Student number:

1 2 3 4 5 6 7 8 9 0

First & last name:

Super

Trooper

Solid State Physics, Minitest 6

March 31st 2016

Good luck!

1. **True or false?**

   (a) Bands with a higher curvature have a higher effective mass. *(10 pt)*

   (b) Conductivity of holes is opposite to the conductivity of electrons. *(10 pt)*

Aaaa

2. **Fermi level of a doped semiconductor**
   Consider a semiconductor with all parameters known, so $m_e, m_h, E_G, E_A, E_D, N_A, N_D$ are all given.

   (a) Draw schematically the density of states $G(E)$ for such a semiconductor, denote all material parameters on the plot. *(10 pt)*

Hello world

small handwriting

(b) Compute the value of E_F in the high temperature limit, such that the semiconductor behaves intrinsically (but still $kT \ll E_G$). *(15 pt)*

This is how I usually write if I write with my hand. At least this is how I learnt it at school

(c) Compute the value of E_F at $T = 0$. *(20 pt)* Justify your answer. *(15 pt)*

[illegible]

(d) Compute the value of E_F when $N_A = 0$ and $T = 0$ (while $N_D \neq 0$). *(10 pt)* Justify your answer. *(10 pt) Hint: in this limit the donor band plays a role similar to the valence band.*

[illegible]

In the questions (b), (c), and (d) use the charge conservation to derive the answers. Reminder: the concentration of conduction electrons in the Boltzmann limit is $n_e = N_C \exp[-(E_G - E_F)/kT]$, where $N_C \sim (m_e T)^{3/2}$ (and a similar expression holds for holes).

$k_x^2 + y^2 - ky$

def onsite(s, t, ...)

rot=2+ y^2

Student number: First & last name:

1 2 3 4 5 6 7 8 9 0

Karl

Marx

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Ha - Ha

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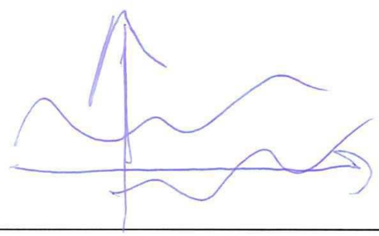

Not at all

(b) Compute the value of E_F in the high temperature limit, such that the semiconductor behaves intrinsically (but still $kT \ll E_G$). *(15 pt)*

(c) Compute the value of E_F at $T = 0$. *(20 pt)* Justify your answer. *(15 pt)*

Test

(d) Compute the value of E_F when $N_A = 0$ and $T = 0$ (while $N_D \neq 0$). *(10 pt)* Justify your answer. *(10 pt) Hint: in this limit the donor band plays a role similar to the valence band.*

Awesome

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Adriaan

Vuik

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False
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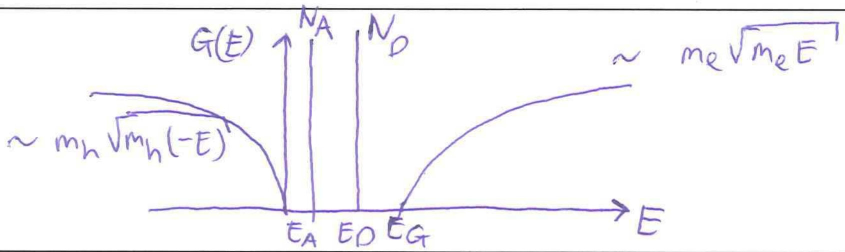

(b) Compute the value of E_F in the high temperature limit, such that the semiconductor behaves intrinsically (but still $kT \ll E_G$). *(15 pt)*

Law of mass action: $np = N_C N_V e^{-E_G/k_BT}$. intrinsic: $n = p = \sqrt{N_C N_V}\, e^{-E_G/2k_BT}$

$$\left.\begin{array}{l} n = N_C\, e^{(\mu - E_G)/k_BT} \\ p = N_V\, e^{-\mu/k_BT} \end{array}\right\} \quad \frac{N_V}{N_C} = e^{(2\mu - E_G)/k_BT} \rightarrow \mu = E_F = \frac{1}{2}E_G + \frac{3}{4}k_BT \ln\left(\frac{m_h}{m_e}\right)$$

(using definitions of N_V and N_C)

(c) Compute the value of E_F at $T = 0$. *(20 pt)* Justify your answer. *(15 pt)*

$T=0$: valence band completely filled. if $N_D > N_A$, acceptor level also completely filled and donor level partially $\longrightarrow$ $E_F = E_D$.
If $N_D < N_A$, all donor electrons go to acceptor levels which becomes partially filled $\rightarrow$ $E_F = E_A$

(d) Compute the value of E_F when $N_A = 0$ and $T = 0$ (while $N_D \neq 0$). *(10 pt)* Justify your answer. *(10 pt) Hint: in this limit the donor band plays a role similar to the valence band.*

between E_D and E_F.

In the questions (b), (c), and (d) use the charge conservation to derive the answers. Reminder: the concentration of conduction electrons in the Boltzmann limit is $n_e = N_C \exp[-(E_G - E_F)/kT]$, where $N_C \sim (m_e T)^{3/2}$ (and a similar expression holds for holes).

(b) Compute the value of E_F in the high temperature limit, such that the semiconductor behaves intrinsically (but still $kT \ll E_G$). *(15 pt)*

Law of mass action: $np = N_C N_V e^{-E_G/k_BT}$. Intrinsic: $n = p = \sqrt{N_C N_V} e^{-E_G/2k_BT}$

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