MACHAKOS UNIVERSITY

University Examinations 2020/2021 Academic Year

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

SECOND YEAR FIRST SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (TELECOMMUNICATION INFORMATION TECHNOLOGY)

BACHELOR OF SCIENCE (APPLIED PHYSICS AND TECHNOLOGY)

SPH 206: SEMICONDUCTOR PHYSICS AND DEVICES

DATE: 16/8/2021 **TIME: 2.00-4.00 PM**

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

QUESTION ONE (COMPULSORY) (30 MARKS)

a) Explain the main shortcomings of the Rutherfold model of the atom (3 marks)

b) Describe the Bohr atomic model (5 marks)

c) i Describe the production of electron-hole pair in a p-n junction. (4 marks)

ii. Charge recombination can be an advantage or a disadvantage. Explain giving an example for each a case. (4 marks)

d) A silicon crystal with 5×10^{28} atoms/m^3 is doped at a concentration of 1 part per million of pentavalent arsenic. If the concentration of the intrinsic charge carriers in the crystal is $n_i = 1.5 \times 10^{16}$ m^3, determine the number of: -

i. Electrons (2 marks)

ii. Holes (3 marks)

e) Outline five advantages of printed circuit boards (PCBs) (5 marks)

f) i. For a transistor, what is a loadline? (1 mark)

ii. Explain how a transistor loadline is obtained (3 marks)

QUESTION TWO (20 MARKS)

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

b) Name and explain three factors that affect the energy band gap of a semiconductor (6 marks)

c) i Show that the energy of an 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, E_o in the permittivity of free space e and m are the electronic charge and mass respectively. (7 marks)

ii. Determine the energy of an electron in the 2nd energy level (3 marks)

QUESTION THREE (20 MARKS)

a) Distinguish between intrinsic and extrinsic semiconductors (3 marks)

b) Describe the production of holes and their movement within a crystal lattice (5 marks)

c) Describe the working of a p-n junction (8 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, determine the carrier concentration when the temperature of the sample is doubled (assume that E_g for the sample is constant). (4 marks)

QUESTION FOUR (20 MARKS)

a) Distinguish thermionic emission and 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 is irradiated using 600 nm light. (3 marks)

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

QUESTION FIVE (20 MARKS)

a) Describe the two main types of transistors (4 marks)

b) Transistors have several applications in electrical circuits. Using simple circuit diagrams, explain how they can be used as a: -

i. Switch (5 marks)

ii. Amplifier (5 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 factor (2 marks)

iii. Current gain factor (2 marks)