2). Calc. intrinsic conductivity of si at room temp if $n = 1.41 \times 10^{16} m^{-3}$, $\mu_e = 0.145\ m^2/V\text{-}s$, $\mu_h = 0.05\ m^2/V\text{-}s$, $e = 1.6 \times 10^{-19} C$. What are the indiv contributions (or) made by e^- & holes.

μ_n

μ_p

$\sigma = qn\mu_n + qp\mu_p$

$\sigma = q n \mu_n + q p \mu_p$. $e = q$

Conductivity of intrinsic . sc is

$\sigma_i = n_i e \mu_e + n_i e \mu_h$.

$= 1.41 \times 10^{16} \times 1.6 \times 10^{-19} \times 0.145 + 1.41 \times 10^{16} \times 1.6 \times 10^{-19} \times 0.05$

$= 0.325 \times 10^{-3} + 1.112 \times 10^{-3}$ S/m $= 0.437 \times 10^{-3}$ S/m

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$, T_1,$

$\mu_e = \frac{e}{KT} D_e$ & $\mu_h = \frac{e}{KT} D_h$

'10)

or $\frac{D_e}{\mu_e} = \frac{D_h}{\mu_h} = \frac{kT}{e} = \frac{T}{11,600}$ $\Rightarrow$ Einsteins Eq.

+ 27.7k

At $23°C$, $T = 300°K$

mobility. diff const.

$k = 8.62 \times 10^{-5}$ eV

$\frac{D}{\mu} = \frac{300}{11,600} = \frac{1}{39}$ or $\mu = 39D$.

3) Calc diffusion constants for e^- & holes at $300°K$ in Si if $\mu_e = 0.15 m^2/V\text{-}s$ & $\mu_h = 0.05\ m^2/V\text{-}s$

Einst. eq. $D = \mu KT/e$ or $D = \mu/39\ m^2/s$ at $300°K$

$D_e = \mu_e/39 = 0.15/39 = 3.85 \times 10^{-3}\ m^2/s$

$D_h = \mu_h/39 = 0.05/39 = 6.4 \times 10^{-5}\ m^2/s$.

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6. Mobilities of free e^- & holes in Pure Ge are 0.38 & 0.18 $m^2/V\text{-}s$. Corresp values for pure Si are 0.13 & 0.05 $m^2/V\text{-}s$ resp.

Find values of intrinsic conductivity for both materials.

Assume $n_i = 2.5 \times 10^{19}/m^3$ for Ge & $n_i = 1.5 \times 10^{16}/m^3$ at room temp.

$q = 1.6 \times 10^{-19}$ C

Soln.

For Ge, $\mu_n = 0.38\ m^2/Vs$, $\mu_p = 0.18\ m^2/Vs$

$n_i = n = p = 2.5 \times 10^{19}\ /m^3$

For Si, $\mu_n = 0.13\ m^2/V.s$, $\mu_p = 0.05\ m^2/V.s$, $n_i = n = p$.

Intrinsic conductivity for germanium

$\sigma_i = q.n_i(\mu_n + \mu_p) = (1.6 \times 10^{-19}) \times (2.5 \times 10^{19}) \times (0.38 + 0.18)$

$= 2.24\ (\Omega\mu)^{-1}$ $(\Omega.m)$

Intrinsic conductivity for Si,

$\sigma_i = q.n_i(\mu_n + \mu_p)$

$\frac{\text{coulomb}}{m^3} \cdot \frac{m^2}{Vs}$ $\frac{m^2}{Vs}$ $\frac{A s}{V s^2}$ $\frac{1}{A.\Omega}$

$= (1.6 \times 10^{-19}) \times (1.5 \times 10^{16}) \times (0.13 + 0.05)\ (\Omega m)^{-1}$

resistivity $= \frac{Vs\ m\ \Omega m}{\text{columb}}$ $= 4.32 \times 10^{-4}\ (\Omega m)^{-1}$

Cond $\Rightarrow$ C $\frac{1}{}$

7. Find intrinsic carrier conc of Ge. if its intrinsic resistivity at 300 K is 0.47 Ω m. Electronic charge is 1.6×10^{-19} columb e- & hole mobilities at 300 K are 0.398 0.19 m^2/Vs resp

$\rho_i = 0.47\ \Omega m$, $q = 1.6 \times 10^{-19}\ C$; $\mu_n = 0.39\ m^2/V\ sec$

$\mu_p = 0.19\ m^2/V\ sec.$

n_i - intrinsic carrier conc of Ge.

conductivity

12.

$\sigma = \frac{1}{\rho} = \frac{1}{0.47} = 2.13\ (\Omega m)^{-1}$

$\sigma = qn(\mu_n + \mu_p)$.

$2.13 = q.n(\mu_n + \mu_p) = 1.6 \times 10^{-19} \times n_i(0.39 + 0.19$

$= 0.93 \times 10^{-19}\ n_i$

$n_i = 2.3 \times 10^{19} / m3.$

8) A sample of Si is doped with donor phosphorous to a density of $10^{21}/m^3$ as well as with acceptor boron to a density of $5 \times 10^{20}/m^3$. What will be conductivity of Si sample. e^- mobility in Si is $0.18\ m^2/V\text{-}S$.

$N_D = 10^{21}/m^3$; $N_A = 5 \times 10^{20}/m^3$

Phos-donor, boron - acceptor.

$\therefore$ net donor density $= N_D' = N_D - N_A = 10^{21} - 5\times10^{20}$

$= 5\times10^{20}/m^3$

No of free e^- $n = N_D' = 5\times10^{20}/m^3$

Conductivity of Si $\sigma = q.n.\mu_n = (1.6\times10^{-19}) \times (5\times10^{20}) \times$

$= 14.4\ (\Omega m)^{-1}$ $0.18\ (\Omega m)^{-1}$

9). A germanium PN jn at 300K has foll param.

$N_D = 5 \times 10^{18}/cm^3$, $N_A = 6 \times 10^{16}/cm^3$, $n_i = 1.5 \times 10^{10}/cm^3$. Calc minority e^- density in P region & minority hole density in N region.

$N_D = 5 \times 10^{18}/cm^3$, $N_A = 6 \times 10^{16}/cm^3$, $n_i = 1.5 \times 10^{10}/cm^3$

$n \to e^-$ density (no) in p region

$p \to$ hole " in n region

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in to

Hall effect
to determine
name of sc mater
P/n, mobile carrier
conc, mobility

no of e^- in P region

$n = \frac{n_i^2}{N_A} = \frac{(1.5\times10^{10})^2}{6\times10^{16}} = 0.375\times10^4 = 3750$

no of holes in N region

$p = \frac{n_i^2}{N_D} = \frac{(1.5\times10^{10})^2}{5\times10^8} = 0.45\times10^{12}$

Hall ⇒ If a specimen of sc carrying I is placed in a transverse mag B, then electric field induced in dir ⊥ to both I & B

10. A sample of N type sc has hall coeff of 160 cm³/columb. if its resistivity is 0.16 Ω-cm, estimate e^- mobility in sample.

$R_H = 160$ cm³/columb , $\rho = 0.16\ \Omega$ cm.

$\mu_H = \sigma R_H = \frac{1}{\rho} R_H = \frac{1}{0.16}\times160 = 1000\ cm^2/V s.$

2) A Si diode has forward V drop of 1.2 V for a forward dc I 100mA. It has a rev. I of 1μA for a rev V of 10V.
Calc. a. bulk & reverse R of diode
b. ac resistance at forward dc I of i) 2.5mA &
ii) 25mA

a) $r_B = \dfrac{V_F - V_B}{I_F} = \dfrac{1.2\ V - 0.7\ V}{100mA} = 5\Omega$

$R_R = V_R / I_R = 10V / 1 mA = 10 M.$

$r_{ac} = r_B + r_j = 5 + 10 = 15\Omega$

b i) $r_j = 25 mV / 2.5 mA = 10\Omega.$

$r_{ac} = 5 + 1 = 6\Omega$

ii) $r_j = 25 mV / 25 mA = 1\Omega.$

3) Using analytical exp. for diode I, calc dynamic slope R of a Ge diode at $290^0 k$ when FB at I of i) $10 \mu A$ & $5 mA$

$$I = I_0 \exp(eV/KT)$$

$$dI = \frac{e}{KT} I_0 \left[\exp\left(\frac{eV}{KT}\right)\right] dV = \frac{e}{KT} I \, dV$$

$$r_d = \frac{dV}{dI} = \frac{KT}{eI} = \frac{25 \times 10^{-3}}{I} \rightarrow I \text{ in ampere.}$$

i) Now $I = 10 \mu A = 10 \times 10^{-6} = 10^{-5} A$

$$r_d = 25 \times 10^{-3} / 10^{-5} = 2500 \Omega$$

ii) $I = 5 mA = 5 \times 10^{-3} A$

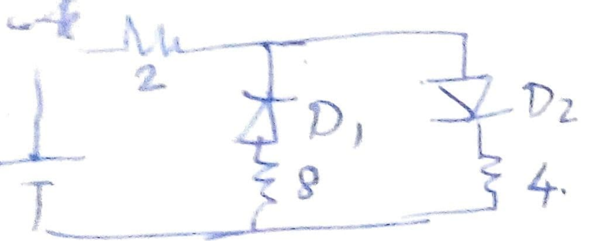
$$r_d = 25 \times 10^{-3} / 5 \times 10^{-3} = 5 \Omega$$

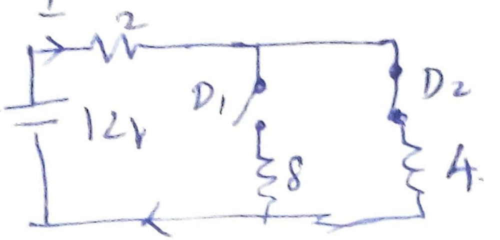
5) A germanium diode draws 40 mA with a FB 0.25V The jn is at room temp of 293°K. Calc. rev. sat. I of diode

$I = I_0 (e^{40V} - 1)$ or $40 \times 10^{-3} = I_0 (e^{40 \times 0.25} - 1)$.

$I_0 = 40 \times 10^{3} / (22,027 - 1) = 1.82 \mu A$

Find I of any circuit which uses 2 opp. connected ideal diodes in ||el.





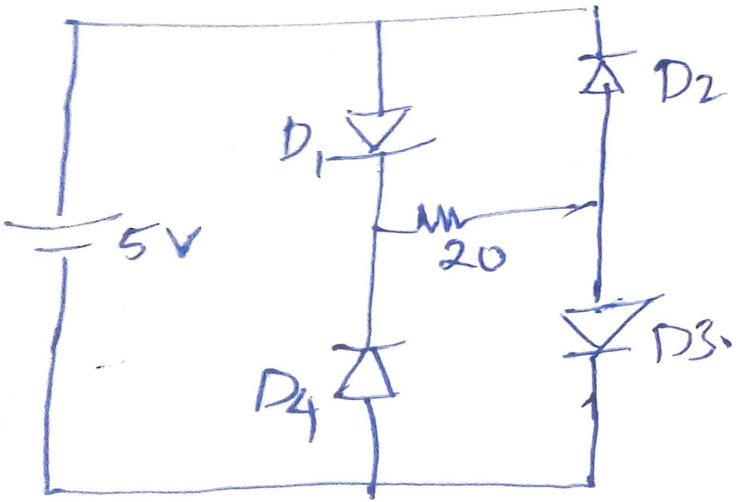
D_1 - R.B. - act as open switch.

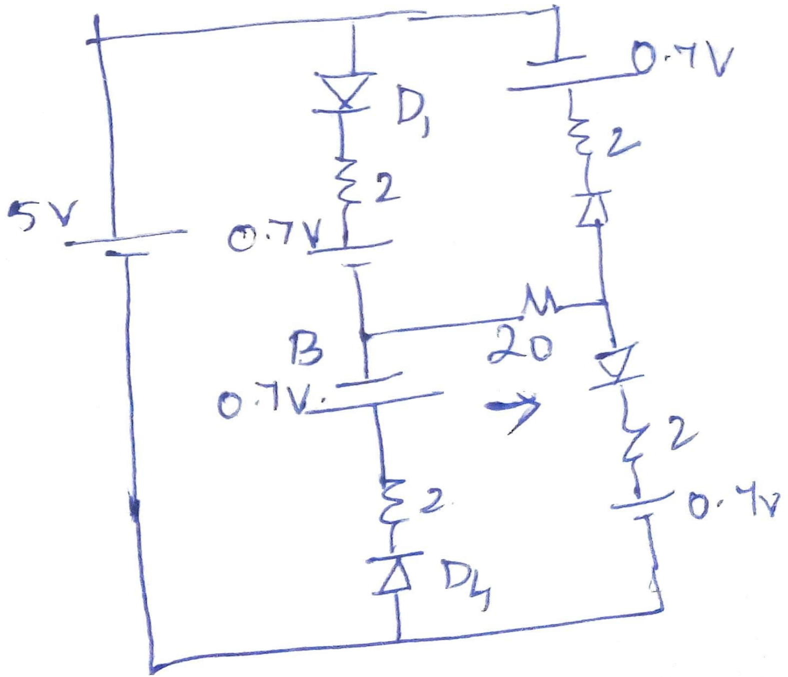
∴ no I thru D_1 & 8Ω resistor.

D_2 - F.B. - short ckt or closed switch. I drawn is

$I = 12/(2+4) = 2A$

Q). Find I thru 20Ω R in fig. Each Si diode has a barrier pot 0.7V & a dynamic R of 2Ω Use diode eqvt ckt technique





Each diode-rep by eqvt ckt.

D_1, D_3 - FB by 5V battery. D_2, D_4 - RB.

I flow from pt A to B then C via 20Ω R, then back term of 5V battery.

Net V in eqvt ckt is

$$V_{net} = 5 - 0.7 - 0.7 = 3.6V.$$

Tot R seen by this net V is

$$R_T = 2 + 20 + 2 = 24Ω$$

Ckt I $\quad I = V_{net} / R_T = 3.6/24 = 0.15A.$