UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE

DEPARTMENT OF PHYSICS

SUPPLEMENTARY EXAMINATION 2006

TITLE OF PAPER	:	**ELECTRONICS I**
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 7 PAGES, INCLUDING THIS PAGE.

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

QUESTION 1

(a) A junction transistor in the common-emitter connection is used in an amplifier with a 12 V supply and a load resistor, R_L of 2 kΩ, as shown in Fig. 1.1. The output characteristics of the transistor are shown is Fig. 1.2.

(i) Draw the load line on the characteristics and choose a suitable operating point. (5 marks)

(ii) If an alternating input voltage changes the base current by ± 20 μA about the quiescent value, what is the variation in the collector-emitter voltage? (Hint: Use the characteristics) (4 marks)

(b) With the aid of diagrams, show that the gain of an emitter follower is approximately equal to unity and is represented by the following equation:

$$A_V = \frac{\left(h_{fe} + 1\right)R_L}{r_\pi + \left(h_{fe} + 1\right)R_L}$$ (10 marks)

(c) The circuit in Fig. 1.3 is used to bias a 2N2222A transistor with the given characteristics with $V_{CEQ} = 5$ V and I_{CQ}=15 mA. $V_{CC} = 12$ V and $V_{BEQ} = 0.7$ V, where Q represents the quiescent or operating point.

(i) Determine R_B and R_L. (4 marks)

(ii) Estimate β. (2 marks)

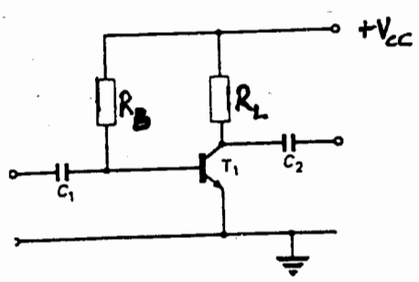

Fig. 1.1

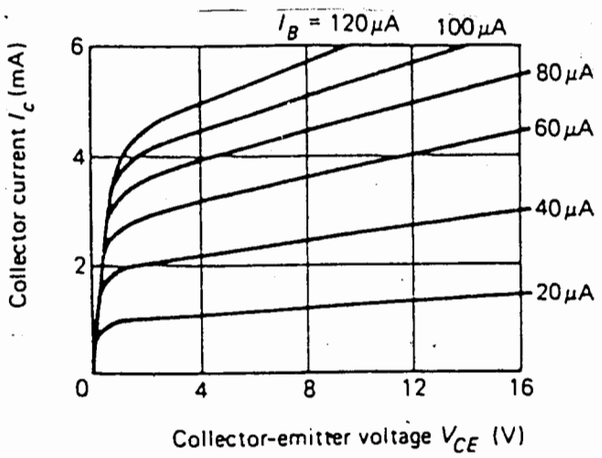

Fig. 1.2

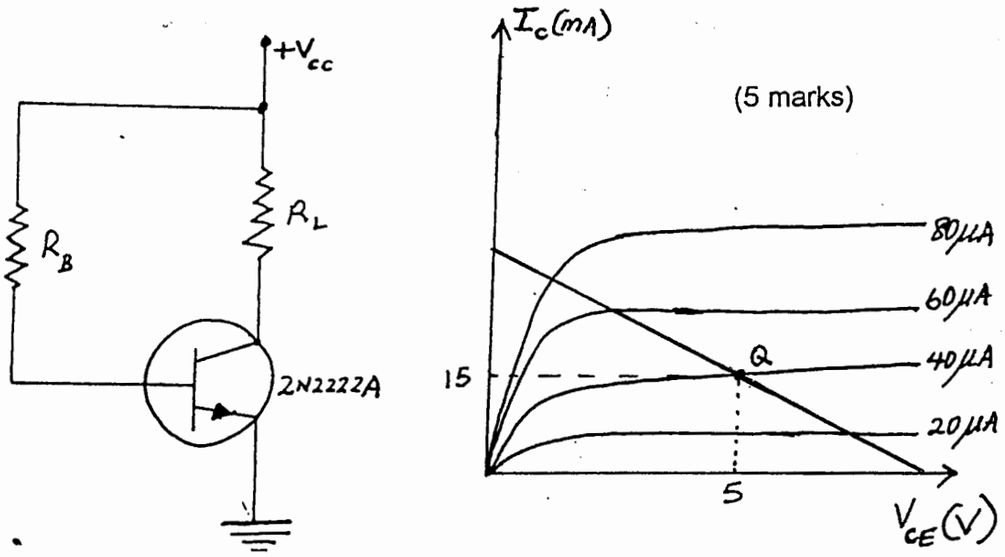

Fig. 1.3

QUESTION 2

(a) The drain current I_D of a JFET is related to the gate-source voltage V_{GS} by the equation

$$I_D = I_{DSS}\left[1-\left(V_{GS}/V_P\right)\right]^2$$

where I_{DSS} and V_P are constants.

(i) Define these constants with the aid of the mutual characteristics of the JFET; (4 marks)

(ii) Use this equation to derive an expression for the mutual conductance of the transistor in terms of V_{GS}. (4 marks)

(b) How does the JFET behave

(i) for small values of $|V_{DS}|$? (2 marks)
(ii) for large $|V_{DS}|$? (2 marks)

(c) (i) Draw the circuit diagram of a common-source amplifier stage in which the dc bias is obtained by means of a source resistor R_s. Label it fully. (3 marks)

(ii) In what way is the dc bias influenced by R_s? Explain. (3 marks)

(iii) Draw a small signal equivalent circuit of this amplifier and use it to derive an expression for the voltage gain of the amplifier. (7 marks)

QUESTION 3

(a) (i) Sketch the circuit for a half-wave rectifier and label it; (2 marks)

(ii) Derive expressions for the average current and voltage. (6 marks)

(b) The output of a half-wave rectifier circuit is to be smoothed by a simple capacitor filter. The capacitance of the smoothing capacitor C is 136 μF. The transformer secondary voltage is 40 V rms at 50 Hz and the average load current supplied is 10mA. Calculate the ripple voltage. (9 marks)

(c) The current *I* which flows through a p-n junction at an absolute temperature T, across which there is a potential difference *V*, is given by the following equation:

$$I = I_o\left[e^{eV/\eta kT} - 1\right]$$

where I_o is the reverse saturation current, e is the electronic charge, k is the Boltzmann constant, η is a dimensionless constant and T = 300 K.

Describe a simple experiment (based on the use of this equation) with a silicon *p-n* junction diode which would enable η to be determined. (8 marks)

QUESTION 4

(a) The output of any rectifier shows an unwanted ac component in the form of a ripple voltage.

(i) Draw a circuit diagram of a full-wave rectifier incorporating a smoothing device. Label it. (2 marks)

(ii) Draw voltage waveforms for a smoothed full-wave rectifier circuit and label the diagram. Show the ripple voltage and the average voltage on your diagram. (3 marks)

(b) With the aid of diagrams, show that the average output voltage of a full-wave rectifier is given by

$$V_{av} = \frac{2V_m}{\pi}$$ (10 marks)

(c) Fig. 4.1 shows the circuit diagram of a differential amplifier utilizing two field-effect transistors.

Derive expressions for the drain current, i_d and show that i_d is proportional to the difference between the two inputs, $v_{in}(1)$ and $v_{in}(2)$.

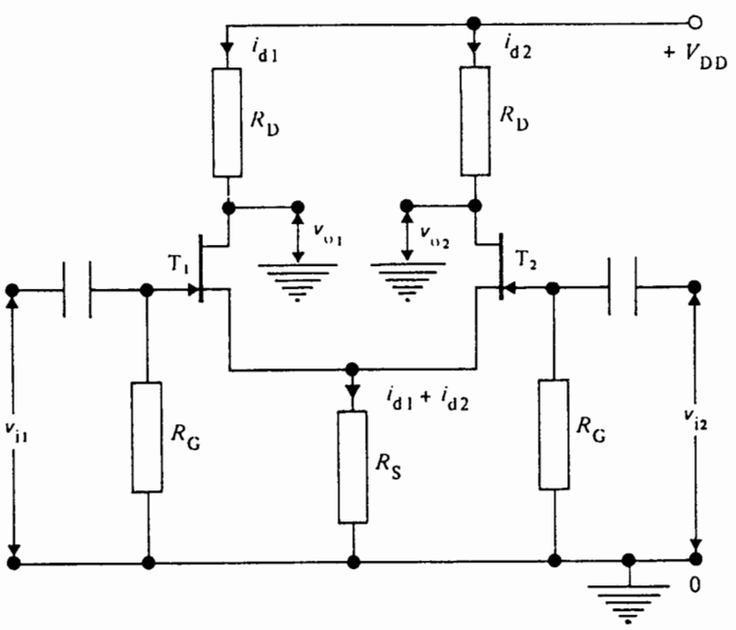

Fig. 4.1

QUESTION 5

(a) Imagine a power supply unit which supplies a steady voltage output from an ac sinusoidal input in which a bridge rectifier configuration is used together with capacitor smoothing. Discuss, with appropriate diagrams and theory, the principle of operation of this circuit, based on a Zener diode. (15 marks)

(b) (i) The Zener diode regulates at 50 V over a range of diode currents, I_z from 5 to 40 mA. The supply voltage V = 200 V. Calculate R to allow voltage regulation for a load current $I_L = 0$ up to $I_{L(max)}$, the maximum possible value of I_L. What is $I_{L(max)}$? (6 marks)

(ii) If R is set as in (b)(i) and the load current is set at $I_L = 25$ mA, what are the limits between which V may vary without loss of regulation in the circuit? (4 marks)

USE THE GRAPH BELOW TO ANSWER QUESTION 1 (a)
(The graph is a copy of Fig. 1.2

NOTE: This graph should be handed in together with your answer book.

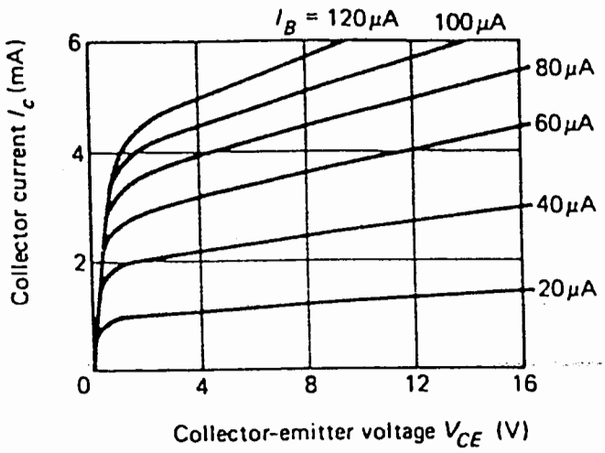

Fig. 1.2