MACHAKOS UNIVERSITY

University Examinations for 2021/2022 Academic Year

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

SECOND YEAR SECOND SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (APPLIED PHYSICS AND TECHNOLOGY)

THIRD YEAR SECOND SEMESTER EXAMINATION FOR

BACHELOR OF EDUCATION (SCIENCE)

SPH 206/SPH 340: SEMICONDUCTOR PHYSICS AND DEVICES

DATE: 10/12/2021 **TIME: 8:30 – 10:30 AM**

INSTRUCTIONS:

Answer question **ONE** which is compulsory and any other **TWO**

Take: *Permittivity due free space,* $\varepsilon_o = 8.854 \times 10^{-12} CN^{-1}m^{-1}$

Charge on electron, $e = 1.6 \times 10^{-19} C$

Planck's constant, $h = 6.626 \times 10^{-34}\ Js$

Mass of electron $m_e = 9.1 \times 10^{-31}\ kg$

SECTION A (COMPULSORY)

QUESTION ONE (COMPULSORY)

a) Explain the main shortcomings of the Bohr atomic model (3 marks)

b) Describe the Rutherfold atomic model (5 marks)

c) Distinguish insulators and semiconductors (4 marks)

d) (i) Describe the production of majority charge carriers in p-n junction. (4 marks)

(ii) Describe charge recombination in semiconductors. (4 marks)

e) A silicon crystal with 5×10^{28} atoms/m^3 is doped at a concentration of 10^{-4} % of trivalent boron. If the concentration of the intrinsic charge carriers $n_i = 1.5 \times 10^{16}$ m^3, determine the number of: -

(i) Electrons (2 marks)

(ii) holes (3 marks)

f) Describe the advantages of integrated circuits (4 marks)

g) Define barrier potential in diodes (2 marks)

h) Explain how a transistor loadline is obtained (3 marks)

QUESTION TWO (20 MARKS)

a) In terms of energy bands, distinguish conductors, semiconductors and insulators. (4 marks)

b) Explain three ways in which the conductivity of a semiconductor can be improved (6 marks)

c) (i) Show that the energy of a hydrogen electron in the nth orbit is given by $E_n = -\frac{me^4}{8\varepsilon_o^2 n^2 h^2}$, where h is the Planck's constant, ε_o the permittivity of free space and m are the electronic charge and mass respectively. (7 marks)

(ii) Determine the energy of a hydrogen electron in the 2nd energy level. Giving a possible reason, account for the variation from the theoretical value. (3 marks)

QUESTION THREE (20 MARKS)

a) Distinguish between intrinsic and extrinsic semiconductors (4 marks)

b) Describe the working of a p-n junction (6 marks)

c) Describe the applications of photovoltaic effect in semiconductors (6 marks)

d) The intrinsic carrier concentration $n_i = n_0 exp\ (-E_g/2K_BT)$, where n_0, E_g, K_B, and T are the initial concentration of the carriers, energy band gap, Boltzmann constant and temperature, respectively. In terms of n_0, compare the carrier concentration at a temperature of 10K and 100 (assume that E_g for the sample is constant). (4 marks)

QUESTION FOUR (20 MARKS)

a) Describe photoelectric effect (2 marks)

b) Explain any two factors affecting photoelectric effect (4 marks)

c) After illuminating a material with beam of light of wavelength 300 nm, a potential of 1.8 V is required to stop the photoelectrons. Determine the: -

(i) Work function of the material (3 marks)

(ii) Maximum velocity of the photoelectrons (2 marks)

(iii) Maximum kinetic energy of the photoelectrons if the material was irradiated using 400 nm light. (3 marks)

d) Explain three failures of classical theory in explaining photoelectric effect (6 marks)

QUESTION FIVE (20 MARKS)

a) Describe the following semiconductor devices

(i) Zener diodes (5 marks)

(ii) Light emitting diodes (5 marks)

b) Distinguish between bipolar and field-effect transistors (4 marks)

c) A transistor has a collector current of 0.98 mA and a base current of 20 μA. Determine the: -

(i) Emitter current (2 marks)

(ii) Current amplification (2 marks)

(iii) Current gain (2 marks)