EECS 170A Final Exam

NAME: ID

QUESTIONS:

1. Fermi energy in silicon at room temperature is 0.3eV below the conduction band edge. Is this p-type or n-type silicon? Calculate the thermal equilibrium electron and hole concentrations?

Some parameters that can be useful

$h = 6.626x10^{-34}\ j.s$ $\quad q = e = 1.6x10^{-19}C$ $\quad k = 1.38x10^{-23}\ j/K$, $\varepsilon_o = 8.85\times10^{-14}\ F/cm$

$m_0 = 9.11x10^{-31}kg$ $\quad 1eV = 1.6x10^{-19}J,$ $\quad K_o = 3.9$ ($for\ silicondioxide, SiO_2$)

Silicon

$m_n^* = 1.08m_0$ $\quad m_p^* = 0.56m_0$ $\quad E_g = 1.12eV,$ $\quad K_S = 11.7$

Germanium

$m_n^* = 0.55m_0$ $\quad m_p^* = 0.37m_0$ $\quad E_g = 0.66eV,$

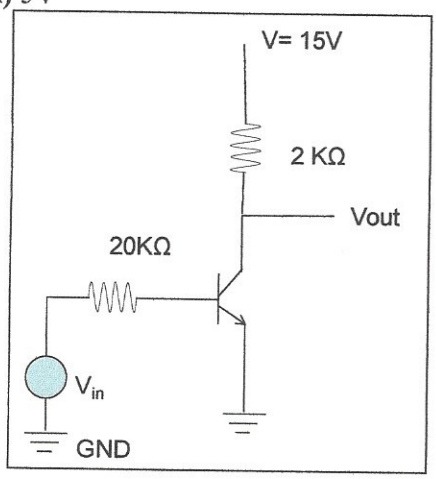
GaAs

$m_n^* = 0.067m_0$ $\quad m_p^* = 0.48m_0$ $\quad E_g = 1.42eV$

2. A uniformly doped abrupt p-n junction (step junction) diode is fabricated. At room temperature 25% of the total space charge region (depletion region) is in the p region. The built in potential is also measured to be 0.710V. a) Calculate the dopant concentrations, b) Size of the space charge region at n side and the p side, c) Calculate the maximum electric filed inside the junction, d) Calculate the current density generated by **majority** carriers at $\mathbf{x=x_n+3\mu m}$ under 0.5V forward bias voltage?

NAME: ID

3. An npn transistor is used to create and amplifier circuit as shown in the figure operating in active (forward active) mode. Assume that $\alpha_F = 0.95$, $\alpha_R = 0.25$, $\alpha_F I_{F0} = I_S = 1\times10^{-14}\,A$ for the transistor. Calculate the input voltages to extract following output voltages (use Ebers-Moll Model) **i)** 10V, **ii)** 5V



4. Metal work function, Φ_M, for aluminum is 4.1V. Electron affinity, χ, for silicon is given as 4.15V. Calculate the metal semiconductor work function (Φ_{ms}) of an MOS capacitor with p-type silicon where acceptor concentration is $4x10^{16}\,cm^{-3}$.

NAME: ID

5. We have an n-channel MOSFET circuit shown in the figure. We are given following parameters: $V_T = 0.5V$, $V_{DD} = 4V$, $V_{SS} = -2V$, $V_{DS} = 0.5V$, $I_D = 1mA$, and $\frac{Z}{L}\bar{\mu}_N C_o = 2\times10^{-3}(A/V^2)$. Determine at which mode the MOSFET is operating? Calculate resistance values for R_D and R_S.