1. You have a buck converter circuit where you are using a power MOSFET as the switch. It has some \textit{small internal resistance} due to the inherent \textit{resistivity of the carriers} within it. When current flows through this small resistance switch, it generates heat due to resistive loss (the all-familiar $I^2R$ loss). Suppose you are operating this converter in two places: a) Chicago where temperature is 30 F and b) Sahara desert in Africa where temperature is 120 F. Assuming, the power loss in the switch is the only source of loss in the converter, which place would you think will give higher efficiency for the converter operation? Explain briefly. \hfill (5)

\textit{Hint}: Higher the loss in the switch, lower the efficiency of the converter.

2. Two pieces of semiconductors, A and B, have same overall concentration gradient but the average doping desity of A is $10^{16}$ cm$^{-3}$ whereas the average doping density of B is $10^{18}$ cm$^{-3}$. For which one the diffusion current will be higher and why? \hfill (5)

3. A silicon sample maintained at room temperature is uniformly doped with $10^{16}$ cm$^{-3}$ donors. Calculate its resistivity. If the doping level is increased to $10^{18}$ cm$^{-3}$, will the resistivity change by two orders of magnitude? Explain your answer. If the temperature changes from 300 K to 400 K for the $10^{16}$ cm$^{-3}$ doping case, what would be new resistivity? Assume mobility varies with temperature as $\mu_n \propto \left(\frac{T}{300}\right)^{-2.42}$ and $\mu_p \propto \left(\frac{T}{300}\right)^{-2.2}$. Mobility at 300 K is 1100 cm$^2$/V.sec and 400 cm$^2$/V.sec for electrons and holes respectively. \hfill (5)

4. The semi-infinite \textit{p-type} bar (see figure below) is illuminated with light which generates $G_L$ electron-hole pairs per cm$^{-3}$-sec uniformly throughout the volume of the semiconductor. Simultaneously, carriers are extracted at $x = 0$ making $\Delta n_p = 0$ at $x = 0$. Assuming a steady state condition has been established and $\Delta n_p(x) \ll p_0$ for all $x$, determine $\Delta n_p(x)$. \hfill (5)