MAASAI MARA UNIVERSITY

REGULAR UNIVERSITY EXAMINATIONS
2022/2023 ACADEMIC YEAR
MASTERS SECOND SEMESTER

SCHOOL OF PURE, APPLIED AND HEALTHY SCIENCES
MASTER OF SCIENCE IN PHYSICS (RENEWABLE ENERGY AND ELECTRONICS)

COURSE CODE: PHY 8209

COURSE TITLE: SEMICONDUCTOR PHYSICS AND DEVICES

DATE: 25/4/ 2023 **TIME: 0830-1130 HRS**

INSTRUCTIONS TO CANDIDATES

1. Answer Question **ONE** and any other **Two** questions

*This paper consists of **four** printed pages. Please turn over.*

Question one [30 Marks]

a. Define the following terms [5marks]
   i. Electronic structure
   ii. Doping
   iii. Phonons
   iv. Hall effect
   v. Valence electrons

b. Consider an n-channel GaAs MESFET at T=300 K with a gold contact. Assume the barrier height is 0.89V. The n-channel doping is 2×10^{-15}cm^{-3} and the channel thickness is 0.6μm. Calculate the pinch-off voltage and the built-in potential. The dielectric of GaAs is 12.4. (Take charge of electron q= 1.6×10^{19} C, kT/q =0.026 and $N_C = 4.7\times 10^{17}$ cm^{-3}). [4marks]

c. Explain Pauli exclusion principle. [2marks]

d. With suitable diagrams, distinguish between intrinsic and extrinsic semiconductor. [4marks]

e. State three main advantages of semiconductor memories [3marks]

f. Sate two differences and two similarities between the JFET and MESFET. [4marks]

g. Draw a well ladled diagram of the structure of thin film solar cell. [4marks]

h. A silicon ingot is doped with 10^{16} asernic aroms/cm^3. Find the carrier concentration and the fermi level at room temperature (300 K). (take n_i =9.65×10^9). [4marks]

<u>QUESTION TWO [20 MARKS]</u>

(a). (i) Describe the term defect engineering [2marks]
(ii) Explain two types of defect engineering [4marks]

(b) Calculate the mean free time of an electron having a mobility of 1000 cm^2/V-s at 300K; also calculate the mean free path. Assume m_n =0.26 m_n in these calculations. (Take m_n =0.91×10^{-30} kg, charge of electron q= 1.6×10^{19} C and thermal velocity of electrons at room temperature to be 10^7cm/s). [4marks]

(c) Show that Boltzmann transport equation is given as; [6marks]

$$\frac{\partial f}{\partial t} = -\frac{1}{\hbar}\vec{F}_{\text{ext}} \cdot \nabla_{\vec{k}} f - \vec{v} \cdot \nabla_{\vec{r}} f + \left.\frac{\partial f}{\partial t}\right|_{collisions}.$$

where symbols have their usual meaning.

(d) With suitable examples, differentiate between volatile and non-volatile memory [4marks]

QUESTION THREE [20MARKS]

(a) Briefly describe the formation of a P-N junction [4marks]

(b) (i) Describe the band gap theory of semiconductors [4marks]

(ii) With the help of a well-labeled diagram, explain the direct and indirect band gap. [6marks]

(c) Describe two types of metal-semiconductor contacts. [4marks]

(d) State and explain two types of charge carriers. [2marks]

QUESTION FOUR [20MARKS]

(a) Sate and explain three types of photonic devices. [6marks]

(b) Discuss two applications of LEDs [4marks]

(c) What is Quantum Efficiency as used in photodiodes? [2marks]

(d) State two applications of MOSFETs. [2marks]

(e) Differentiate between cathodoluminescence and radioluminescence [2marks]

(f) Draw a diagram to illustrate processes of intrinsic photoexcitation from band to band, and extrinsic photoexcitation [4marks]

QUESTION FIVE [20MARKS]

(a) State three challenges inhibits commercialization perovskite solar cells [3marks]

(b) Briefly discuss three generations of solar cells. [6marks]

(c) A sample of Si is doped with 10^{16} phosphorus atoms/cm^3. Find the Hall voltage in the sample with W=500 μm, A=2.5×10^{-3} cm^2, I=1 mA, and B_z =10^{-4} Wb/cm^2. [4marks]

(d) What is a semiconductor laser? Explain how optical amplification is achieved in a semiconductor laser [3marks]

(e) Different between Quantum-Effect Devices and Hot-Electron Devices.[2marks]

(f) What is a Heterojunction photodiode? [2marks]

//END//