1. We know that with temperature, the mobility increases. So in Sahara desert we’ll have less mobility $\rightarrow$ higher resistance $\rightarrow$ higher $I^2R$ loss $\rightarrow$ lesser efficiency.

2. With increase in the doping density, mobility decreases. Here ‘B’ has doping density of $10^{18}$ cm$^{-3}$, and thus has lower mobility than A. Now from Einstein’s equation

$$\mu = \frac{kT}{q}$$

Therefore ‘B’ has lower $D$ i.e. the diffusion coefficient.

So, $D_B < D_A \Rightarrow qD_B < qD_A, \frac{dN}{dX} < \frac{dN}{dX}$. as $\frac{dN}{dX}$ is same for both A and B.

3. i) Mobility $\mu_n = 1100$ cm$^2$ V$^{-1}$ sec$^{-1}$

$\mu_p = 400$ cm$^2$ V$^{-1}$ sec$^{-1}$

The sample is doped with donors. So the sample is N type.

$n = 10^{16}$ cm$^{-3}$

$p = n_i^2/n = 10^{4}$ cm$^{-3}$

$$\rho = \frac{1}{nq\mu_n + pq\mu_p} = 0.567 \Omega \cdot m$$

ii) If the doping level is increased to $10^{18}$ cm$^{-3}$, the resistivity will not change by two orders of magnitude. This is because the mobility will not remain constant and will decrease. That will somewhat compensate for the change in the doping density.

iii) $\mu_n \propto \left(\frac{T}{300}\right)^{-2.42}$, $\mu_{300} = 1100$, hence $\mu_{400} = 1100 \times (400/300)^{2.42}$

$\rho_{400K} = 1.138 \ \Omega \cdot \text{cm}.$

4. We have to apply continuity equation to solve this problem. There is no electric field. So, the only terms will be diffusion, generation, and recombination terms. We can write,

$$D_n \frac{d^2n_p}{dx^2} + G_L - \frac{n_p}{\tau_n} = 0$$

This is a 2nd order non-homogeneous ordinary differential equation. Its general solution is given by the sum of two separate parts. They are called complimentary function and particular integral.

Complimentary function is the solution of the corresponding homogeneous equation i.e. $D_n \frac{d^2n_p}{dx^2} - \frac{n_p}{\tau_n} = 0$ and is given by,

$$n_p(x) = Ae^{-x/\sqrt{D_n\tau_n}} + Be^{x/\sqrt{D_n\tau_n}}$$
The particular integral is given by,

\[ P.I. = \frac{1}{D^2} \int \frac{G_n}{D_n} \, dx = \frac{1}{D_n \tau_n} \int \frac{G_n}{D_n} \, dx = n_n \tau_n \]

So, the minority carrier electron density is given by,

\[ n_p(x) = A e^{-\sqrt{D_n \tau_n}} + B e^{\sqrt{D_n \tau_n}} + G_n \tau_n \]

Putting boundary condition, \( n_p(x) \big|_{x=0} = 0 \), we get, \( A + B + G_n \tau_n = 0 \). Also, from the semi-infinite bar approximation we know that \( A \) has to be zero (otherwise as \( x \to \infty \), we don’t have any physically meaningful carrier density). So, \( A = 0, \Rightarrow B = -G_n \tau_n \)

Therefore, the minority carrier density is given by,

\[ n_p(x) = G_n \tau_n \left( 1 - e^{\sqrt{D_n \tau_n}} \right) \]