MACHAKOS UNIVERSITY

University Examinations for 2021/2022 Academic Year

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

SECOND YEAR FIRST SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (APPLIED PHYSICS AND TECHNOLOGY)

THIRD YEAR SECOND SEMESTER EXAMINATION FOR

BACHELOR OF EDUCATION (SCIENCE)

SPH 206/340: SEMICONDUCTOR PHYSICS AND DEVICES

DATE: **TIME:**

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) Distinguish between BJT and FET transistors (4 marks)

d) (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)

(e) 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 $n_i = 1.5 \times 10^{16}$ m^3, determine the number of: -

(i) Electrons (2 marks)

(ii) holes (3 marks)

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

Question 2

(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 a hydrogen electron in the nth orbit is given by $E_n = -\frac{me^4}{8\varepsilon_0^2 n^2 h^2}$, where h is the Planck's constant, e and m are the electronic charge and mass respectively. (7 marks)

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

Question 3

(a) Distinguish 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. Assuming that E_g for the sample is constant, determine the effect of doubling the temperature of the carrier concentration in terms of the n_0. (4 marks)

Question 4

(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 eV 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 600 nm light. (3 marks)

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

Question 5

(a) Describe the working of a full wave bridge rectifier (5 marks)

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

(i) Switch (4 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)