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Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2016/2017

COURSE NAME	:	ADVANCED SEMICONDUCTOR DEVICES
COURSE CODE	:	BED 41003
PROGRAMME CODE	:	BEJ
EXAMINATION DATE	:	JUNE 2017
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWERS **FIVE (5)** QUESTIONS ONLY

THIS QUESTION PAPER CONSISTS OF **EIGHT (8)** PAGES

Q1 (a) **Figure Q1 (a)** shows a schematic diagram of a BJT. With the emitter- base junction forward biased and the collector-base junction reversed biased, describe the currents flow in the BJT and hence the existence of I_E, I_B and I_C. Show the relation between the three currents.

(10 marks)

(b) The transistor in **Figure Q1 (b)** has a value of $\beta = 50$, $I_{ES} = 10^{-14}$A and $v_{CE} = 5$V and $i_E = 10$ mA. From the Schokley equation, calculate the values of v_{BE}, v_{BC}, i_B, i_C and α. Make suitable assumption where necessary.

(10 marks)

Q2 (a) With the aid of suitable diagram explain the existence of Early effect in BJT. Show how the Early voltage can be estimated from the output transfer characteristic and show the relation between Early effect and output conductance g_o.

(5 marks)

(b) Refer to **Figure Q1 (b)** which shows an npn bipolar transistor in a common-emitter configuration with a small signal voltages and currents. Show the complete hybrid-pi equivalent circuits between the B-E, C-E and B-C terminals.

(10 marks)

(c) For the BJT circuit in Figure **Q2 (c)**, draw the small signal equivalent circuit. State the assumption that you make.

(5 marks)

Q3 (a) With the aid of diagrams describe the construction and operation principles of depletion and enhancement n-channel MOSFETs

(6 marks)

(b) Give **FOUR (4)** reasons why n-channel MOSFETs are preferred to p-channel MOSFETs

(4 marks)

(c) Refer to Figure **Q3 (c)**, the drain current of the MOSFET is given by

$$I_D = 3 \times 10^{-4} (V_{GS} - V_T)^2$$

If $V_T = +4V$, find

(i) the Q-point (5 marks)

(ii) the transconductance g_m (2 marks)

(iii) the voltage gain V_o / V_i (3 marks)

Q4 (a) Draw to scale (using a linear graph) the ideal drain-source characteristic for an n- channel FET, given that it has a threshold voltage (below which $I_D = 0$) of $V_{GS} = +2V$ and a transconductance $g_m = 5$ mS. Draw the characteristics V_{GS} values at 2 V intervals up to a maximum I_D of 50 mA and a maximum V_{DS} of 50 V. You may assume that the transconductance is constant over this range and the dynamic gain resistance is infinite.

(5 marks)

(b) The transistor in Q4 (a) is used as an amplifier as shown in Figure **Q4 (b)**. Given the values of $R_2 = 10$ kΩ, $R_D = 1$ kΩ and $V_{DD} = 40V$, draw the d.c. and a.c load lines characteristics. Assume R_S is negligible.

(4 marks)

(c) Choose operating points on the characteristics which will allow the maximum undistorted signal voltage across the load resistance. Calculate the values of R_1 to give the required operating point.

(4 marks)

(d) Culculate the quiescent power dissipated in the transistor, the maximum undistorted signal power dissipated in R_L for the sinusoidal input signal and the efficiency.

(7 marks)

Q5 (a) Explain the difference between homojunction and heterojunction in semiconductor.
(2 marks)

(b) Define the work function of a metal and electron affinity.
(2marks)

(c) A Schottky barrier is formed between a metal having a work function $\phi_m = 4.3$ eV and a p-type Si (electron affinity $\chi = 4$ eV). The acceptor doping in the Si is 10^{17} cm^{-3}. The energy gap of Si is 1.1 eV.

(i) Draw the band diagram of Si showing the position of E_i and E_F.
(6 marks)

(ii) Find the work function of the semiconductor and draw the equilibrium band diagram of the junction, showing a numerical value for qV_0.
(5 marks)

(iii) Draw the band diagram of the junction with 0.3V forward bias and 2V reverse bias.
(5 marks)

Q6 (a) Sketch the graph showing the I-V relation of an illuminated solar cell. Explain why must a solar cell be operated in the fourth quadrant of the junction I-V characterictic. Show how you can determine the maximum power output and hence the efficiency η of of a solar cell.
(10 marks)

(b) An illuminated Si solar cell has a short-circuit current of 100 mA, an open-circuit voltage of 0.8V and a fill-factor of 0.7. Calculate maximum power delivered to a load by this cell.
(3 marks)

(c) The maximum power delivered by a solar cell can be found by maximizing the I-V product. Show that maximizing the power leads to the expression

$$(1 + qV_{mp}/kT)\, e^{qV_{mp}/kT} = 1 + I_{sc}/I_{th}$$

where V_{mp} is the voltage for maximum power, I_{sc} is the magnitude of short-circuit current, and I_{th} is the thermally induced reverse saturation current.
(7 marks)

-END OF QUESTIONS –

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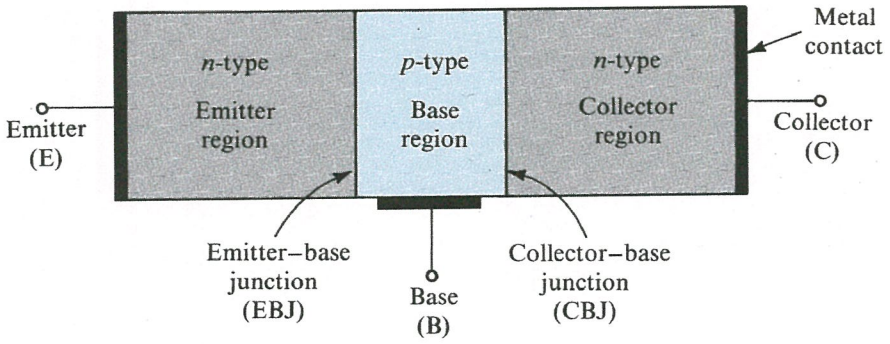

Figure Q1 (a)

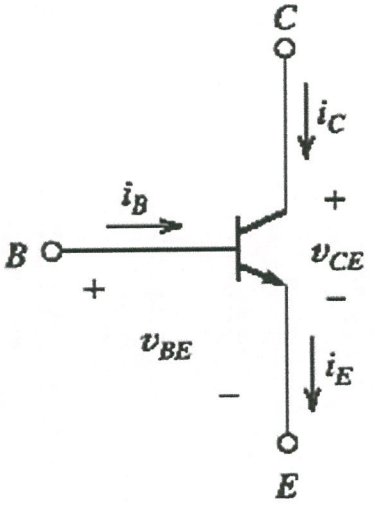

Figure Q1 (b)

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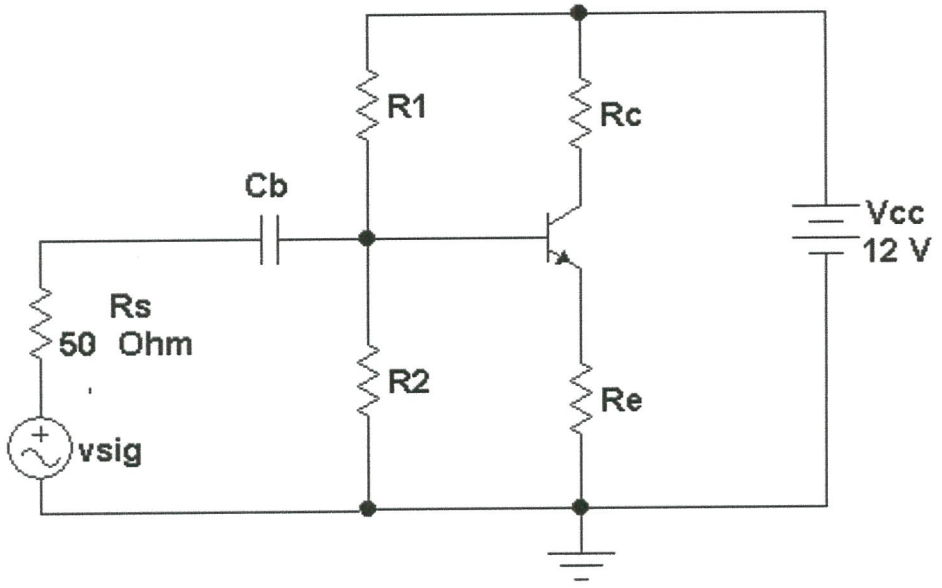

Figure Q2 (c)

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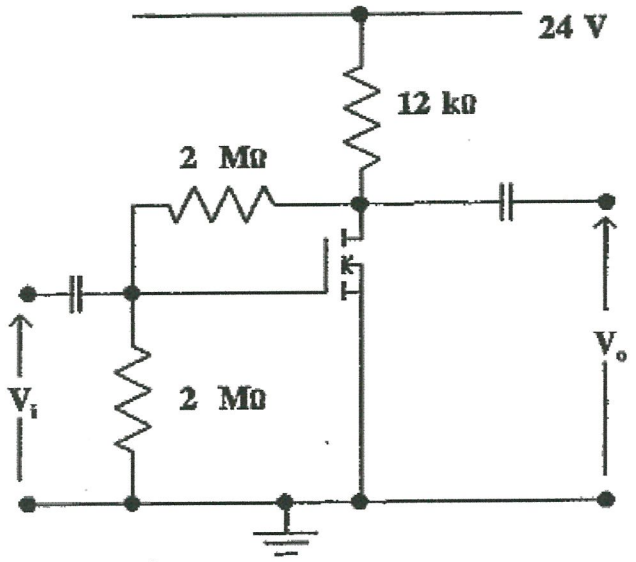

Figure Q3 (c)

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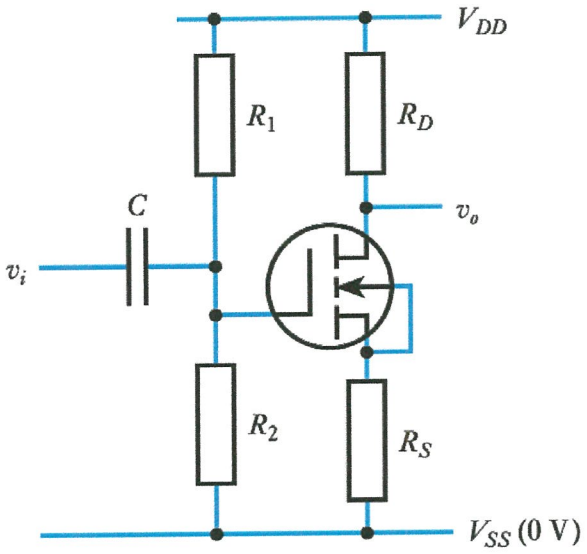

Figure Q4 (b)