THE CATHOLIC UNIVERSITY OF EASTERN AFRICA

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MAIN EXAMINATION

MAY – JULY 2019 TRIMESTER

FACULTY OF SCIENCE

DEPARTMENT OF PHYSICS

SPECIAL / SUPPLEMENTARY EXAMINATION

PHY 307: PHYSICAL ELECTRONICS

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

Constants

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= $1.38\,X\,10^{-23}\,j/K$

1. (a) i, Differentiate between a conductor and a semi- conductor? (2mks)
ii, What do you understand by the term "negative coefficient" (1mk)
iii, Explain the following terms;
- Acceptor ion
- Doping

- Mean lifetime (3mks)

(b) i, State the mass action law (1mk)

ii, Calculate the intrinsic conductivity of Silicon at room temperature

if $n_i = 1.41\,X\,10^{16}\,m^{-3}$, $\mu_e = 0.145\,m^2/V.s$, $\mu_p = 0.05\,m^2/V.s$ and

$q = 1.6\,X\,10^{-19}\,C$. What are the individual contributions made by electrons and

holes. (8mks)

(c) i, Distinguish between forward and reverse biasing of a P-N junction. (2mks)

ii, State three applications of semi- conductor diodes in modern electronic circuitry?

(3mks)

(d) i, 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 $1.4\,X\,10^{16}\,m^{-3}.(4\,mks)$

(e) A specimen of Silicon is 0.2mm long and a cross sectional area of 0.2 X 0.2mm. One

Volt is impressed across the bar results in a current of 8mA. Assuming that the current

is due to electrons, calculate

i, Concentration of free electrons

ii, Drift velocity given at 300K, $\mu_n = 1300m^2/V.s$ and q = $1.6\,X\,10^{-19}\,C$ (6mks)

2.(a) Find the length of a round copper wire of diameter 1mm which will have a resistance of 1Ω and conductivity $1.58\,X\,10^7$S/m. If the wire is subjected to an electric field of 10mV/m, What is the current density? (7mks)

(b) A conduction wire has a resistivity of $1.54\,X\,10^{-8}$Ωm at room temperature. There are $5.8\,X\,10^{28}\,c$onduction electrons perm^3. Calculate the mobility of the electrons. (5mks)

(c) The mobility of free electrons and holes in pure germanium are 0.38 and 0.18m^2/V.s, The corresponding values in Silicon are 0.13 and 0.05m^2/V.s respectively. Find the value of intrinsic conductivity for both materials. Assume $n_i = 2.5\,X\,10^{19}/m^3$ for Ge and $1.5\,X\,10^{16}/m^3$ for Si at room temperature. (8mks)

3. (a) From Fermi - Dirac probability distribution function, Show that for an intrinsic semi-conductor, the Fermi level lie midway between the conduction and valence bands (10mks)

(b) A specimen of pure Germanium at 300K has a density of charge carriers of $2.5\,X\,10^{19}¿m^3$. Its doped with a donor impurity atoms at the rate of one atom for every 10^6atoms of Germanium. All impurity atoms may be ionized. The density of Ge atom is $4.2\,X\,10^{28}\,atoms/m^3$. Find the resistivity of the doped germanium if the electron mobility is $0.36m^2$/V.s (5mks)

(c) Silicon is doped with acceptor atoms to a density of $10^{22}\,m^{-3}$. If its assumed that all acceptor centres are ionized, calculate the conductivity of extrinsic silicon. Given that intrinsic density is $1.4\,X\,10^{16}\,m^{-3}$. $\mu_e = 0.145\,m^3 \wedge \mu_p = 0.05\,m^{-3}$. (5mks)

4.(a) What do you understand by the terms

i, Potential barrier of a P-N junction (2mks)

ii, Bulk resistance of a semi-conductor material (2mks)

(b) Germanium diode has saturation current of $10\mu A$ at room temperature 300K. Find the saturation current at 400K. (4mks)

(c) Show that the junction resistance for silicon or germanium diode is given by the equation;

$r_j = \frac{26}{I_F}$ Where I_F is the diode current in milliamperes. (12mks)

5. (a) An intrinsic semi-conductor (Silicon) has $5\,X\,10^{28}\,atoms/m^3$ at $20℃$ room temperature. At this temperature, there are $1.5\,X\,10^{16}\,electron-hole$ pairs. Find the conductivity (σ ¿ of silicon at $20℃$. If the above material is doped with indium atoms at the rate of 1atom per 10^7 silicon atoms, Find the conductivity of doped material at room temperature. If the conductivity increases at the rate of 5% per$℃$ then find also the conductivity of doped silicon at $34℃$
$(\mu_e = 0.145\,m^2/V.s, \mu_p = 0.05\,m^2/V.s, K = 1.38\,X\,10^{-23} \wedge q = 1.6\,X\,10^{-19}C$ ¿ (10mks)

(b) Determine the germanium P-N junction diode current for a forward bias voltage of 0.22V at room temperature $25℃$ with a reverse saturation current equal to 1mA. Take η = 1 (5mks)

(c) A silicon diode has a bulk resistance of 2Ω and forward current of 12mA. What is the actual value of V_F for the device?
(5mks)

END