

**230A problem:**

1. Consider a two-level system at thermal equilibrium. The concentration of particles  $N = 10^{18} \text{ cm}^{-3}$ . There are  $10^{19} \text{ cm}^{-3}$  states at each energy level.

(a) Assuming  $E_2=1.1\text{eV}$ ,  $E_1=1.0 \text{ eV}$ ,  $T= 300\text{K}$ , find  $N_1$  and  $N_2$  if the system obeys Boltzman statistics. ( $k_B T = 0.026 \text{ eV}$ ).  $N_1$  and  $N_2$  are the carrier concentrations at each level.

$N_2$  —————  $E_2$

$N_1$  —————  $E_1$

(b) Describe what will happen if the system in (a) is cooled from 300K to 100K.

(c) Find the Fermi level and  $N_1$  and  $N_2$  if the particles are Fermions and the system is cooled to 0K.

**230B problem:**

2. Consider an n-channel MOSFET with 20 nm thick gate oxide and uniform p-type substrate doping of  $10^{17} \text{ cm}^{-3}$ . The gate work function is that of  $\text{n}^+ \text{Si}$ .
- (a) What is the threshold voltage? Sketch the band diagram at threshold condition,  $\psi_s = 2\psi_B$ .
  - (b) What is the threshold voltage if a reverse bias of 1 V is applied to the substrate? Sketch the band diagram at threshold.