UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE AND ENGINEERING

DEPARTMENT OF PHYSICS

SUPPLEMENTARY EXAMINATION 2016

TITLE OF PAPER : ELECTRONICS 1

COURSE NUMBER: P311

TIME ALLOWED : THREE HOURS

INSTRUCTIONS : ANSWER ANY FOUR OUT OF FIVE QUESTIONS

EACH QUESTION CARRIES 25 MARKS

MARKS FOR DIFFERENT SECTIONS ARE SHOWN IN THE RIGHT-HAND MARGIN.

THIS PAPER HAS 6 PAGES, INCLUDING THIS PAGE.

DO NOT OPEN THE PAPER UNTIL PERMISSION HAS BEEN GIVEN BY THE INVIGILATOR.

QUESTION 1

(a) The voltage supplied by an a.c. power-line is nominally 120 V r.m.s. The line is connected to a step-down transformer with a turns ratio of 50. Calculate the peak-to-peak secondary voltage of the transformer. (6 marks)

(b) Fig. 1.1 shows a basic Zener diode voltage regulator. Discuss the principle of operation of this regulator.

State the conditions that should be satisfied to ensure that the regulator gives a constant output voltage and that the diode is not damaged. (11 marks)

(c) A 9.1 V, 1.3 W Zener diode has a minimum current requirement of 20 mA and is to be used as a voltage regulator. The supply voltage is 20 V± 10% and the constant load current is 30 mA.

(i) Calculate the series resistance required; (2 marks)

(ii) Find the load resistance; (2 marks)

(iii) How much power is dissipated in the diode when the supply voltage is 22 V? (4 marks)

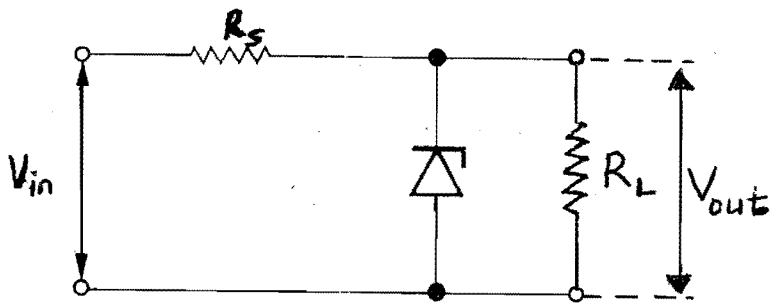

Fig. 1.1

QUESTION 2

(a) Explain what the term 'hybrid parameters' means. (3 marks)

(b) Explain what is wrong with the following statement: "An npn transistor is connected in the common-emitter configuration. The base-emitter junction is forward biased and its collector-base junction is reverse-biased. When the base-emitter voltage is made more negative the collector current is reduced". (3 marks)

(c) Consider a bipolar junction transistor amplifier with a collector resistor $R_C = 2$ kΩ. The transistor has the following h-parameters: $h_{fe} = 200$, $h_{ie} = 1$ kΩ and $h_{oe} = 2\text{x}10^{-5}$ Ω^{-1}.

(i) Draw a detailed a.c. equivalent circuit of this amplifier and label it. (3 marks)

(ii) Find the voltage gain of the amplifier when the output resistance, $1/h_{oe}$ is neglected ($1/h_{oe} >> R_C$). (3 marks)

(d) An npn silicon transistor for which h_{FE} is 200 is used in a common-emitter amplifier circuit shown in Fig. 2.1, with a potential divider network (R_1 and R_2) and emitter resistor R_E to establish the dc bias conditions. Assuming that I_{BB}, the current in the potential divider network, is greater than $10I_B$, that is $I_{BB} >> I_B$, calculate the values of the direct currents, I_E and I_B and the d.c. voltages V_B, V_C and V_{CE}. Let $V_{BE} = 0.6$ V. (13 marks)

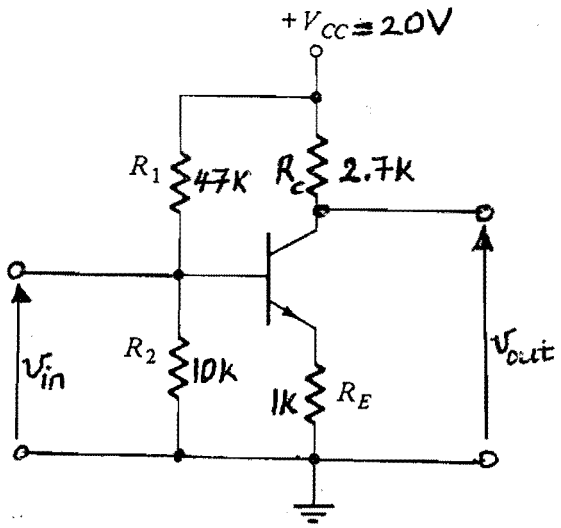

Fig. 2.1

QUESTION 3

(a) Explain briefly why a p-n junction diode acts as a rectifier. (3 marks)

(b) Consider a bridge-rectifier circuit with a filter capacitor C placed across the load resistor R for the case in which the transformer secondary delivers a sinusoid of 12 V (rms) having a 60-Hz frequency and assuming $V_D = 0.7$ V and a load resistance $R_L = 100\ \Omega$.

(i) Draw a schematic diagram of the bridge rectifier with a capacitor filter. (2 marks)

(ii) What is the dc voltage of the output? (4 marks)

(iii) Find the average current through R_L. (2 marks)

(iv) Find the value of C which results in a peak-to-peak ripple voltage of 1 V. (3 marks)

(c) The step-down transformer of the full-wave rectifier shown in Fig. 3.1 has a turns ratio of 8:1. The r.m.s. voltage at the secondary of the transformer is 18 V. The load resistance is 1 kΩ and the diode voltage is 0.6 V. Calculate

(i) The r.m.s primary voltage. (3 marks)

(ii) The peak value of the current flowing in the load. (4 marks)

(iii) The average or d.c. current through the load. (4 marks)

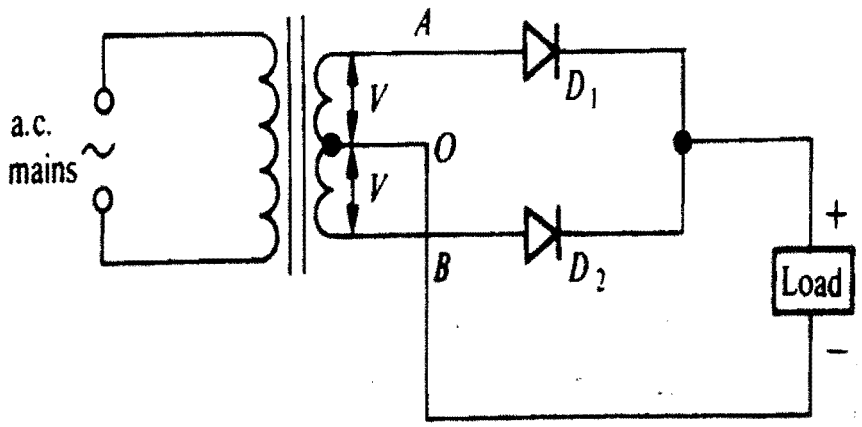

Fig. 3.1

QUESTION 4

(a) Use a suitable diagram(s) to explain how you would fabricate a p-channel junction JUGFET. (10 marks)

(b) With the aid of a diagram(s) and characteristics, explain how the transistor referred to in Q. 4(a) above works. (8 marks)

(c) (i) Draw an a.c. equivalent circuit of an n-channel JFET amplifier connected in the common-source configuration. (3 marks)

(ii) Show that the voltage gain of the common-source amplifier is given by the following equation:

$$\frac{v_{out}}{v_{in}} = \frac{g_m}{\frac{1}{R_D} + \frac{1}{r_d}},$$

where the symbols have their usual meanings. (4 marks)

QUESTION 5

(a) Sketch the energy band diagram of phosphorous- doped n-type silicon and label it. Comment on the meaning of the diagram. (5 marks)

(b) The Zener diode stabiliser shown on page 2, Fig. 1.1 has an input voltage, $V_i = 15V$ and a load resistance, $R_L = 1.2\ k\Omega$. The current through the Zener diode is 6 mA and the voltage across the load is 9 V.

(i) Calculate the value of the series resistance, R_S. (4 marks)

(ii) Calculate the diode current when $R_L = 1\ k\Omega$. (4 marks)

(c) (i) Suppose that you were required to measure the characteristics of an n-p-n transistor that is connected in the common-emitter configuration. Draw a diagram to show how you would connect the circuit. Label it. (3 marks)

(ii) Sketch the output characteristics of the transistor and show the saturation, cut-off and active regions. Label the characteristics. (5 marks)

(d) Consider an n-channel JUGFET connected in the common-source configuration. Assume that when the gate-source voltage, V_{GS} is kept constant, a change in the drain-source voltage, V_{DS} of 1V results in a change in the drain current, I_D of 0.2 mA.

Calculate the drain resistance, r_d of the JUGFET. (4 marks)