UNIVERSITY OF SWAZILAND

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FACULTY OF SCIENCE AND ENGINEERING

DEPARTMENT OF PHYSICS

SUPPLEMENTARY EXAMINATION, JANUARY 2020

TITLE OF PAPER : ELECTRONICS 1

COURSE NUMBER : PHY 311

TIME ALLOWED : THREE HOURS

INSTRUCTIONS : Answer FOUR (4) questions only.

: Each question carries 25 Marks

: Marks for different sections are shown in far right margin.

THIS PAPER HAS 6 PAGES, INCLUDING THIS ONE.

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1. (a) Define the following

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(i) Intrinsic semiconductor [1]

(ii) Doping [1]

(iii) pn-junction. [1]

(b) Sketch a bridge rectifier and the output (without a smoothening capacitor) and explain how it works. [5]

(c) Assume that a smoothening capacitor C was connected across the load resistor of the bridge rectifier. With the aid of a schematic diagram of the variation of the output signal with time, show that the ripple voltage, V_r can be written as [7]

$$V_r = \frac{I_{av}}{2fC},$$

where I_{av} is the d.c. current and f is the frequency.

(d) Modify the bridge circuit in (b) above to obtain a voltage doubler circuit and sketch the output signal if the input is sinusoidal. [4]

(e) Consider the circuit in Figure 1 .

(i) Using the Zener diode model, obtain the load line equation for the circuit. [4]

(ii) Sketch the I-V characteristics of the diode together with the load line. [2]

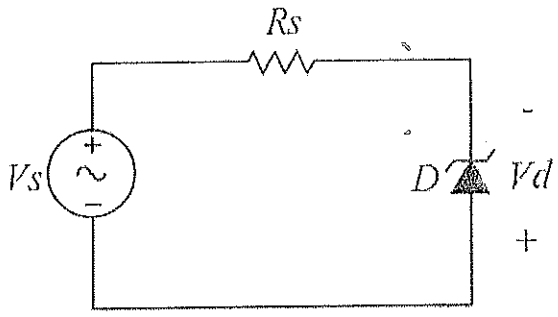

Figure 1

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2. (a) With the aid of a diagram(s) and characteristics, discuss the principle of operation of the n-channel JFET. [12]

   (b) Write the equation relating the drain current, I_D in terms of V_{GS} of an n-channel JFET. [3]

   (c) Sketch the small signal equivalent circuit of a common-source amplifier in terms of current dependent voltage source. [3]

   (d) An n-channel JFET with a saturation current $I_{DSS} = 6mA$ and pinch-off voltage $V_P = -6V$ is used in the self-bias circuit of Figure 2. Given that $V_{DD} = 12V$, $R_D = 1.5$ kΩ and $R_S = 500\Omega$, determine the operating point (I_D, V_{DS} and V_{GS}). [7]

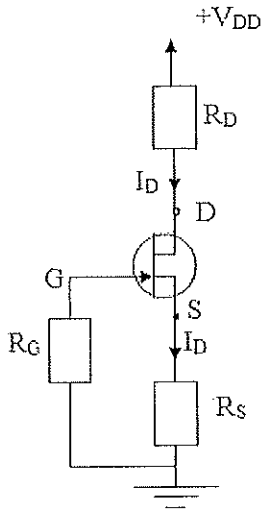

Figure 2: Self-bias circuit of a JFET

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3. (a) What are semiconductor materials? [2]

(b) Define energy gap of a semiconductor. [1]

(c) Describe the dynamics of the formation of the depletion region. [6]

(d) Sketch the charge density (ρ), electric field (E), and electric potential (V) of a pn-junction. [3]

(e) Describe the steps you would undertake to determine the conduction state of an ideal diode? [4]

(f) The table below shows the I-V characteristics of a low voltage diode connected as shown in Figure 1.

Forward voltage (V)	0	0.7	0.8	0.9	1	1.1	1.2	1.3	1.4
Forward current (mA)	0	1	5	28	65	120	165	240	330

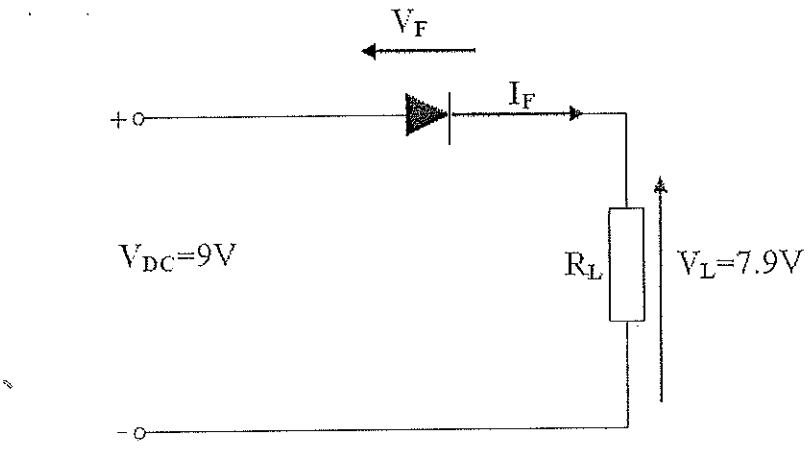

Figure 1: Low voltage diode

(i)Draw the I-V characteristics of the diode. [2]

(ii) Determine the current flowing in the diode. [4]

(iii) Calculate the value of the load resistor R_L [1]

(iv) Calculate the power dissipated in both the diode and R_L. [2]

4. (a) Consider an npn-transistor shown in Figure 2. Show that and $\beta = \alpha/(1-\alpha)$, where $\alpha = I_C/I_E$ and $\beta = I_C/I_B$. [3]

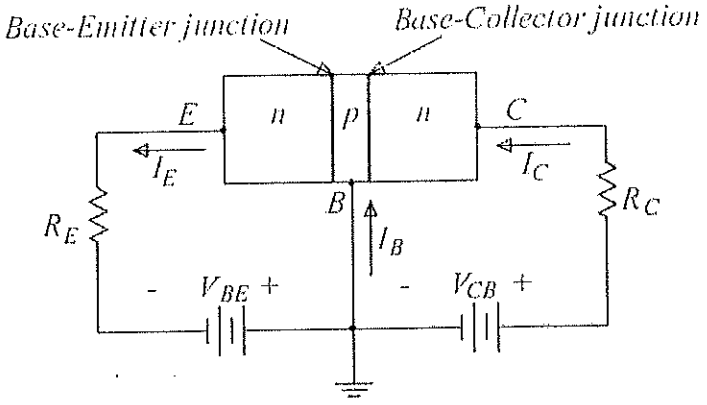

Figure 2: Biasing voltages of npn transistor

(b) Sketch the I-V characteristics of the above transistor, indicating the operating regimes. [6]

(c) Briefly explain the operating regions mentioned in (b) above. [4]

(d) Define the hybrid parameters of the transistor in Figure 2 in terms of the d.c. currents and voltages . [2]

(e) Describe how you would determine the hybrid parameters of a bipolar transistor from the input and output characteristics of the transistor. [6]

(f) Draw the small-signal equivalent circuit of a bipolar transistor containing a current-dependent voltage source. [2]

(g) A bipolar transistor with a forward current gain $\beta = 100$ passes a collector current of 26mA. Estimate the input resistance of the transistor. [2]

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5. (a) Consider the circuit of the basic common-emitter amplifier shown in Figure 3.

(i) State the uses of C_1 and C_E. [2]

(ii) Why are the resistors R_1 and R_2 included in the circuit? [1]

(b) In Figure 3 $V_{CC} = 12V$, $I_C = 2mA$, and $V_{BE} = 0.65V$.

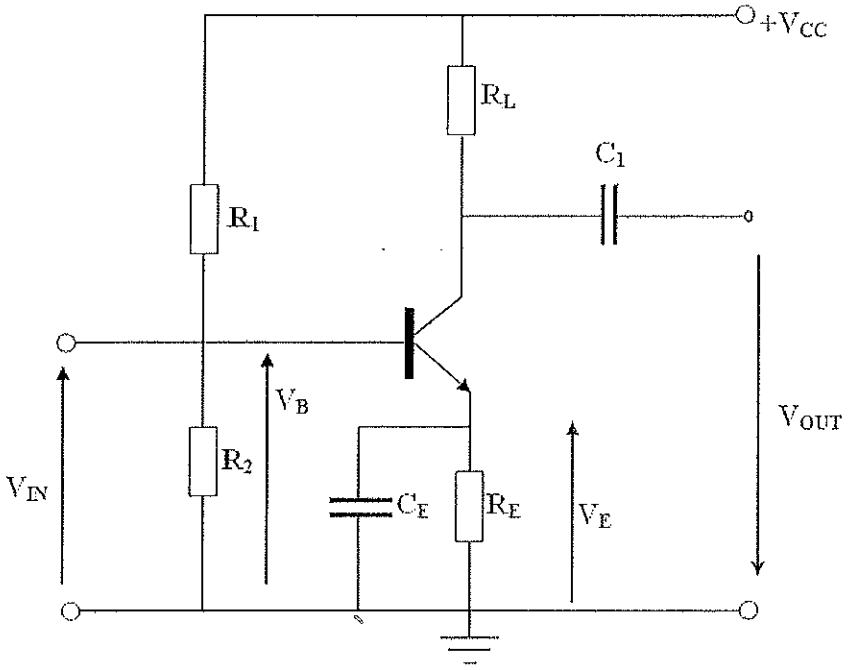

Figure 3: Common Emitter Amplifier

(i) Calculate R_E when $1/10th$ of the supply voltage appears across it. [4]

(ii) Calculate R_L when $V_{CE} = V_{CC}/2$. [4]

(iii) Calculate I_B given that $\beta = 100$, [2]

(iv) Determine the value of R_2 when $I_{R_2} = 10I_B$. [4]

(c) A Zener diode stabilizing circuit has an input voltage of 18 V and a diode current of 8 mA to give 10 V across a load resistor of 1200 Ω. Calculate

(i) the value of the series resistor. [5]

(ii) the diode current when the load resistor is 1000 Ω. [3]

END