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MAIN EXAMINATION

SEPTEMBER –DECEMBER 2021

FACULTY OF SCIENCE

DEPARTMENT OF NATURAL SCIENCES

REGULAR PROGRAMME

PHY 307: PHYSICAL ELECTRONICS

Date: DECEMBER 2021	**Duration: 2 Hours**
INSTRUCTIONS: Answer Question ONE and any TWO Questions	

You may use the following list of constants

- Planks constant (h) 6.63×10^{-34} J.s
- Electronic charge 1.602×10^{-19} C
- Germanium electron mobility $(\mu¿¿n)¿$ 3600 $cm^2V^{-1}s^{-1}$
- Intrinsic carrier concentration of germanium(n_i) 2.5×10^{13} cm^{-3}
- Ratio ¿¿) for germanium at 300K 2.0
- Speed of light in a vacuum 2.99792×10^8 m/s
- μ_n for silicon $0.135 m^3$/v-s
- μ_p for silicon $0.048 m^3$/v-s

Q1.

a) Differentiate between elemental and compound semiconductors **(2 marks)**

b) Using sketches of energy band diagrams distinguish between direct and indirect transition in semiconductors citing examples in each case. **(4 marks)**

c) Find the room temperature resistivity of an n-type silicon doped with 10^{15} phosphorus atoms/cm^3**.** **(3 marks)**

d) Determine the miller indices of a plane intercepting the x-axis, y-axis and z-axis at ,$\frac{1}{3}$, -1 and 1 respectively **(3 marks)**

e) Distinguish between the valence band and conduction band in semiconductors clearly explaining the concept of band gap in semiconductors **(4 marks)**

f) Using energy band diagrams clearly differentiate between metals semiconductors and insulators in terms of their electrical behavior **(4 marks)**

g) Define the following terms
   i. Doping
   ii. Drift current
   iii. Diffusion current
   iv. Mobility (**4 marks)**

h) With the aid of a diagram distinguish between forward and reverse biasing of a P-N junction **(4 marks)**

i) Determine the germanium P-N junction diode current for the forward bias voltage of 0.25 V at room temperature of 26°C with reverse saturation current equal to 2 mA. Take η=2. **(4 marks)**

Q2.

a) A germanium semiconductor at 300kis doped with donor impurity at a rate of 10^6 germanium atoms for every donor atom. Calculate the resistivity of the resulting semiconductor device. Assume there are 4.2 x 10^{22} germanium atoms per cubic centimeter. **(6 marks)**

b) Movement of charge carriers a cross a P-N junction determines the total current passing through the junction. State and explain any two processes through which charge carriers move across the P-N junction. What are the factors that affect their movement?. **(5 marks)**

c) Draw the current – voltage (I-V) characteristics of a p-n junction diode, state the equation relating the total current through the junction and the applied voltage. **(3 marks)**

d) Given that the drift current density is

$$J_{drift} = e(\mu_p p + \mu_n n)E$$

Show that the resistivity of an n-type material is given as $\rho = \frac{1}{e\mu_n n}$ **(6 marks)**

Q3.

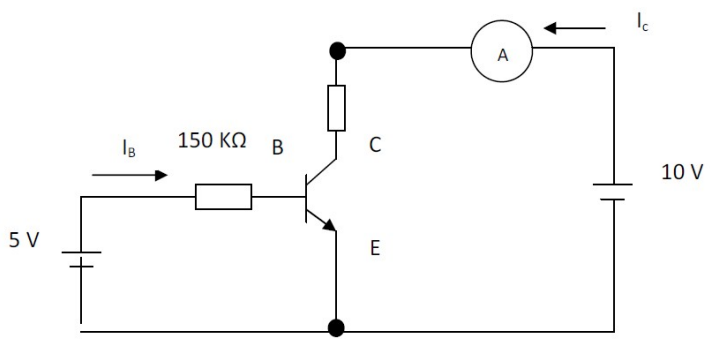
a) Briefly explain the following terms
   (i) Active region in C-B configuration **(2 marks)**
   (ii) Saturation region in C-E configuration **(2 marks)**

b) Draw a circuit for 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 marks)**

c) Using a circuit diagram explain any bipolar junction transistor (BJT) model. **(4 marks)**

d) The collector current in common base configuration is 6 mA, given that the base current is 150 μA. Determine the emitter current. **(3 marks)**

e) Find the following transistor currents in the circuit shown below given that V_{BE}=0.7 V and β=100
   i). I_B, I_C and I_E
   ii). V_{CB}



(4 marks)

Q4.

a) A sample of Si is doped with 10^{17} phosphorus atoms/cm^3. Given that W=500 μm, A=0.0025 cm^2, I=1 mA and BZ=1x10^{-4} Wb/cm^2, find the Hall voltage. **(4 marks)**

b) Outline the two categories of JFET **(2 marks)**

c) Define the following terms as used in JFET **(4 marks)**
   (i) Pinch voltage
   (ii) Transconductance
   (iii) Channel
   (iv) I_{DSS}

d) A wire of radius 1.0×10^{-3}m and conductivity of 5.8×10^{7}s/m and electron mobility $0.0032m^2/Vs$ is subjected to an electric field of 20mV/m.
Find
   i). The charge density of the free electrons **(3 marks)**
   ii). The current density **(2 marks)**
   iii). The current flowing in the wire **(3 marks)**
   iv). The electron drift velocity **(2 marks)**
(3 marks)

Q5.

a) What is a p-n junction diode **(1 mark)**
b) Explain the possible biasing of a junction diode in a circuit **(2 marks)**
c) Silicon diode has a saturation current of 0.01 μA at room temperature of 300K. Find the saturation current at 400K. **(5 marks)**
d) A transistor has β=180. Calculate the approximate collector and base currents, if the emitter current is 12 mA. **(3 marks)**
e) Determine the germanium P-N junction diode current for the forward bias voltage of 0.25V at a temperature of 500K with reverse saturation current of 1 mA. **(3 marks)**
f) With the aid of a diagram explain forward and reverse biasing of a p-n junction **(4 marks)**
g) Describe how a space charge region is formed in a p-n junction. **(2 marks)**

END