THE CATHOLIC UNIVERSITY OF EASTERN AFRICA

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MAIN EXAMINATION

JANUARY – APRIL 2019 TRIMESTER

FACULTY OF SCIENCE

DEPARTMENT OF PHYSICS

REGULAR PROGRAMME

PHY 307: PHYSICAL ELECTRONICS

Date: APRIL 2019	**Duration: 2 Hours**
INSTRUCTIONS: Answer Question ONE and any other Two Questions	

Electron charge q = $1.6\,X\,10^{-19}\,C$

Mobility of electron in silicon $\mu_e = 0.145\,m^2/$¿ V.s

Mobility of holes in silicon $\mu_p = 0.05\,m^2/$¿ V.s

Mobility of electrons in Germanium $\mu_e = 0.38\,m^2/$¿ V.s

Mobility of holes in Germanium $\mu_p = 0.18\,m^2/$¿ V.s

Boltzmann constant $k = 1.38\,X\,10^{-23}\,J/$¿K

Q1 a) i) State the mass action law **(1mark)**

ii) Determine the intrinsic carrier density of Germanium at 300K **(2marks)**

b) Distinguish between the following terms

i) Recombination and Generation of charge carriers **(2marks)**

ii) Diffuse and Drift currents **(2marks)**

c) Define the following terms

i) Negative temperature coefficient **(1 mark)**

ii) Doping **(1mark)**

iii) Mean lifetime **(1mark)**

iv) Acceptor ion **(1mark)**

d) i) Calculate the resistivity of an intrinsic Germanium at 300K **(3marks)**

ii) Write a mathematical definition of the 'volt equivalence of temperature'. Hence determine its value at $27^{O}C$ **(2marks)**

e) i) Distinguish between forward and reverse biasing of a P-N junction **(2marks)**

ii) Calculate the Barrier potential at room temperature (300K) for a P-N junction In silicon which is doped to a carrier density of $10^{21}m^{-3}$ on the P – side and $10^{22}m^{-3}$ on the N- side. The intrinsic carrier density for silicon is $1.4 \times 10^{16}m^{-3}$. **(3marks)**

f) Determine the Germanium PN junction diode current for a forward bias voltage of 0.22V at room temperature $25^{O}C$ with reverse saturation current of 1mA.Take $\eta = 1$ **(3marks)**

g) i) State three applications of semi-conductor diodes in modern electronic Circuitry. **(3marks)**

ii) Using the approximate Boltzmann's diode equation, find the change in Forward bias for doubling the forward current of a Germanium Semiconductor at 290K **(3marks)**

Q2. a) A copper wire of 2mm diameter with conductivity of 5.8×10^{7} S/m and electron mobility (μ¿ of $0.0032m^2/V$-s is subjected to an electric field of 20mV/m. Find

i) The charge density of the free electron **(2 marks)**
ii) The current density **(2 marks)**
iii) The current flowing in the wire **(3 marks)**
iv) The electron drift velocity **(1 mark)**

b) A conduction wire has resistivity of $1.54 \times 10^{-8}\Omega$-m at room temperature. There are 5.8×10^{28} Conduction electrons per m^3. Calculate the mobility of the electrons **(5marks)**

c) Find the intrinsic carrier concentration of silicon at 300K for which $N = 3 \times 10^{25} m^{-3}$, E_g = 1.1eV $\mu_e = 0.145m^2/V$-s and $\mu_p = 0.05m^2/V$-s. Also find the conductivity of silicon. **(5 marks)**

Q3. a) A germanium diode has a saturation current of 10 μA at room temperature (300K). Find the Saturation current at 400K **(4marks)**

b) The current flowing in a certain P-N junction diode at room temperature is 2×10^{-7}A,When a large reverse voltage is applied. Calculate the current flowing when 0.1V forward Bias is applied at room temperature. **(6 marks)**

c) Sketch the characteristic curve of a p-n junction diode and explain its shape? **(6marks)**

d) The current- voltage characteristic of a p-n junction diode is given by the relatio $I = I_o\,(e^{\frac{qv}{\eta kT}} - 1)$ the diode current is 0.5mA at V = 440mV. Determine the value of η. Assume kT/q =25mV. **(4marks)**

Q4. a) From the Fermi- Dirac probability distribution function, show that for an intrinsic Semiconductor, the Fermi level lie midway between the conduction band and the Valence band. **(10marks)**

b) An intrinsic semi conductor (silicon) has 5×10^{28} atoms/m³ at 20°C room temperature. At this temperature, there are 1.5×10^{16} electron- hole pairs. Find the conductivity of silicon at 20 °C.
If the above material is doped with indium atoms at the rate of 1 atom per 10^7 silicon atoms.
Find the conductivity of the doped material at room temperature. If the conductivity increases at the rate of 5% per °C then find the conductivity of silicon at 34°C also. **(10marks)**

Q5. a) Derive an expression for the Barrier potential, VB in terms of the impurity densities causing it. **(8marks)**

b) An npn transistor in a CE mode is used as a simple voltage amplifier with a collector current of 4mA. The terminal of an 8V battery is connected to the collector through a load resistance R_L and to the base through a resistor R_B. The collector – emitter voltage V_{CE}= 4V, Base- emitter voltage V_{BE}=0.6V and the base current amplification factor β = 100.

i) Draw the physical representations and the schematic symbols for an npn transistor **(2marks)**

ii) Determine the value of R_L and R_B **(10marks)**

END