NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY
FACULTY OF INDUSTRIAL TECHNOLOGY
BACHELOR OF ENGINEERING DEGREE
DURATION 3 HOURS – MAY 2013

TEE 1203 ELECTRONIC DEVICES AND CIRCUITS

INSTRUCTIONS TO CANDIDATES:

1. ANSWER **ANY FOUR** QUESTIONS.
2. ALL QUESTIONS CARRY EQUAL MARKS.
3. SHOW YOUR STEPS CLEARLY IN CALCULATIONS.
4. START THE ANSWER FOR EACH QUESTION ON A FRESH PAGE.

QUESTION 1

1.1. By suitable drawing illustrate and explain
   a) The formation of a PN junction.
   b) The behavior of the PN junction when forward biased.
   c) The behavior of the PN junction when reverse biased.

[5 points]

1.2. For the circuit diagram shown in Figure 1, calculate the current through and the voltage across each resistor, and the output voltage.

[4 points]

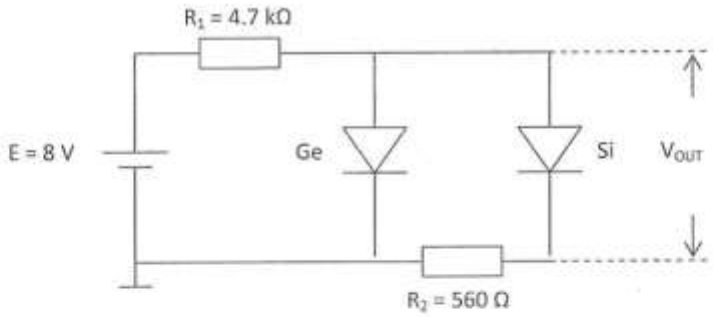

Figure 1

1.3. For the circuit shown in Figure 2, assume that the input voltage is sine wave voltage with an amplitude value of 10 V. Sketch the output voltage waveform and the waveform across the resistor R with respect to the input voltage waveform.

[4 points]

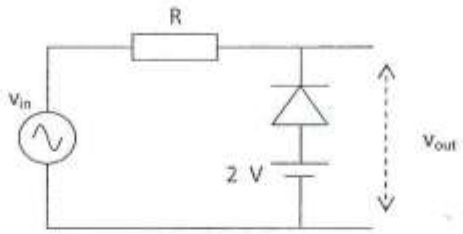

Figure 2

1.4. Show the structure and explain the operation of an N-channel Junction Field-Effect Transistor (JFET).

[5 points]

1.5. For the circuit shown in Figure 3, assume that R_{B1} = 68 kΩ, R_{B2} = 33 kΩ R_E = 1.8 kΩ, R_C = 3.6 kΩ, V_{CC} = 18 V, V_{BE} = 0.7 V, and β =150. Calculate I_B, I_E, I_C, V_B, V_E, V_{CE}, I_{CSAT} and V_{CEOFF}.

[7 points]

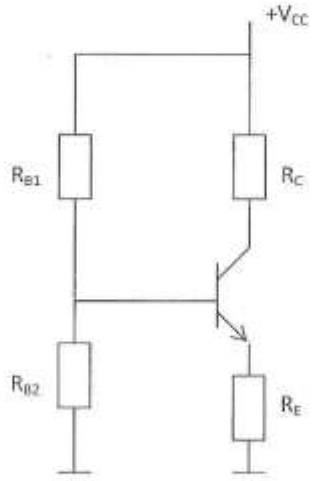

Figure 3

QUESTION 2

2.1. The diode equation is given with the following expression:

a) $$I_D = I_R(e^{V_D/\eta kT} - 1),$$

Where k = 8.6×10^{-5} eV/ °K is the Boltzmann's constant, and η = 2. The diode voltage is given the following values: 0.1 V, 0.15 V, 0.2 V, 0.25 V, 0.3 V, 0.4 V, 0.5 V, 0.6 V, 0.7 V, -1 V, -5 V and -10 V. The diode reverse current is 25 nA. Calculate the diode current for each of the above voltage values at temperature of 25 °C.

[6 points]

2.2. Show the circuit diagram for a bridge rectifier that produces positive rectified output voltage from a sine wave voltage. Clearly mark the current path for the positive and the negative halves of the input voltage. Indicate the voltage values associated with the full-wave rectified signal.

[4 points]

2.3. For the circuit shown in Figure 4, assume that the input voltage is sine wave voltage with an amplitude value of 12 V. Sketch the output voltage waveform with respect to the input voltage waveform.

[5 points]

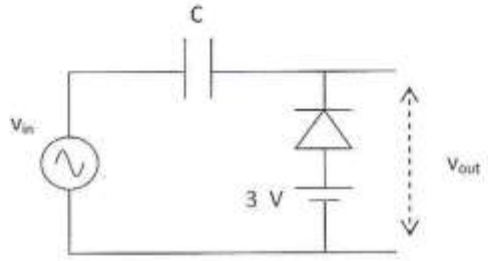

Figure 4

2.4. Derive an expression for the reverse current in a Bipolar Junction Transistor (BJT) connected in a Common Emitter (CE) configuration with respect to the reverse current of the same transistor in Common Base configuration.

[4 points]

2.5. For the circuit shown in Figure 5, assume that R_B = 1.1 MΩ, R_C = 4.7 kΩ , R_E = 1.8 kΩ, V_{CC} = 18 V, V_{BE} = 0.7 V, and β =160. Calculate I_B, I_E, I_C, V_E, V_{CB}, V_{CE}, V_{RC}, I_{CSAT}, V_{CEOFF}. [6 points]

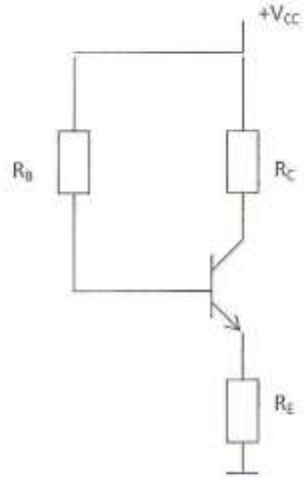

Figure 5

QUESTION 3

3.1. By suitable drawing illustrate the generation of majority and minority current carriers in an N-type semiconductor. [4 points]

3.2. For the circuit shown in Figure 6, assume that all the diodes are silicon and the supply voltage E = 12 V. Calculate the current through each resistor. [4 points]

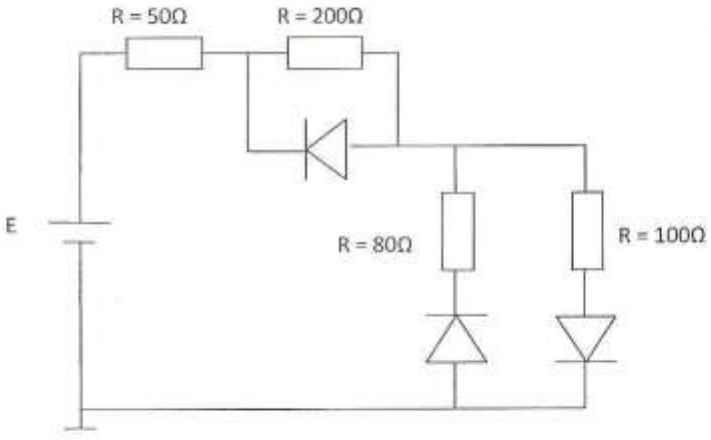

Figure 6

3.3. For the circuit shown in Figure 7, assume that the input voltage is sine wave voltage with an amplitude value of 10 V. Sketch the output voltage waveform with respect to the input voltage waveform.

[6 points]

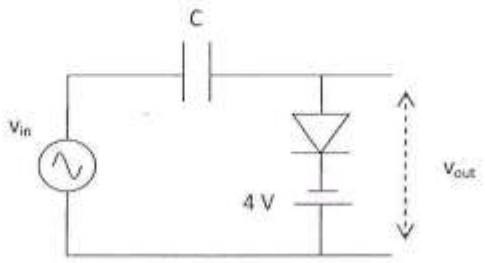

Figure 7

3.4. Give the equations for the relationship between currents and voltages expressed in terms of **'h'** parameters. Define each of the h parameters.

[5 points]

3.5. For the circuit shown in Figure 8, assume that R_B = 0.9 MΩ, R_C = 3.3 kΩ , R_E = 1.8 kΩ, V_{CC} = 12 V, V_{BE} = 0.7 V, and β =120. Calculate I_B, I_E, I_C, V_E, V_{CB}, V_{CE}, V_{RC}, I_{CSAT}, V_{CEOFF}.

[6 points]

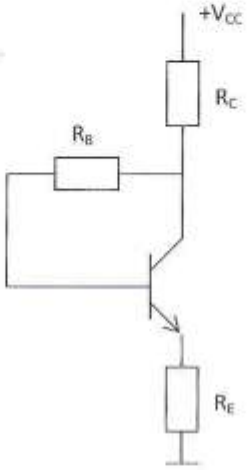

Figure 8

QUESTION 4

4.1. Outline the similarities and the differences in the current-voltage characteristics in forward and reverse direction for a rectifying, diode, light-emitting diode and Zener diode.

[4 points]

4.2. For the circuit diagram shown in Figure 9, calculate the current through and the voltage across each resistor.

[4 points]

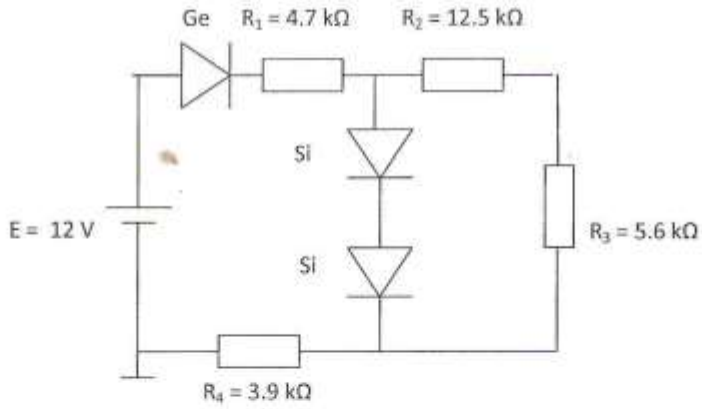

Figure 9

4.3. For the circuit shown in Figure 10, assume that the input voltage is sine wave voltage with an amplitude value of 8 V. Sketch the output voltage waveform and the waveform across the resistor R with respect to the input voltage waveform.

[6 points]

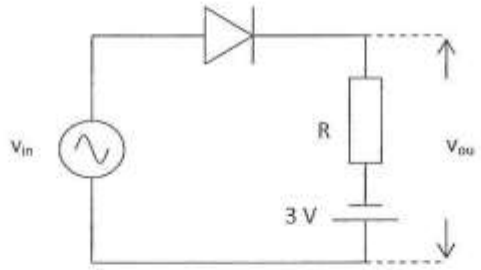

Figure 10

4.4. For a Bipolar Junction Transistor (BJT) prove the relationship between the transistor's α and the transistor β.

[4 points]

4.5. For the circuit shown in Figure 11 assume that R_{B1} = 67 kΩ, R_{B2} = 33 kΩ, R_E = 2.2 kΩ, V_{CC} = 20 V, V_{BE} = 0.7 V, and β = 150. Calculate I_B, I_E, I_C, V_B, V_E, V_{CE}, V_{CB}, V_C and I_{CSAT}.

[7 points]

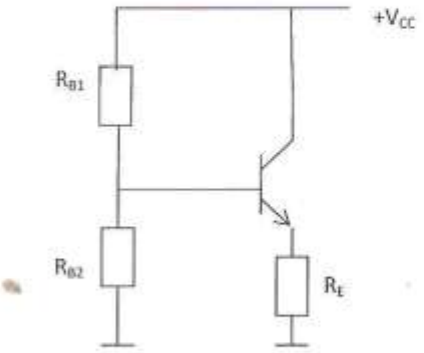

Figure 11

QUESTION 5

5.1. Draw the circuit diagram for a common anode 7-segment display. Explain on what condition a particular segment will light.

[4 points]

5.2. For the circuit shown in Figure 12, determine the voltage across each resistor and the output voltage if:

a) E = 12 V.
b) E = - 3 V.

[5 points]

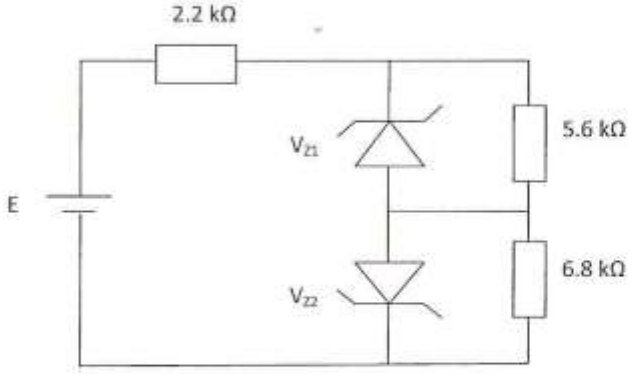

Figure 12

5.3. For the circuit shown in Figure 13, assume that the input voltage is sine wave voltage with an amplitude value of 12 V. Sketch the output voltage waveform and the waveform across the resistor R with respect to the input voltage waveform.

[4 points]

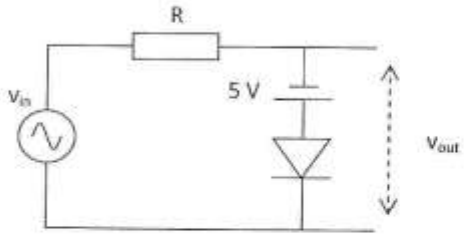

Figure 13

5.4. Using a suitable drawing illustrate the operation of a Bipolar Junction Transistor (BJT). Give an expression for the relationship between the currents in the transistor.

[6 points]

5.5. Assume that a Bipolar Junction Transistor (BJT) is connected in a Common Base configuration. The respective biasing resistors and voltages values are R_E = 12 kΩ, R_C = 5.6 kΩ , V_{EE} = - 9V and V_{CC} =15 V.

a) Draw the circuit diagram.
b) Calculate I_B, I_E, I_C, V_{CE}, V_C, V_E and V_{CB}, assuming that the transistor β = 80.
c) Draw the d.c. load line and mark the operating (Q) point.

[6 points]

QUESTION 6

6.1. Explain the nature of the following currents associated with semiconductor materials:

a) Drift Current.
b) Diffusion Current

[4 points]

6.2. For the circuit diagram shown in Figure 14, calculate the current through and the voltage across each resistor.

[5 points]

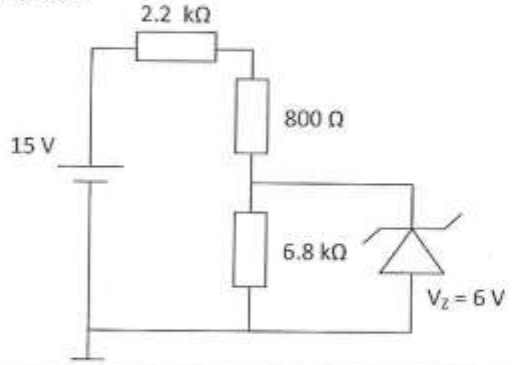

Figure 14

6.3. For the circuit shown in Figure 15, assume that the input voltage is sine wave voltage with an amplitude value of 10 V. Sketch the output voltage waveform with respect to the input voltage waveform.

[5 points]

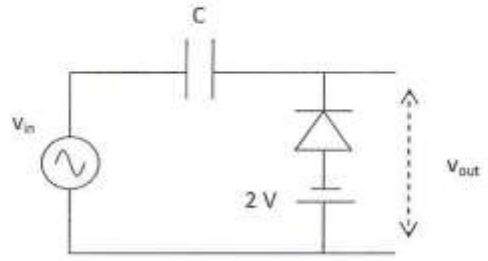

Figure 15

6.4. For a Bipolar Junction Transistor (BJT) in Common Base (CB) configuration, show the following families of static current-voltage characteristics and explain their main features:

a) The Input Characteristics.
b) The Output Characteristics.

[6 points]

6.5. For the circuit shown in Figure 16 assume that R_{B1} = 33 kΩ, R_{B2} = 12 kΩ, R_{E1} = 200 Ω, R_{E2} = 1 kΩ, R_C = 1 kΩ, V_{CC} = 6 V, V_{BE} = 0.7 V, and β = 75. Calculate I_B, I_E, I_C, V_B, V_E, V_{CE}, V_{CB}, V_C and I_{CSAT}.

[5 points]

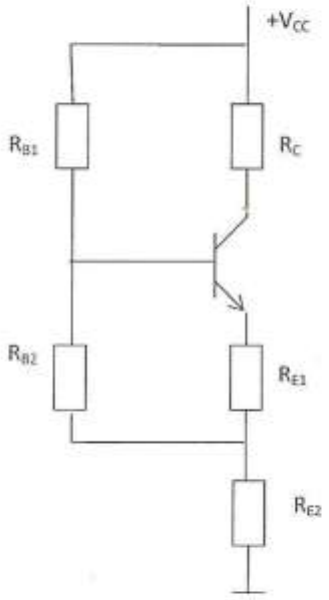

Figure 16