MACHAKOS UNIVERSITY

University Examinations 2017/2018

SCHOOL OF PURE AND APPLIED SCIENCES
DEPARTMENT OF PHYSICAL SCIENCES
THIRD YEAR SECOND SEMESTER EXAMINATION FOR
BACHELOR OF EDUCATION (SCIENCE)

SPH 340: SEMICONDUCTOR PHYSICS AND DEVICES

DATE: 5/12/2017 **TIME: 2.00-4.00 PM**

INSTRUCTIONS TO CANDIDATES

Answer **QUESTION ONE** which is *COMPULSORY* and **ANY OTHER TWO** questions.

Question 1 carries **30** marks and the others carry **20** marks each.

YOU MAY USE:

You may need to use the following constants

- Permittivity of free space, $\varepsilon_o = 8.85 \times 10^{-12}$ F/m ($k = 8.99 \times 10^9$ Nm^2C^{-2})
- Mass of an electron, $M_e = 9.11 \times 10^{-31}$ Kg
- Electronic charge, $e = 1.6 \times 10^{-19}$ C
- Permeability of free space, $\mu_o = 4\pi \times 10^{-7}$ Tm/A
- $1eV = 1.6 \times 10^{-19}$J

QUESTION ONE (COMPULSORY) (30 MARKS)

a) Differentiate between allowed and forbidden bands of a solid (2 marks)

b) What is meant by an intrinsic and extrinsic semiconductor? (4 marks)

c) Define and draw a schematic of a PN junction diode (3 marks)

d) State two disadvantages of semiconductor devices (2 marks)

e) Define an IMPATT and list any 3 uses (5 marks)

f) (i) Define an operation amplifier (2 marks)

(ii) Define CMRR and explain why an OP-AMP have a high CMRR (4 marks)

g) An input signal with $4V_{rms}$ is imputed into a 741 Op-amp. The output voltage is found to be $22V_{rms}$. Calculate the voltage gain in linear and decibel scales. (4 marks)

h) (i) Define a MOSFET (2 marks)

(ii) Draw the symbol of a MOSFET (2 marks)

QUESTION TWO (20 MARKS)

a) Name the four classes of microwave semiconductor devices (4 marks)

b) Showing illustrations, differentiate between a BJT and JFET (4 marks)

c) Define and describe the structure and operations of a TRAPATT diode (7 marks)

d) A PN-junction employs the following doping levels: $N_a = 10^{16}cm^{-3}$ and $N_d = 5 \times 10^{15}cm^{-3}$. Determine the hole and electron concentrations on the two sides given that $n_i = 1.08 \times 10^{10}cm^{-3}$. (5 marks)

QUESTION THREE (20 MARKS)

a) Define the following terms;

i) Valence band

ii) Conduction band

iii) P-type semiconductor

iv) N-type semiconductor

v) Doping (5 marks)

b) In terms of electronic band diagrams only, explain an insulator, conductor and semiconductor. (6 marks)

c) With aid of diagrams, describe the two transport phenomena for semiconductors (5 marks)

d) Show that the electrical conductivity of an extrinsic semiconductor is given by;

$$\sigma = e(n\mu_n + p\mu_p)$$ (4 marks)

QUESTION FOUR (20 MARKS)

a) Differentiate between forward and reverse biasing of a PN junction (4 marks)

b) Draw the I-V characteristics of a semiconductor clearly showing reverse, forward, knee and breakdown regions (6 marks)

c) Show that for a transistor in active mode configuration (7 marks)

$$\alpha_{dc} = \frac{\beta_{dc}}{1 + \beta_{dc}}$$

d) Identify 3 applications of a transistor (3 marks)

QUESTION FIVE (20 MARKS)

a) Describe 3 types of OP-AMPS (6 marks)

b) Show that the voltage gain for an inverting amplifier is given by; (5 marks)

$$G = -\frac{R_2}{R_1}$$

c) Show that for an ideal non-inverting amplifier, the voltage gain is given by;

$$G = 1 + \frac{R_2}{R_1}$$

(5 marks)

d) Name any four characteristics of an ideal op-amp (4 marks)