1. At room temperature, the intrinsic carrier concentration, $n_i$, in Silicon is about $1.4 \times 10^{10}/\text{cm}^3$. This is a very strong function of temperature. Find the temperatures at which (a) $n_i$ decreases by 5 orders of magnitude to $10^5/\text{cm}^3$ (b) $n_i$ increases by 5 orders of magnitude. If you dope this with donor impurity concentration of $10^{20}/\text{cm}^3$, what would be the value of resistivity? You can ignore the temperature dependence of band gap, however you should include the temperature dependence of density of states, while computing these temperatures.

2. Silicon wafer is doped n-type with donor impurity concentration of $10^{15}/\text{cm}^3$. At room temperature what is the electron and hole concentration in this wafer. How far is the location of Fermi level from Intrinsic level. Sketch the band diagram and locate the Fermi level position.

3. Now suppose that the Silicon wafer in problem 2, is cooled to 77 K. At this temperature you would expect carrier freeze out, since not all the donor impurities are ionized. Under this condition find the following : (a) intrinsic carrier concentration at 77 K (b) Concentration of ionized donor impurities (c) Concentration of electrons and holes (d) Sketch the band diagram and locate the Fermi level position

4. (a) Find the resistivity of intrinsic silicon at room temperature. If you dope silicon with donor impurity concentration of $10^{15}/\text{cm}^3$, $10^{20}/\text{cm}^3$, what would be the resistivity values for these two cases? (c) If you dope silicon with acceptor impurity concentration of $10^{15}/\text{cm}^3$, $10^{20}/\text{cm}^3$, what would be the resistivity values for these two cases? (Use the mobility values for electrons and holes from the mobility versus impurity concentration graphs from any reference books)

5. Silicon would have the maximum resistivity, if $\mu_n$ were to be equal to $\mu_p$. However, $\mu_n > \mu_p$ and hence intrinsic Si does not give the maximum resistivity. Find the type of dopant and doping concentration corresponding to the maximum resistivity assuming $\mu_n = 3\mu_p$

6. An n-type Si cube with each side measuring 1mm, is doped with $10^{15}/\text{cm}^3$ Arsenic. If a potential of 1 volt is applied across two opposite surfaces, what would be the values of current density and the current?

7. An n- channel transistor has a uniform substrate p-type doping concentration of $10^{18}/\text{cm}^3$ and gate oxide thickness of 5nm. The gate material used is heavily doped n+ polysilicon. What is the value of threshold voltage for an ideal oxide (no charges) ? If the oxide quality is bad and has a fixed positive trap density of $10^{11}/\text{cm}^3$ at Si-SiO$_2$ interface, what would be the value of threshold voltage? What is the value of depletion width in the substrate under inversion condition?

8. A p- channel transistor has uniform substrate n-type doping concentration of $10^{17}/\text{cm}^3$ and gate oxide thickness of 5nm. The gate material used is heavily doped p+ polysilicon. What is the value of threshold voltage for an ideal oxide. If the gate material is replaced with n+ polysilicon, then what would be the value of threshold voltage (ideal oxide) ?

9. What is the ideal value of subthreshold slope at 77 K?