KENYATTA UNIVERSITY

UNIVERSITY EXAMINATIONS 2011/2012

FIRST SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF EDUCATION, BACHELOR OF SCIENCE AND BACHELOR OF TELECOMMUNICATION AND INFORMATION TECHNOLOGY

SPH 206/340: SEMICONDUCTOR PHYSICS AND DEVICES

DATE: Tuesday, 6th December, 2011 TIME: 11.00 a.m. – 1.00 p.m.

INSTRUCTIONS: Attempt Question **one** and any other **two** questions in this paper. Question one carrier 30 marks while the rest of the questions carry 20 marks each. Credit will be awarded for clear explanations, presentations and illustrations used.

Assume

Silicon concentration at Room temperature = $1 \times 10^{10}\ cm^{-3}$

Question One (Compulsory) (30 Marks)

a) What are extrinsic semiconductors and explain their importance to semiconductor device properties. (3 mks)
b) Define mobility and electrical conductivity as applied to semiconductors. (4 mks)
c) Discuss the *I–V* characteristics of a tunneling diode. (5 mks)
d) Draw the circuit symbol for an n-p-n bipolar junction transistor and indicate the respective current directions and voltage polarities. (4 mks)
e) Explain the operations of an *Insulated-gate Bipolar Junction Transistor* (IGBJT) and state **three** advantages that it has over both metal oxide semiconductor field effect transistor (MOSFET) and traditional Bipolar Junction Transistor (BJT) devices. (6 mks)

f) A silicon atom is doped with 1 x 10^{17} cm^{-3} arsenic atoms. Determine the equilibrium electron and hole concentrations at room temperature and the relative position of the Fermi level relative to intrinsic Fermi level? (5 mks)

g) In the circuit diagram Fig 1–1, the operational amplifier has infinite gain, infinite input impedance and negligible output impedance. Determine the expression for the circuit transfer function. (3 mks)

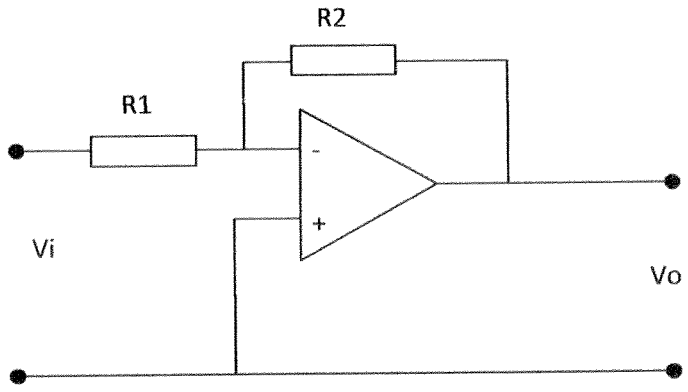

Fig. 1–1

Question Two (20 Marks)

a) Explain what is meant by an *energy gap* for an electron state in a solid. Use this concept to explain why diamond is transparent and silicon is opaque. (4 mks)

b) Explain why *energy gaps* are important in describing the electronic properties of materials. In your explanation distinguish between metals, semiconductors and insulators. (5 mks)

c) Explain with the help of well labeled diagrams, how a p-type semiconductor is formed from a crystal of intrinsic silicon and a trivalent impurity. (3 mks)

d) Starting with diffusion hole-current density given by the equation;

$$J_p = -q\frac{dp}{dx}$$

Derive the Einstein equation and hence show that for a non-uniformly doped intrinsic semiconductor

$$n_i^2 = pn,$$

where the notations have their usual meanings. (8 mks)

Question Three (20 Marks)

a) Briefly explain the following terms:
   i. Active region in common-base configuration. (2 mks)
   ii. Saturation region in common-emitter configuration. (2 mks)

b) Draw a circuit for an n-p-n transistor in the common-emitter (C-E) configuration for an active mode operation and derive an expression for the collector current. (5 mks)

c) State and explain **any** Bipolar Junction Transistor (BJT) model and illustrate your explanation using a circuit diagram. (4 mks)

d) The collector current in Common-Base configuration is 6 mA, ginen that the base current is 150 μA. Determine the emitter current. (2 mks)

e) Figure 3–1 shows a transistor in Common-Emitter configuration.

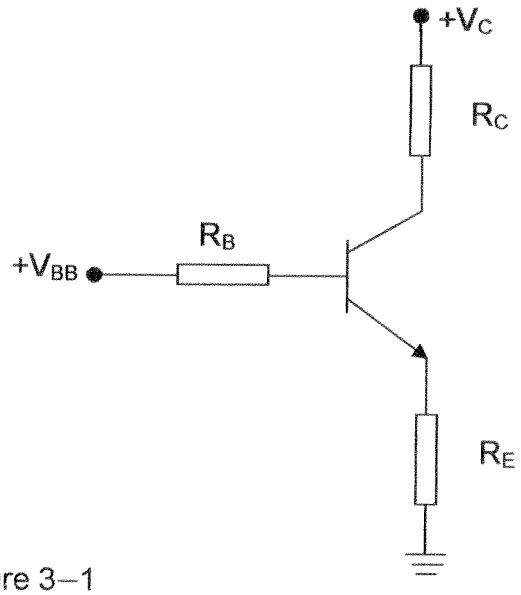

Figure 3–1

Given that the transistor has the following parameters: $h_{FE} = 50$, $V_{CC} = 25$ V, $V_{BB} = 10$ V, $R_B = 40$ KΩ , $R_C = 15$ KΩ and $R_E = 5$KΩ. Assume that the transistor is in saturation find I_B and I_C (5 mks)

Question Four (20 Marks)

a) Explain any **four** advantages that makes Field Effect Transistors (FET) more commonly used as compared to Bipolar Junction Transistor (BJT). (4 mks)

b) Using block diagrams of Junction FET, explain the main differences between n-channel and P-channel JFET. (4 mks)