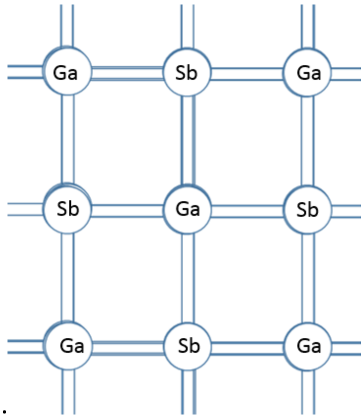
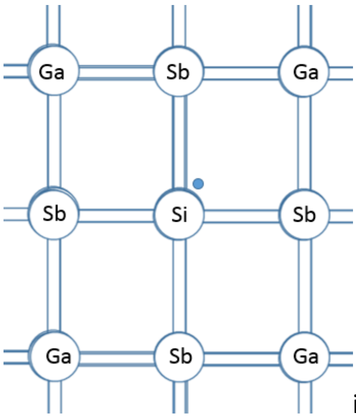
ECE 305 – Spring 2018

Homework 2 Solution

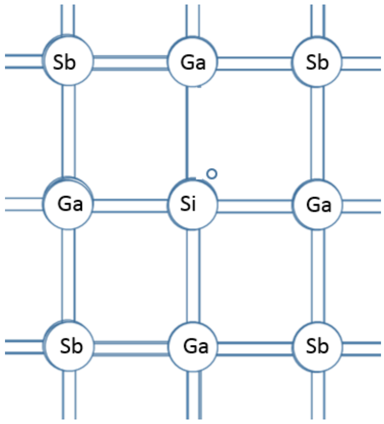
1. a.



b. i.



ii.

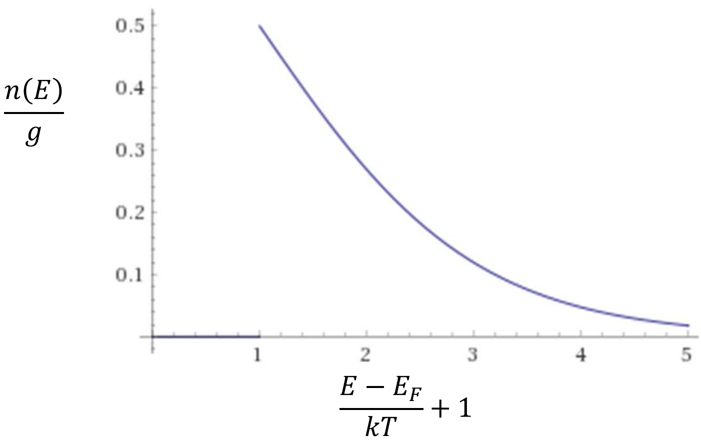


c. i.

ii.

2. a. $n(E) = g(E) \times f(E) = g \times \frac{1}{1+e^{\frac{E-E_F}{k_B T}}} = \frac{g}{1+e^{\frac{E-E_F}{k_B T}}}$

Sketch of $\frac{n(E)}{g}$ versus energy: (Assuming E_F=E_g)



b. $n = \int_{E_g}^{E_g+\Delta} \frac{g}{1+e^{\frac{E-E_F}{k_BT}}}\, dE$

Assuming E>>E_F to simplify integration:

$n = \int_{E_g}^{E_g+\Delta} g e^{-\left(\frac{E-E_F}{k_BT}\right)}\, dE$ = $[-gk_B\mathrm{T}\, e^{-\frac{E-E_F}{k_BT}}]_{Eg}^{Eg+\Delta}$=$-gk_B\mathrm{T}\, e^{-\frac{Eg+\Delta-E_F}{k_BT}} + gk_B\mathrm{T}\, e^{-\frac{Eg-E_F}{k_BT}}$

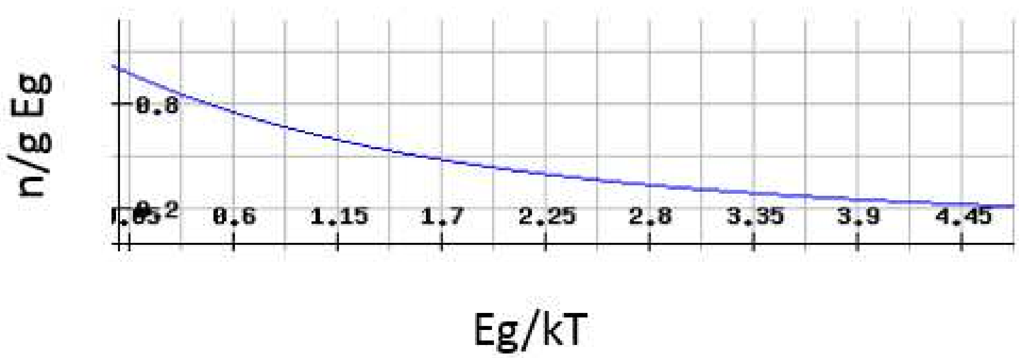
Exact solution: $n = g\left\{\Delta - k_BT\log\left[\frac{\exp(E_g+\Delta-E_F)+1}{\exp(E_g-E_F)+1}\right]\right\}$

c. Δ=E_F=E_g

$n = -gk_B\mathrm{T}\, e^{-\frac{Eg}{k_BT}} + gk_B\mathrm{T}\, e^{0}$= $gk_B\mathrm{T} - gk_B\mathrm{T}\, e^{-\frac{Eg}{k_BT}}$

$\frac{n}{gE_g}$=$\frac{k_B\mathrm{T}}{E_g}$ - $\frac{k_B\mathrm{T}}{E_g}e^{-\frac{Eg}{k_BT}}$

Plot:



As the temperature decreases, the carrier concentration goes down as the gk_BT term dominates.