# National Exams May 2012

## 07-Elec-A5, Electronics

3 hours duration

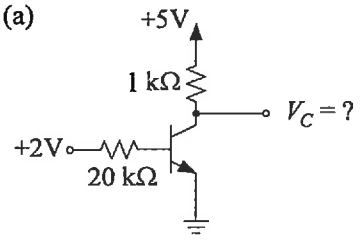
Notes:

1. If any doubt exists as to the interpretation of any question, the candidate is urged to submit, within their answer, a clear statement of any assumptions made.
2. This is a CLOSED BOOK EXAM.
   A Casio or Sharp approved calculator is permitted.
3. FIVE (5) questions constitute a complete exam paper.
   The first five questions as they appear in the answer book will be marked.
4. All questions are worth 20 marks each.
5. Please start each question on a new page and clearly identify the question number and part number, e.g. Q4(a).
6. In schematics, ground and chassis may be assumed to be common, unless specifically stated otherwise.
7. Unless otherwise specified, assume that Op-Amps are ideal and that supply voltages are ±15V.
8. Some questions require an answer in essay format. Clarity and organization of the answer are important. Provide block diagrams and circuit schematics whenever necessary.

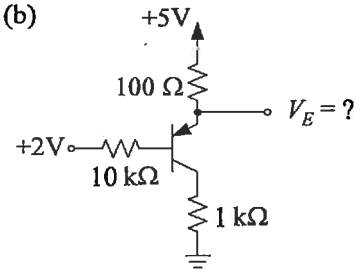
## QUESTION (1)

In the following questions, all BJT transistors have $\beta = 50$, $V_{BE,on}$ or $V_{EB,on} = 0.6V$, $V_{CE,sat}$ or $V_{EC,sat} = 0.3V$ and $V_A = \infty$. Solve for the required voltages. (20 points)

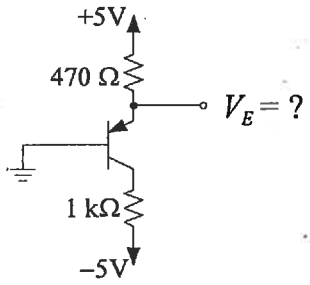
(a) (4 points)



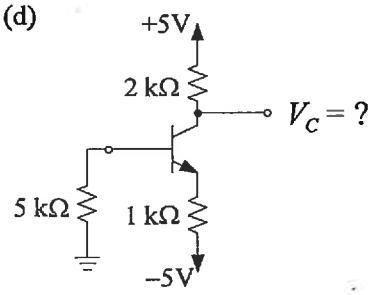

(b) (4 points)



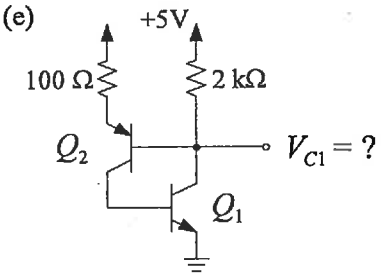

(c) (4 points)




(d) (4 points)




(e) (4 points)

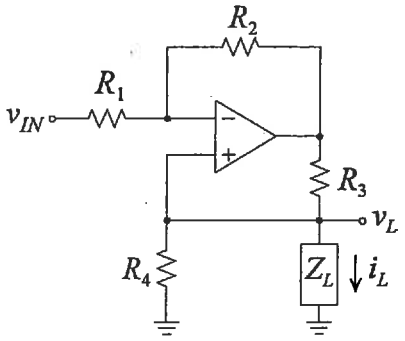


## QUESTION (2)

For the following op amp circuit:

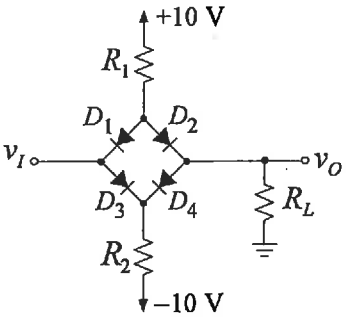
a) Provide an expression for $i_L$ as a function of $v_{IN}$, $R_1$, $R_2$, $R_3$, $R_4$ and $Z_L$. (16 points)

b) What is a possible function for this circuit? (4 points)




## QUESTION (3)

For this diode circuit, assume that all the diodes are ideal with **forward voltage drop** of $V_{on}$ = 0.7 V. Given that $R_1 = R_2 = R_L = 10$ kΩ, Sketch accurately in your answer book the transfer function $v_O$ versus $v_I$ for the range $-10\text{V} \leq v_I \leq +10$ V. (20 points)



## QUESTION (4)

Transistor $M_1$ in this circuit has the following characteristics:

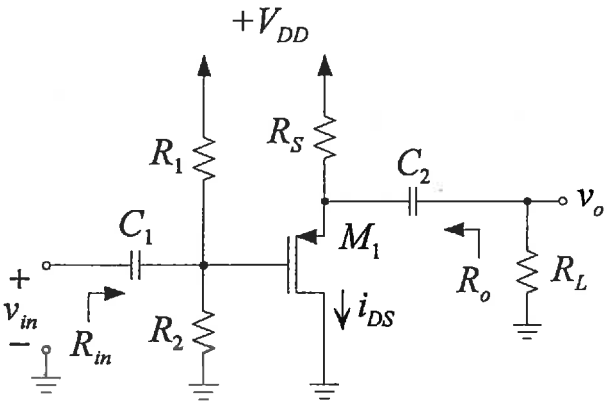
$|V_{TH}| = 1$ V

$K = 2$ mA/V$^2$ $\quad \lambda = 0.01$ V$^{-1}$

Given:

$V_{DD} = 10$ V $\quad R_L = R_S = 2$ kΩ

$C_1 = C_2 = \infty$




a) Design this circuit to have the following specifications:
$R_{in} = 100$ kΩ, $I_{SD} = 2$mA
Provide values for $R_1$, and $R_2$. (8 points)

b) Determine the output resistance, $R_o$. (6 points)

c) Determine the maximum undistorted peak to peak output voltage? (6 points)

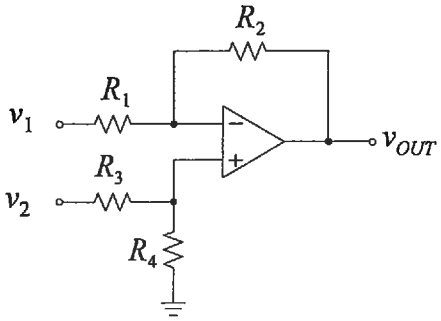
Useful formulae: for p-channel MOSFET

$$i_{SD} = K\left[2(v_{SG} - |V_{TH}|)v_{SD} - v_{SD}^2\right] \quad \text{triode region}$$

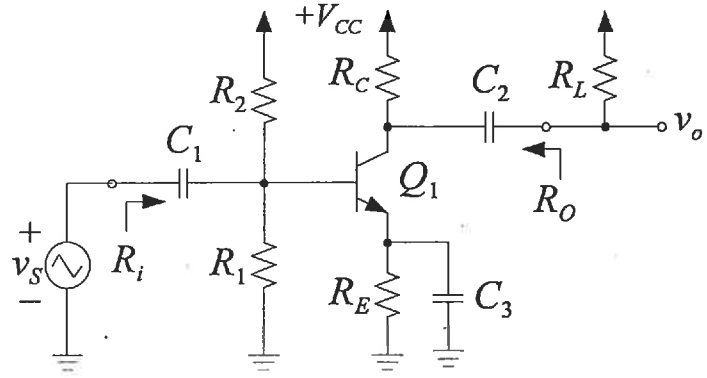
$$i_{SD} = K\left(v_{SG} - |V_{TH}|\right)^2\left(1 + \lambda v_{SD}\right) \quad \text{saturation region}$$

## QUESTION (5)

In the following circuits, the op amp is ideal except for an input offset voltage, $V_{OS} = 3$ mV, input bias current, $I_B = 0.2$ μA, and input offset current of $I_{OS} = 50$ nA. If $R_1 = R_3 = 10$ kΩ, and $R_2 = R_4 = 1$ MΩ, find the worst case (largest) dc offset voltage at the output, $v_{OUT}$. (20 points)




## QUESTION (6)




Assume that the BJT has the following characteristics:

$\beta = 100$
$V_{BE(on)} = 0.7$V
$V_{CE(sat)} = 0.3$V
$V_A = \infty$

Given:

$V_{CC} = 10$V
$R_L = 4.7$kΩ
$R_E = 1$kΩ

a) Design this common emitter amplifier circuit to have the following specification:
DC bias current, $I_E = 2$mA,
A mid-band voltage gain $v_{out}/v_S = 50$ V/V
Provide values for $R_1$, $R_2$, and $R_C$. (15 points)

b) What is the equivalent output resistance, $R_O$? (2 points)

c) What is the maximum undistorted peak to peak output voltage swing at the output? (3 points)