UNIVERSITY OF SWAZILAND
RESIT/SUPPLEMENTARY EXAMINATION, JULY 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.

THIS PAPER IS NOT TO BE OPENED UNTIL PERMISSION HAS BEEN GIVEN BY THE INVIGILATOR

THIS PAPER HAS SEVEN (7) PAGES INCLUDING THIS PAGE

QUESTION 1 *(25 marks)*

(a) **(i)** Write a simple explanation of the existence and behaviour of **holes** in semiconductors. *(4 marks)*

(ii) Explain in simple terms why current flows in only one direction through a **p–n junction**. *(7 marks)*

(b) Given that the Shockley (Diode) Equation is

$$i_D = I_S\left(e^{\frac{qv_D}{nkT}} - 1\right)$$

where $q = 1.6\times10^{-19}$ **C**, $k = 1.38\times10^{-23}$ **J/K**, T = **absolute temperature K, and** $n = 1$.

(i) If $I_S = 1\times10^{-12}$ **A and** $T = 300\,\text{K}$, use the above formula to calculate the diode voltage when the diode current is

a. **1 mA,**

b. **10 mA,**

c. **100 mA.** *(9 marks)*

(ii) Electronics engineers often use the approximate **"60 mV per decade" rule.** This rule states that the current through a forward-biased diode is **multiplied by a factor 10** (one decade) when the diode voltage **increases by 60 mV**. Compare this rule with your results from part b(i). *(5 marks)*

QUESTION 2 *(25 marks)*

(a) For the diode circuit given in **Fig. Q2a**, calculate the currents through the two diodes assuming that each diode drops a voltage of **0.7 V** when conducting. *(6 marks)*

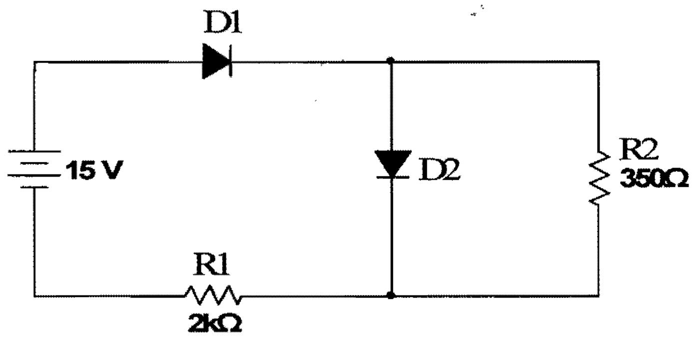

Fig. Q2a

(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 **200 Ω** in parallel with a smoothing capacitor **C.** It is required that the **average** of the voltage at the output be **10 V** and that the peak-to-peak ripple in the output be no more than **200 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 the required output voltage, indicating the maximum and minimum expected amplitudes. *(4 marks)*

(iii) Determine the rms value of voltage required in the transformer secondary. Work backwards from the output and remember to include the diode voltage drops in your calculations. *(8 marks)*

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

Note that $V_r = \frac{V_m T_p}{R_L C}$

QUESTION 3 *(25 marks)*

(a) A zener diode regulator circuit is shown in **Fig. Q.3a**. The zener diode has a breakdown voltage of **100 V** and a maximum current of **100 mA** and **R1 = 1500Ω**

(i) If **R2** is fixed at **1000 Ω,** find the range of supply voltage V_S which gives a constant output voltage V_O. *(6 marks)*

(ii) If supply voltage V_S is fixed at **150 V**, determine the range of **R2** over which the output voltage V_o remains constant. *(6 marks)*

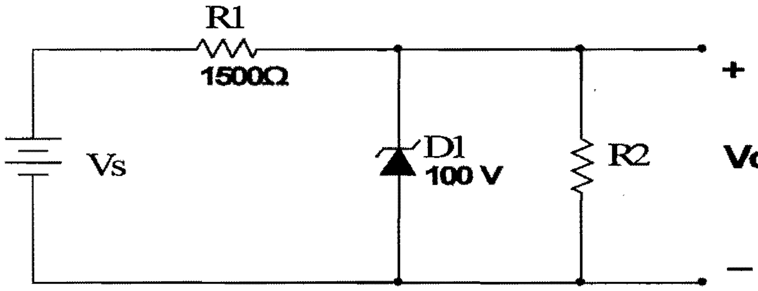

Fig. Q.3a

(b) The diode circuit shown in **Fig.Q.3b** is used as a high voltage power supply for a microwave magnetron. Assume that all diodes and capacitors are ideal.

(i) Evaluate, explaining your procedure, the voltage **Vo** in the circuit. *(9 marks)*

(ii) Determine the **peak inverse voltage** required in Diode **D3**. *(4 marks)*

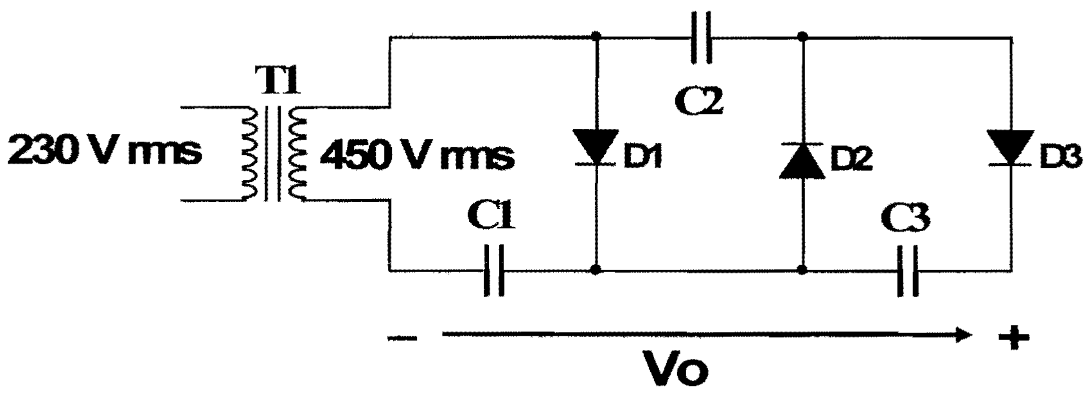

Fig. Q.3b

QUESTION 4 ***(25 marks)***

(a) An npn transistor (BJT), operating in a circuit, gives the following voltages, all measured with respect to ground. In each case determine, giving your reasons, the region of operation of the BJT.

(i) $V_B = 0.7$ V, $V_E = 0$ V and $V_C = 0.1$ V. *(2 marks*

(ii) $V_B = 0.7$ V, $V_E = 0$ V and $V_C = 10$ V. *(2 mark)*

(iii) $V_B = 0.3$ V, $V_E = 0$ V and $V_C = 10$ V. *(2 marks)*

(b) A simple common emitter npn transistor amplifier stage is shown in **Fig. Q.4b**. The transistor has $\beta = 50$. If $V_{CEsat} = 0.2$ V, find the value of **Rb** which just turns the transistor on. *(7 marks)*

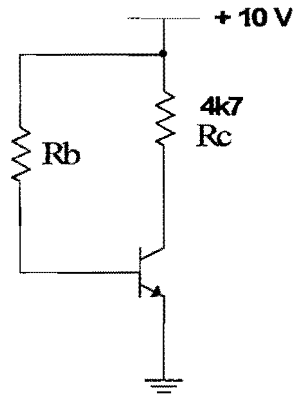

Fig.Q.4b

(c) In the circuit of **Fig Q.4c,** use superposition, or otherwise, to determine an expression for the output voltage **Vo** in terms of the input voltages **V₁, V₂, V₃, and V₄**. Simplify your expression as much as possible. *(12 marks)*

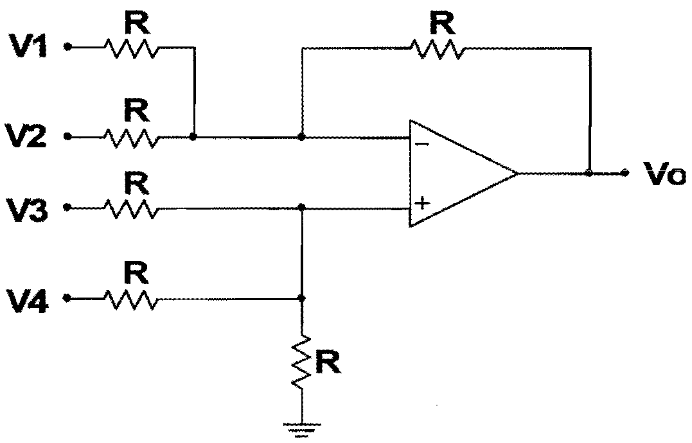

Fig. Q.4c

QUESTION 5 *(25 marks)*

Consider the amplifier circuit shown in **Fig.Q5**. You are given that the transistor used has $\beta = 100$ *and* $V_A = \infty$.

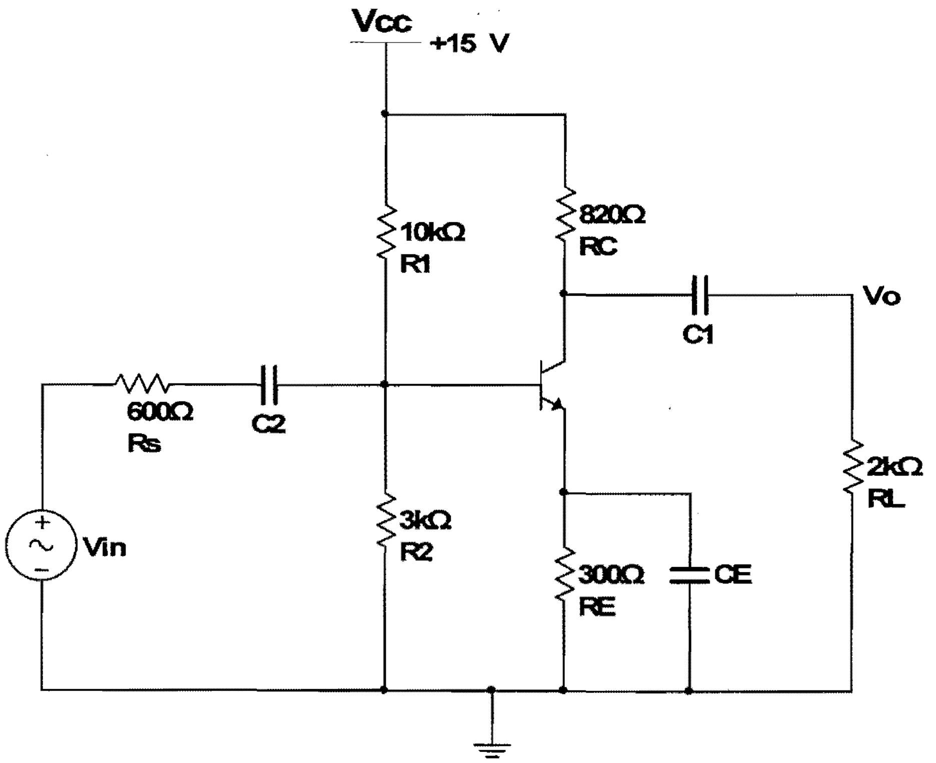

Fig. Q5

(a) Perform d.c. analysis to find the operating point, I_{CQ} and V_{CEQ} 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 $V_A = 100$ 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.**