Benha University
Faculty of science
Physics department
2019/2020

Semiconductor
PHY 451
4th Year Level
Time: 3 Hours

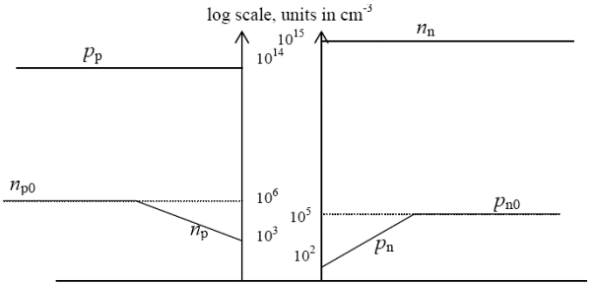
Answer only 5 questions: [each question 5x16 mark=80 marks]

1- .
   a. By using the periodic table, could u explain how the semiconductors compounds materials are bonding?
   b. If the energy spread of a band in solid state is of the order 1 eV or less. What are the consequences, regarding the temperature at which an experiment to determine the energy-level separation, must be carried out?
   c. Which band can partake in electrical conduction, complete fully, complete empty or partial occupy? And why?

2- .
   a. A 5-Ω resistor is to be made from a bar-shaped piece of n-type Si. The bar has a cross sectional area of 10^{-2} cm^2. The silicon is doped with $N_D = 5\times10^{17}$cm^{-3} and $N_A = 4\times10^{17}$ cm^{-3}. Determine the length of the silicon bar. [μ_n = 300 cm^2/Vs]
   b. Calculate the velocity of an electron in a piece of n-type silicon due to its thermal energy at RT and due to the application of an electric field of 1000 V/m across the piece of silicon. [$m_e^* = 1.18m_o$ and m_o = 9.11x10^{-31} Kg, k=1.38x10^{-23}m^{2}Kg s^{-2} K^{-1} and μ_e = 0.15 m^2/(V.S)]

3-
   a. Define Domain in semiconductors and Negative differential resistance
   b. What is the Gunn diode? How it works?

4-
   a. Derive the built-in potential, V_{bi} in p-n junction.
   b. The figure below is a dimensioned plot of the steady state carrier concentration inside a p-n junction diode at 300 K.
      i. Is the diode forward biased or reverse biased? Explain.
      ii. What are the p-side and n-side doping concentrations?
      iii. Determine the applied voltage, V_A.



5- An abrupt silicon p-n junction diode has the following characteristics.

P-side:	N-side:
$N_A = 10^{16}$ cm^{-3}	$N_D = 4\times10^{16}$ cm^{-3}
μ_n= 1000 cm^2/Vs	μ_p = 350 cm^2/Vs
$\tau_p = 10^{-7}$sec	$\tau_p = 10^{-7}$sec

Area $A = 10^{-2}$ cm^2

Calculate the following (a-d) quantities:
   a) Reverse saturation hole current component.
   b) Reverse saturation electron current component.
   c) Minority carrier concentrations at the edge of the depletion layer, $n_p(0)$ and $p_n(0)$, for a forward voltage of 0.6 V.
   d) Electron and hole current for the bias condition of (c).

6- Derive the Depletion Capacitance for p-n junction.

$$J_p = \mu_p (p\frac{dE_i}{dx} - kT\frac{dp}{dx}) = 0 \quad (3)$$

$$p = n_i \exp(\frac{E_i - E_f}{kT}) \Rightarrow \frac{dp}{dx} = \frac{p}{kT}(\frac{dE_i}{dx} - \frac{dE_f}{dx})$$

$$J_p = \mu_p p\frac{dE_f}{dx} = 0 \quad (4)$$

we conclude that $\frac{dE_f}{dx} = 0$ *which states that*
the Fermi Level is a CONSTANT at equilibrium.

$$J_n = \mu_n n\frac{dE_f}{dx} = 0 \quad (5)$$

With my best wishes