot v \cdot A$

Therefore number of electrons per unit volume = n = $\times 10.5$

$n = \; = 6 \times 10^{22}$ per cm^3

or $n = 6 \times 10^{28}$ per m^3

Cross section area $A = \Pi r^2 = \Pi \times (10^{-3})^2 = 3 \times 10^{-6}\ m^2$

Now current $I = q \cdot n \cdot v \cdot A$

$v = \; =$

$\mathbf{= 7\ \ 10^{-4}\ m/s.}$

Ex. 3 An n-type semi-conductor is to have a resistivity 10Ω cm. Calculate the number of donor atoms which must be added to achieve this.
Given that $\mu_d = 500\ cm^2/V.S$

Soln :

Given :

Resistivity $\rho = 10\Omega$ cm, $\mu_d = 500\ cm^2/V.S$

Formula required :

Conductivity σ and $\sigma\ n_d \cdot e \cdot \mu_d$

$n_d = \ = \ =$

= 1.25

Ex. 4 Calculate the conductivity of specimen if a donor impurity is added to an extent of one part in 10^8 Ge atoms at room temperature?

Soln :

Given :

Avogadro number = 6.02×10^{23} atoms/gm.mole.

At.wt. of Ge = 72.6,

Density of Ge = 5.32 gm/c.c,

Mobility $\mu = 3800 cm^2/v.s.$

Formula required :

$$\sigma = n \cdot e \cdot \mu_e$$

Concentration of Ge atoms =

As there is one donor atom per 10^8 atoms of Ge

n_d

Conductivity $\sigma = n_d \cdot \mu_e \cdot e$

0.268 mho/cm

Ex. 5 A silver wire is in the form of ribbon 0.50 cm. wide and 0.10 mm thick. When a current of 2 amp passes through the ribbon, perpendicular to 0.80 Tesla magnetic field calculate the Hall voltage produced. The density of silver = 10.5 gm/cc

Soln :

Given :

B = 0.8 Tesla, Density = 10.5 gm/cc

Formula required :

$$V_H = B.v.d.$$

The number of electrons in 1cc of silver are :

As each silver atom contributes one electron, the number of electrons per m3 = 6

Area A = 0.5

Hall voltage V_H = B.v.d.

The drift vel

V_H =

= 0.333 volts

Ex. 6 A copper specimen having length 1 meter, width 1 cm and thickness 1 mm is conducting 1 amp. Current along its length and is applied with a magnetic field of 1 Tesla along its thickness. It experiences Hall effect and a hall voltage of 0.074 microvolts appears along its width. Calculate the Hall coefficient and the mobility of electrons in copper. (Conductivity of copper is $\sigma = 5.8 \times 10^7 (\Omega m^{)-1})$)

Soln :

Given :

l = 1 m, d = 1 cm = 10^{-2} m

W = 1 mm = 10^{-3} m, I = 1 Amp

B = 1 Tesla, V_H 0.074×10^{-6} Volts

$\sigma = 5.8 \times 10^7$ mho/m

Formula required :

V_H

The Hall voltage is

$V_H = R_H \times$

R_H =

R_H

Mobility $\mu = \sigma \times R_H =$

$\boldsymbol{\mu = 4.3 \times 10^{-3}}$ **m²/volt.sec**

Ex. 7 A slab of copper 2.0 mm in length and 1.5 cm wide is placed in a uniform magnetic field with magnitude 0.40 T. When a current of 75 amp flows along the length, the voltage measured across the width is 0.81 μV, determine the concentration of mobile electrons in copper.

Soln :

V_H R_H

R_H =

=

n =

= 11.79 /cu.m

Ex. 8 A silver wire is in form of a ribbon 0.50cm Wide and 0.10 mm thick. When a current of 2 amp passes through the ribbon, perpendicular to 0.80 Tesla magnetic field, Calculate the Hall voltage produced. The density of silver 10.5 gm/cc. And atomic weight of Ag = 108.

Soln :

Given :

Numbers of electrons $n = 6.025 \times 10^{23} \times \approx 5.857 \times 10^{22}$ per c.c.

$= 5.857 \times 10^{28}$ per m^3.

Formula :

V_H

$V_H = 1.70 \times 10^{-6}$ V = **1.7 μV**

Ex. 9 Calculate the mobility of charge carriers in a doped silicon of which conductivity is 100 mho/m and the Hall coefficient is $3.6 \times 10^{-4} m^3/c$

Soln :

Hall Co-efficient R_H

Conductivity $\sigma = 100$ mho/m

Formulae : $\sigma = ne\mu$

$\mu =$

= 0.036m²/V.s