Assignment – 2: (Total 30 marks)

Instruction:

1. All students are expected to go beyond the classroom teaching and add additional materials based on studies from internet and books.

2. Copying/plagiarism from each other and internet sources (in terms directly using the same sentence) is strictly prohibited. Wherever figures are adopted appropriate references should be provided.

Questions:

1. Categorize the following semiconductors as transparent, partially transparent, opaque for visible light (λ = 0.4–0.7 μm): Si, Ge, GaAs, GaP, GaN. Give suitable reasons. (**3 marks**).

2. Band gap of Si has an empirical depends on the temperature as: E_g = 1.17 eV − 4.73 × 10^{-4} $\frac{T^2}{T+630}$. Obtain the concentration of electrons in the conduction band of intrinsic (undoped) Si at T = 77 K and 400K if at 300 K n_i = 1.05 × 10^{10} cm^{-3}. Comment on conduction at different temperatures. (**3 marks**).

3. Hole mobility of GaAs at room temperature is 1500 cm^2/Vs. Estimate the diffusion coefficient of the charge carrier at 300 K. If the diffusion length of the charge carrier is 1 μm, estimate the charge carrier lifetime. (**3 marks**).

4. Estimate the thermal velocity of electrons and holes in GaAs at 77 K, 300 K, 400 K. Effective mass of electron is 0.063 m_e and hole is 0.53 m_e. (**3 marks**).

5. A Silicon sample is doped by donor impurities with a concentration $\boldsymbol{N_D}$ = $\mathbf{10^{15}}$/cc. The difference in energy level between the donor impurity level and the intrinsic Fermi level is 0.4 eV. If the energy gap and levels for Silicon do not vary with temperature. The intirinsic carrier concentration at different temperature is given as : 10^{10} /cc at 300 K and 10^{15} /cc at 600 K

   A) Estimate the position of Fermi level at 300 K and draw all the energy level of this semiconductor (**3 marks**).
   B) Repeat the calculation for 600 K and comment on the semiconductor properties. (**3 marks**).

6. Estimate the height of the potential barrier for a Au-*n*-Ge Schottky contact at room temperature (T = 293 K) if ρ = 1 Ω cm, ψ_{Au} = 5.1 eV, and χ_{Ge} = 4.0 eV. Electron mobility in Ge is 3900 cm^2/Vs , DOS in the conduction band is = 1.98 × 1015 × $T^{3/2}$ /cc . **(3 marks).**

7. Assume a M-Si diode with $N_D = 10^{17}$ /cc and that the metal is gold (Au) with a Schottky barrier height of $\Phi_B = 0.25$ eV. Estimate the saturation current density, if the effective mass of electrons is 0.036 m_e. (**3 marks**)

8. Radiative, band-to-band, recombination is observed to be proportional to the product of electron and hole concentrations. Consider a p-type semiconductor with an impurity concentration N_A:

a) Find an expression for its radiative lifetime under low bias voltage of 1 V. (**3 marks**)

b) Find an expression for its radiative lifetime when the device is operated at 10 V. Comment the results you obtain. (**3 marks**).

Note : Consider that the LED switches on at 0.9 V.