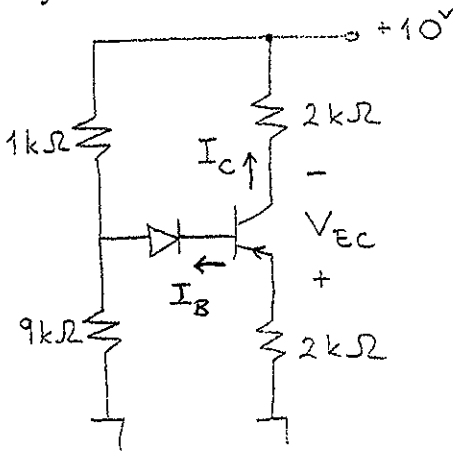
In the following two questions, show all your work and put your answer in the designated boxes.

n-MOSFET	$\|V_{Tn}\| = 1V$	$K_n = 1mA/V^2$				
p-MOSFET	$\|V_{Tp}\| = 2V$	$K_p = 0.5mA/V^2$				
npn-BJT	$\beta_F = 149$	$\beta_R = 10$	n = 1	$V_A \to \infty$	$V_{BE(ON)} = 0.7V$	$V_{CE(SAT)} = 0.2V$
pnp-BJT	$\beta_F = 99$	$\beta_R = 4$	n = 1	$V_A \to \infty$	$V_{EB(ON)} = 1V$	$V_{EC(SAT)} = 0.2V$
Diode	$V_\gamma = 0.6V$	n = 1				
Zener diode	$V_\gamma = 0.5V$	$V_Z = 5V$	n = 1			

Q1. (20 points)

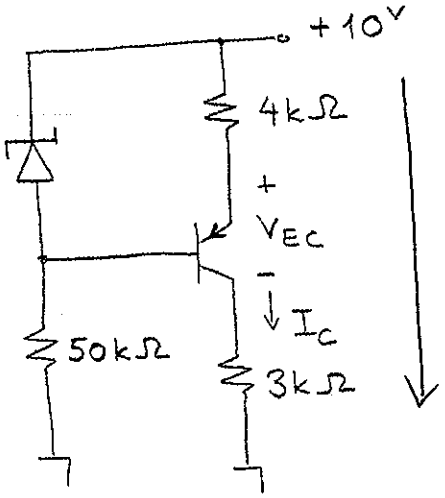
a. (5 points) Determine the states of the diode and the transistor, and find I_C and V_{EC}. Justify your answers.



Diode state	OFF
Transistor state	OFF
I_C	0 mA
V_{EC}	-10 V

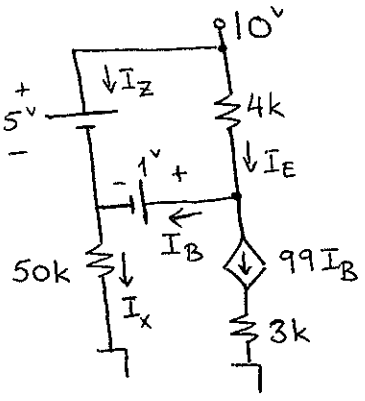
Base current is positive always
Diode opposes the current ⇒ OFF
Transistor also OFF

b. (5 points) Determine the states of the diode and the transistor, and find I_C and V_{EC}. Justify your answers.



Diode state	BREAKDOWN
Transistor state	FORWARD ACTIVE
I_C	0.99 mA
V_{EC}	3.03 V

assume pnp is in F. ACT and the zener in BRKDWN



$I_E = \frac{10^V - 6^V}{4k\Omega} = 1mA$

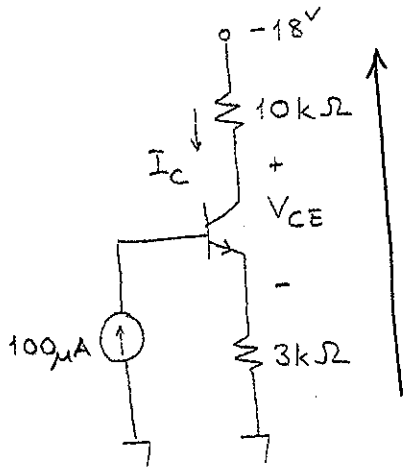
$I_B = \frac{1mA}{\beta+1} = 10\mu A$ $\quad I_C = 990\mu A$

$I_x = \frac{5^V}{50k\Omega} = 100\mu A$

$V_{EC} = 6^V - 3k \cdot I_C$

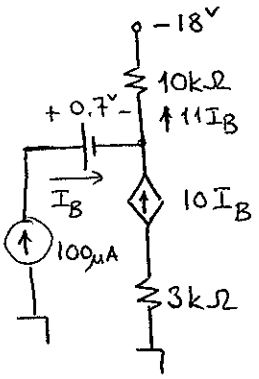
$V_{EC} = 3.03^V > V_{EC_{SAT}}$ ✓

c. (5 points) Determine the state of the transistor, and find I_C and V_{CE}. Justify your answers.



Transistor state	REVACT
I_C	− 1.1mA
V_{CE}	− 4V

assume REVACT



$I_B = 100\mu A$

$18^V - 0^V = 10 \cdot I_B \cdot 3k\Omega + V_{CE} + 11I_B \cdot 10k$

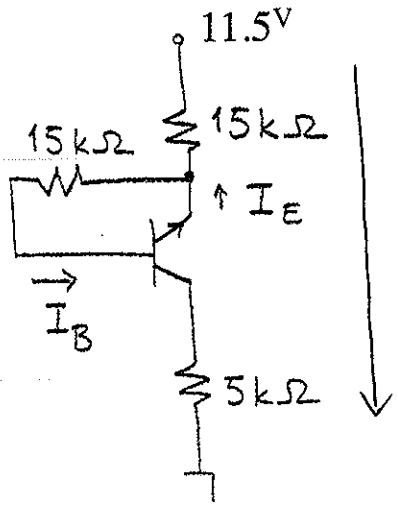
$V_{CE} = -4^V$

$V_{EC} = 4^V > V_{EC_{SAT}}$

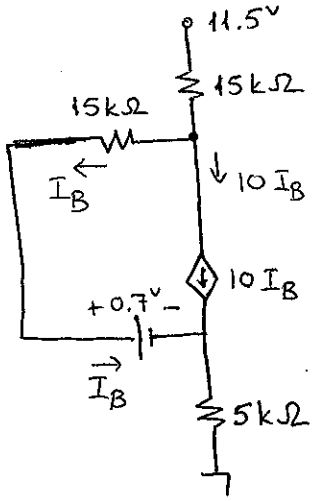
$I_C = -11I_B = -1.1mA$

d. (5 points) Determine the state of the transistor, and find I_E and I_B. Justify your answers.

Transistor state	REVACT
I_E	−459.57μA
I_B	45.957μA



assume REVACT



$11.5^V = 15k \cdot 11I_B + 15k \cdot I_B + 0.7 + 5k \cdot 11I$

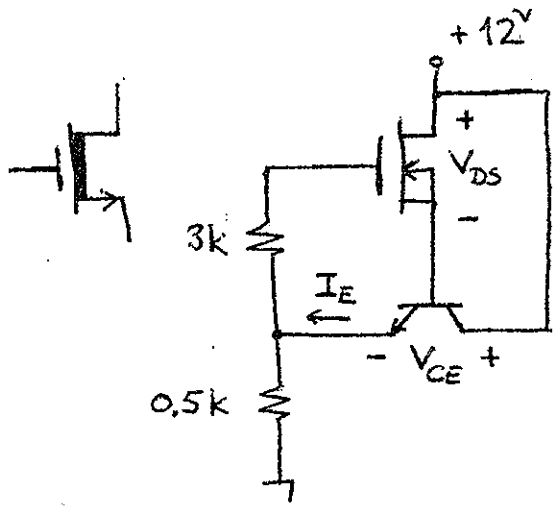
$I_B = 45.957\mu A$

$I_E = -10 \cdot I_B = -459.57\mu A$

$V_{EC} = 15k I_B + 0.7^V$

$V_{EC} = 1.389^V > V_{EC(SAT)}$

b. (10 points) Determine the following currents and voltages, justify your answer.



V_{DS}	4.55^V
V_{CE}	5.25^V
I_E	$13.5mA$

n-ch depletion mosfet

$V_T = -1^V$ $K_n = 1mA/V^2$ +1

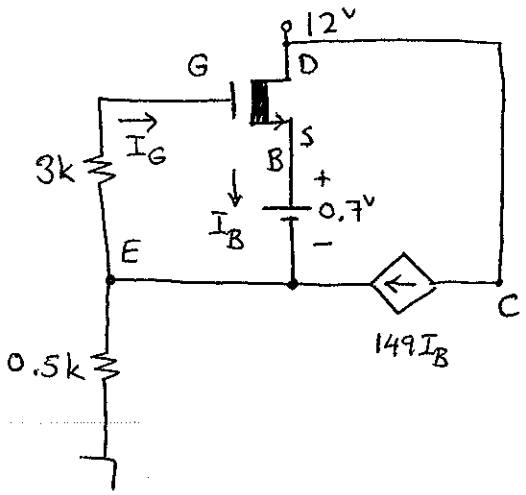
npn BJT $\beta = 149$ $V_{BE_{ON}} = 0.7^V$

$V_{CE_{SAT}} = 0.2^V$

+1

assume n MOS SAT

n BJT F. ACT



$I_G = 0 \Rightarrow V_G = V_E$ +1

$V_{GS} = V_{ES} = -0.7^V$ +1

$I_B = I_D = K_n (V_{GS} - (-1))^2 = 90\mu A$ +2

$V_E = (\beta+1) I_B \cdot 0.5k = 6.75^V$ +1

$I_E = (\beta+1) I_B = 13.5mA$ +1

$V_D = V_C = 12^V$

$V_{CE} = 5.25^V > V_{CE_{SAT}}$ +1 BJT F.ACT

$V_{DS} = 12^V - (V_E + 0.7^V) = 4.55^V > V_{GS} - V_{Th}$

$4.55^V > 0.3^V$

nMOS SAT

+1