MASENO UNIVERSITY

UNIVERSITY EXAMINATIONS 2016/2017

THIRD YEAR FIRST SEMESTER EXAMINATIONS FOR THE DEGREE OF BACHELOR OF SCIENCE AND BACHELOR OF EDUCATION SCIENCE WITH INFORMATION TECHNOLOGY

MAIN CAMPUS

SPH 307: INTRODUCTION TO ELECTRONICS

Date: 28th November, 2016 Time: 3.30 - 6.30 pm

INSTRUCTIONS:

- Answer ALL questions in SECTION A and any TWO questions in SECTION B.

SECTION A. This section is **COMPULSORY.**
It carries a total of **30 marks.**

1. a) (i) What is the most important characteristic that differentiates semiconductors from metals and insulators? Expain. **(3 marks)**
(ii) Electrons do not recombine with holes in the p-type base region as they diffuse to the collector. Why? **(2 marks)**
(iii) Using a diagram, derive the relation between *drift velocity* (v_d)and *current density (J).* **(5 marks)**

b) (i) State three important parameters of semiconductor diodes. **(3 marks)**
(ii) Describe the phenomenon of *avalanche* and *Zener* breakdown effects. **(5 marks)**
(iii) Figure 1 shows the characteristics of a Zener diode.

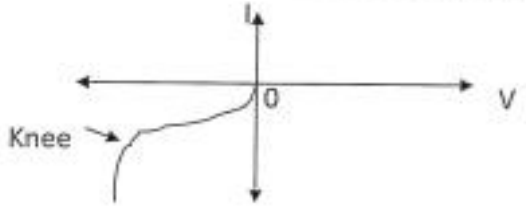

Fig.1

Explain the significance of the *knee*? **(3 marks)**

c) (i) Explain why NPN transistor is more popular than PNP transistor. **(2 marks)**
(ii) In practice, why are transistors most often used in *common-emitter* configuration. **(2 marks)**
(iii) State two important features of a transistor. **(2 marks)**

d) (i) What is an *oscillator*? **[1 mark]**
(ii) Draw an oscillator equivalent circuit. **[2 marks]**

SECTION B. Answer **ONLY TWO** questions from this section.
Each question carries twenty (20) marks.

2. a) The diagram in figure 2 shows a simplified transistor circuit with a few discrete components.

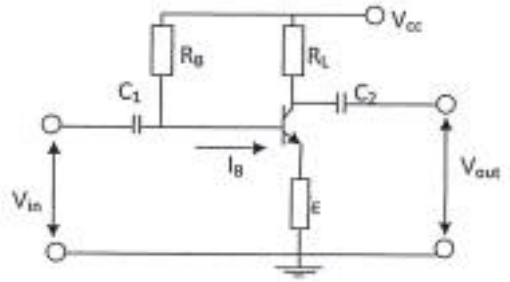

Fig. 2

You are given that $R_B = 1.8\ M\Omega$, $R_L = 4.7\ k\Omega$, $R_E = 1\ k\Omega$, $C_1 = C_2 = 10\mu F$ and $V_{CC} = 15V$.

(i) Explain how V_{out} and I_B are developed. **[2 marks]**

(ii) What is the purpose of C_1 and C_2 in the circuit? **[2 marks]**

b) Sketch an improved method of the biasing mode in figure 2 and explain how it works. **[10 marks]**

c) (i) Write the *load line equation* for the circuit in figure 2. **[2 marks]**

(ii) If $V_{CE} = 7.5V$ and $\alpha_E = 50$, calculate I_C and I_B. **[4 marks]**

3. a) (i) Indium antimonide has a narrower forbidden gap than silicon. But why is silicon more desirable for semiconductor devices than it? **[2 marks]**

(ii) Name four areas of application for semiconductor devices. **[2 marks]**

(iii) Semiconductor devices have many important advantages over other types of electronic devices. Name any four advantages. **[2 marks]**

b) (i) Explain why electrons in the valence band of a semiconductor can conduct current at room temperature. **[2 marks]**

(ii) What is a *compensated crystal*? **[2 marks]**

(iii) Explain *doping* as used in semiconductors. **[2 marks]**

c) (i) What is a semiconductor? **(2 marks)**

(ii) What happens to the silicon crystal lattice if its temperature is raised above absolute temperature? **(2 marks)**

(iii) What happens to the conductivity of silicon:

I) when you dope the material with equal numbers of donors and acceptors? **(2 marks)**

II) when you dope silicon with unequal numbers of both kinds of dopants? **(2 marks)**

4. a) (i) Give any four characteristics of an ideal operational amplifier. **[3 marks]**

(ii) Describe what bandwidth means and give an example of an amplifier application where bandwidth is important. **[3 marks]**

b) (i) Give a schematic diagram of an operational amplifier. **[2 marks]**

(ii) Draw a circuit of an op-amp wired as an *integrator*. Show the currents in the circuit. **[4 marks]**

c) Prove that the output voltage V_0 and the input voltage V_s of the integrator are related as:

$$V_0 = -(1/RC)\int V_s dt \qquad \textbf{[8 marks]}$$

5. a) (i) By indicating the flow of carriers in a diagram and explaining each step, derive the expression of conductivity (σ) of an intrinsic semiconductor in terms of mobility (μ). **(10 marks)**

(ii) As in (a) above, derive the expression of conductivity of N and P types of semiconductors. **(6 marks)**

b) W hat is the resistivity of an intrinsic germanium semiconductor at 300^0K given that $q = 1.6\times10^{-19}$C, $n_i = 2.5\times10^{13}$, $\mu_n = 3600$ and $\mu_p = 1700$. **(4 marks)**

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