UNIVERSITY OF SWAZILAND
MAIN EXAMINATION, MAY 2018

FACULTY OF SCIENCE AND ENGINEERING

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

TITLE OF PAPER:	**BASIC ELECTRONICS**
COURSE NUMBER:	**EEE222/EE221**
TIME ALLOWED:	**THREE HOURS**

INSTRUCTIONS:

1. There are five questions in this paper. **Answer any FOUR questions.**
2. Each question carries 25 marks.
3. Marks for different sections are shown on the right hand margin.
4. Show the steps clearly in all your calculations. This is because marks may be awarded for method and understanding, even if a final answer is incorrect.
5. If you think not enough data has been given in any questions you may assume reasonable values and state those assumptions.
6. A sheet containing useful formulae and other information is attached at the end.

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THIS PAPER HAS NINE (9) PAGES INCLUDING THIS PAGE

QUESTION 1 *(25 marks)*

(a) Three elements: Boron, Silicon, Phosphorus have 3, 4 and 5 valence electrons respectively. Which element or combination of elements is:

(i) used as an **extrinsic semiconductor**? *(1 mark)*

(ii) used as an **acceptor** impurity? *(2 mark)*

(iii) used as a **donor** impurity? *(2 mark)*

(iv) used to get **n-type** semiconductor? *(1 mark)*

(v) used to get **p-type** semiconductor? *(1 mark)*

(b) A silicon diode has $I_S = 1\times10^{-14}$ **A** and $n = 1$

(i) What is the voltage across the diode when a current of 30 mA flows in the diode? *(3 marks)*

(ii) What is the voltage across the diode when a current of -0.8×10^{-14} **A** flows, i.e. a reverse current. *(3 marks)*

(c) For the circuit in Fig. Q1c find the currents in R_1, R_2 **and** $D1$ *(8 marks)*

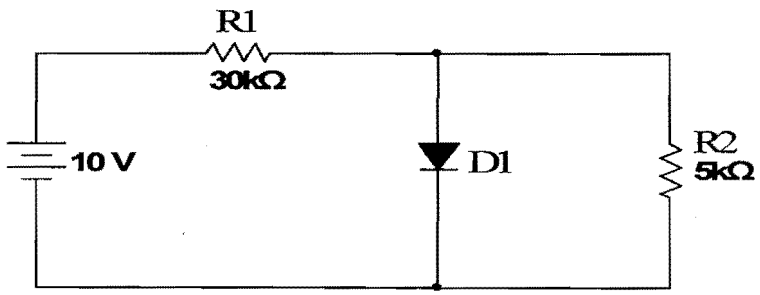

Fig.Q.1c

(d) Draw a circuit of a **voltage doubler** showing where the output voltage is. *(4 marks)*

QUESTION 2 *(25 marks)*

(a) Using ideal operational amplifiers, design, giving component values, a circuit which implements the following input-output relations:

(i) $v_o = -0.5v_1 + 3.3v_2$ *(4 marks)*

(ii) $v_o = -1.5\frac{dv_1}{dt}$ *(5 marks)*

(b) A transformer full-wave bridge rectifier is fed from a 230 V, 50 Hz mains supply. The rectifier is connected to a load resistor 500 Ω in parallel with a smoothing capacitor C. It is required that the average of the voltage at the output be 12 V and that the ripple in the output be no more than 400 mV. Assume that the diodes have a voltage drop of 0.7 V when conducting.

(i) Draw the full circuit of the rectifier. *(2 marks)*

(ii) Sketch its output voltage. *(3 marks)*

(iii) Determine the rms value of voltage required in the transformer secondary. *(6 marks)*

(iv) Determine the required value C. *(5 marks)*

QUESTION 3 *(25 marks)*

(a) A BJT transistor has $i_B = 25\ \mu A$ and $\alpha = 0.985$. Determine:

(i) its β. *(2 marks)*

(ii) the collector current i_C. *(1 mark)*

(iii) the emitter current i_E. *(2 marks)*

(b) A simple common emitter npn transistor amplifier stage is shown in Fig. Q.3b. The transistor has $\beta = 85$.

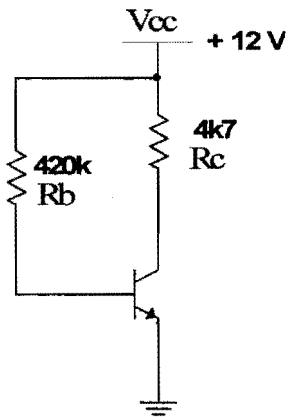

Fig.Q.3b

(i) Determine the collector current. *(3 marks)*

(ii) Determine the mode in which the transistor is operating. *(2 marks)*

(iii) What happens if the transistor is replaced with one which has a current gain 20% higher? *(4 marks)*

(iv) What happens if the transistor is replaced with one which has a current gain 50% lower? *(4 marks)*

(c) **(i)** List three properties of an ideal opamp. Of what consequence is each of the properties you have listed in the analysis of opamp circuits? *(4 marks)*

(ii) Explain what is meant by the '**virtual zero**' principle of opamp circuits. *(3 marks)*

QUESTION 4 *(25marks)*

A common emitter npn transistor amplifier works from a 15 V supply. Determine suitable values of a resistor divider bias circuit with R_E, R_C, R_1, and R_2, so that the quiescent operating point is as stable as possible at $I_{CQ} = 2$ mA and $V_{CEQ} \approx V_{CC}/2$ as β of the transistor varies between 300 and 400.

(25 marks)

QUESTION 5 *(25 marks)*

(a) Consider the amplifier circuit shown in Fig.Q5b. You are given that the transistor used has $\beta = 200$ and $V_A = \infty$.

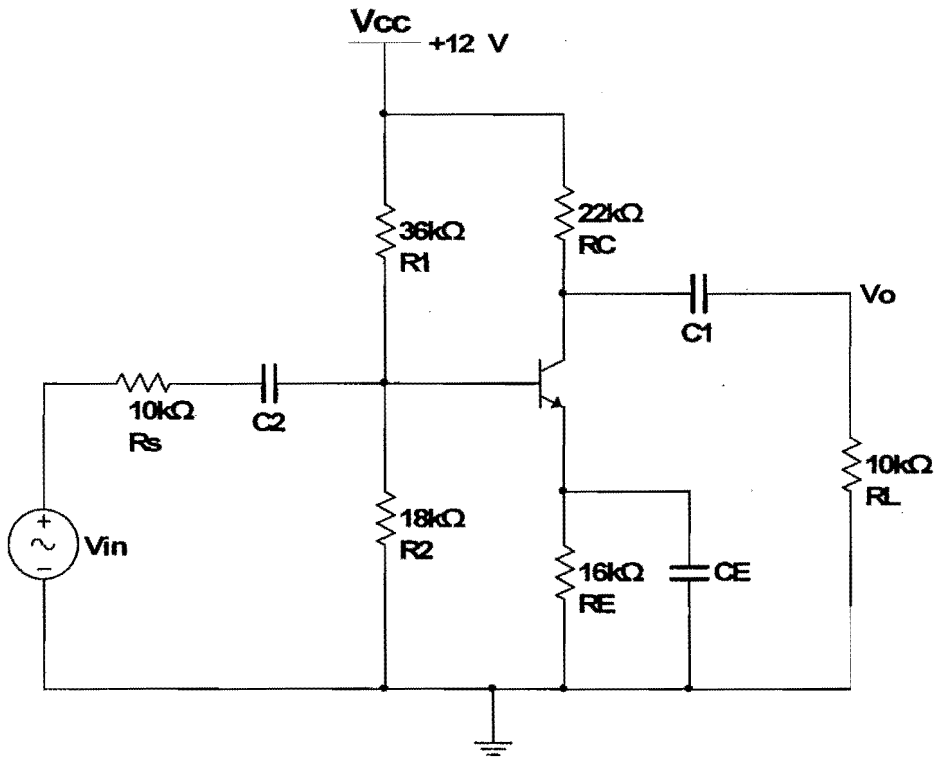

Fig. Q5b

(a) Perform d.c. analysis to find the operating point, I_C and V_{CE}, of the transistor.

(10 marks)

(b) Assuming that the capacitors used are very large, perform a.c. analysis to find the gain v_o / v_{in} of the circuit. *(10 marks)*

(c) If the transistor has a finite Early Voltage of V_A = **75 V** with the current gain β remaining unchanged, calculate the new gain of the amplifier. *(5 marks)*

USEFUL INFORMATION AND FORMULAE

1. **E12 Range:** 10 12 15 18 22 27 33 39 47 56 68 82

2. **Diode:** $i_D = I_S\left(e^{\frac{v_D}{nV_T}} - 1\right) \approx I_S e^{\frac{v_D}{nV_T}}$ **in forward bias**

3. **Unless otherwise stated, assume that** $V_{BEon} = 0.7$ **V ,** $V_{CEsat} = 0.1$ **V and** $V_T = 25$ **mV .**

4. **Unless otherwise stated, assume that opamps are ideal.**