MACHAKOS UNIVERSITY

University Examinations for 2022/2023 Academic Year

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

FIRST YEAR …….. SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (……

SMA 130: INTRODUCTION TO ELECTRONICS

DATE: **TIME:**

INSTRUCTIONS ***Answer question One and any other Two Questions***

QUESTION ONE (COMPULSORY) (30 MARKS)

a) Explain the salient features of Bohr's atomic model. (4 marks)

b) Explain the difference between energy level and energy band. (2 marks)

c) Explain the term CMRR and outline its significance in OP-Amps. (2 marks)

d) Calculate the value of the kinetic, potential and total energy of an electron revolving in Bohr's first orbit in a hydrogen atom. (6 marks)

e) Explain the difference between intrinsic and extrinsic semiconductors. (2 marks)

f) Sketch the atomic structure of copper and explain why it is a good conductor and how its structure is different from germanium and silicon. (4 marks)

g) Why do conduction band electrons possess very high energy? (2 marks)

h) Why are junction transistors called bipolar devices? (2 marks)

i) List the three parameters that limit the operating conditions of a PN junction. (3 marks)

j) Figure 4.0 shows the transfer characteristics curve of a JFET. Write the equation for drain current. (3 marks)

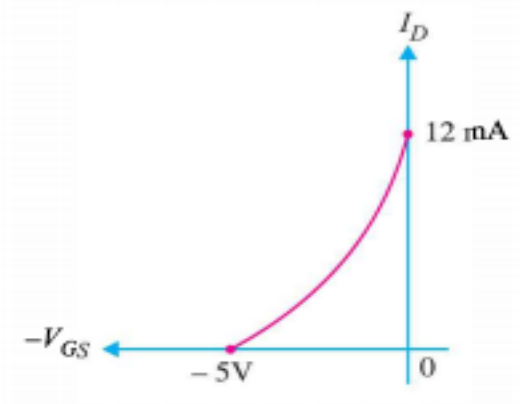

Figure 4.0

QUESTION TWO (20 MARKS)

a) What is an instrumentation amplifier? Draw a schematic diagram of an instrumentation amplifier using two OP-Amps with a variable voltage that can be used to achieve a high input resistance. From your circuit diagram, show that the voltage gain is:

$$A_V = 1 + \frac{R_2}{R_1} + \frac{2R_2}{R_3}$$

Where R3 is the variable resistor. (10 marks)

b) With the aid of relevant diagrams, describe the hole formation process in semiconductors. (10 marks)

QUESTION THREE (20 MARKS)

a) Why is the FET called a unipolar transistor? Draw the diagram of an n-channel transistor and explain the terms drain, gate and source. (5 marks)

b) Describe in detail using relevant diagrams, the Volt-Ampere characteristics of a PN junction. (10 marks)

c) The characteristics shown in Figure Q3.0 refer to a germanium diode. Determine the resistance of the diode when the forward current is 2.5 *mA* and when the forward voltage is 0.65 *V* and comment on your solution. (5 marks)

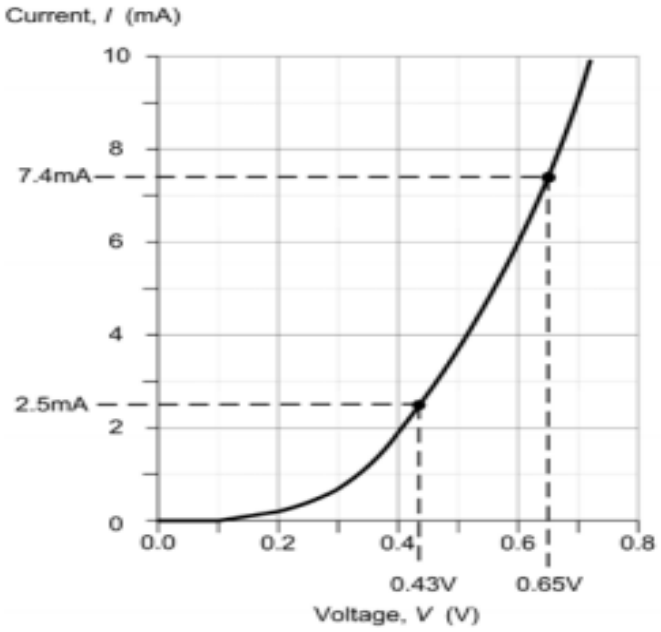

Figure Q3.0

QUESTION FOUR (20 MARKS)

a) Describe the formation of depletion layer and explain its operation in terms of its energy band diagram. (10 marks)

b) For the JFET amplifier circuit shown in Figure Q4.0, calculate the voltage gain with: (10 marks)

i) R_S bypassed by a capacitor
ii) R_S unbypassed.

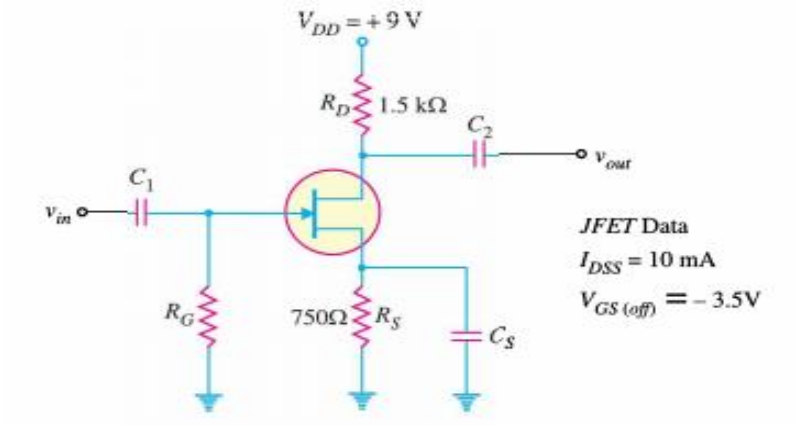

Figure Q4.0

QUESTION FIVE (20 MARKS)

a) Explain why the FET is called a voltage amplifier and the BJT a current amplifier. (4 marks)

b) Outline the four characteristics of an ideal OP-Amp. (4 marks)

c) With reference to the circuit shown in Figure Q5.0, identify whether they operate in the active mode or saturation mode. What is the emitter voltage in each case? If active what is the collector voltage? Given $|V_{BE}| = 0.7\ V$, $\beta = 100$. (12 marks)

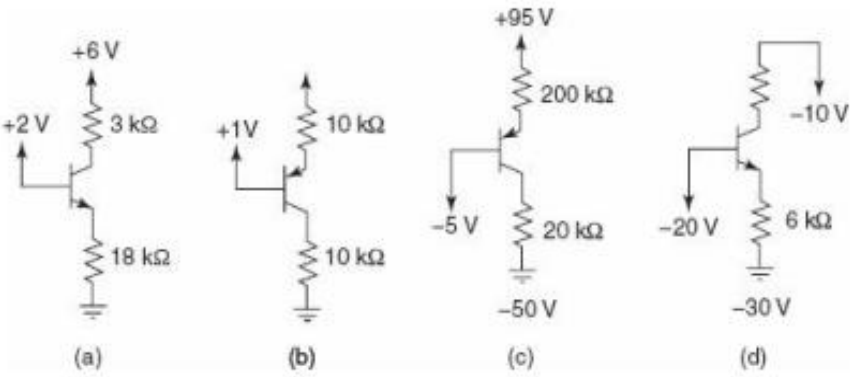

Figure Q5.0

Physical constants

Electronic charge, $e = 1.6 \times 10^{-19}C$

Mass of an electron, $m_e=9.11x10^{-31}kg$

Planck's Constant , $h=6.625x10^{-34}JS$

Permittivity of free space , $E_0=8.854x10^{-12}\ FM^{-1}$

Permeability of free space, $\mu_0=4\pi x10^{-7}\ Hm^{-1}$

Electron mobility $\mu_e=0.38m^2v^{-1}s^{-1}$ (intrinsic Ge)

Hole mobility, $\mu_n=0.18m^2v^{-1}s^{-1}$ (intrinsic Ge)

Boltzmann's constant , $k_B=1.38x10^{-23}JK^{-1}$

Rydberg constant , $R_H=1.1x10^7m^{-1}$

Electron volt (eV) $=1.6 \times 10^{-19}J$

Intrinsic carrier density for Germanium , $n_i = 2.5x10^{19}m^{-3}$

Intrinsic carrier density for silicon , $n_s = 1.5x10^{16}m^{-3}$ Z for hydrogen =1

Density of Germanium atoms density=$4.2x10^{28}$ atoms $/m^3$