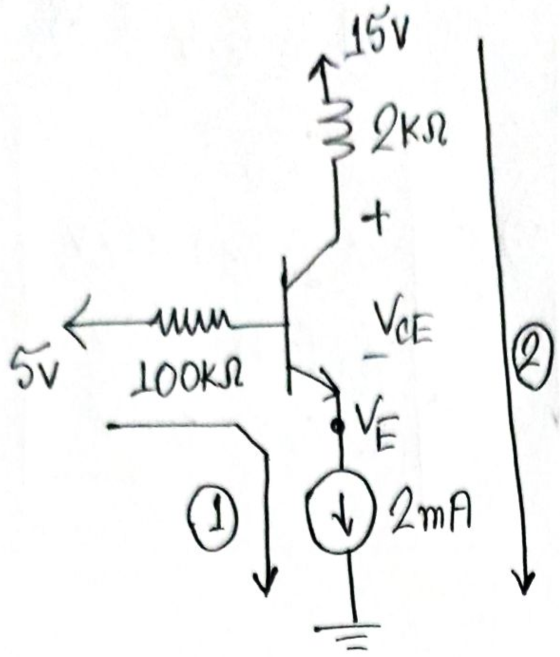
(1)



Find I_B, I_C, I_E & V_{CE}

$\beta = 100$

$V_{BE}(active) = 0.7V$

$V_{BE}(sat) = 0.8V$

$V_{CE}(sat) = 0.2V$

Assuming active —

$I_E = 2mA \quad \because I_E = (\beta+1)I_B$ in active mode

$$\therefore I_B = \frac{2}{101} mA = 0.0198mA$$

$\therefore I_C = 1.98mA$

KVL in (2) — $2 \times 1.98 + V_{CE} = 15 - V_E$ [KVL upto node E] —(i)

To solve for V_{CE} we need the value of V_E.

KVL in (1) — $100 \times 0.0198 + V_{BE}(active) = 5 - V_E$ [upto node E]

$$\Rightarrow 1.98 + 0.7 = 5 - V_E \Rightarrow V_E = 2.32V$$

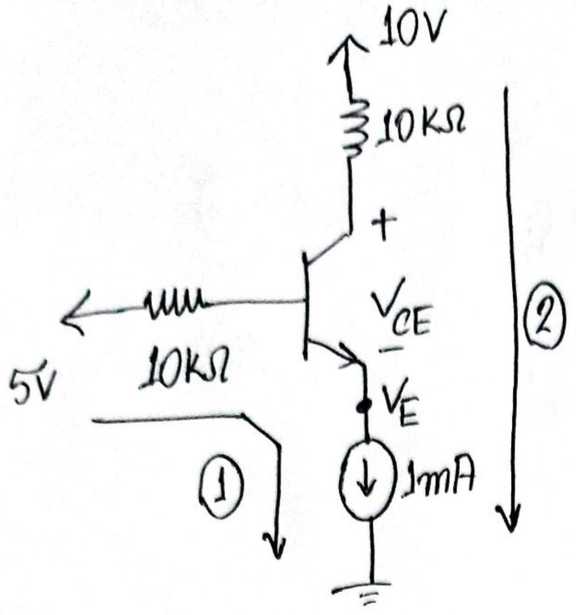
$\therefore$ (i) $\Rightarrow V_{CE} = 15 - 2.32 - 3.96 = 8.72V > V_{CE}(sat)$

$\therefore$ assumption is correct

Required quantities $\longrightarrow$ $I_B = 0.0198mA$; $I_C = 1.98mA$; $I_E = 2mA$;

$V_{CE} = 8.72V$

(2)



Find I_B, I_c, I_E & V_{CE}

$\beta = 100$

$V_{BE}(active) = 0.7V$

$V_{BE}(sat) = 0.8V$

$V_{CE}(sat) = 0.2V$

Assuming active —

$I_E = 1mA \quad \therefore I_B = \frac{1}{\beta+1} = 0.99 \times 10^{-2}\, mA \quad \therefore I_c = \beta I_B = 0.99\, mA$

KVL in line (2) upto node E —

$10 \times 0.99 + V_{CE} = 10 - V_E$ — (i)

KVL in line (1) upto node E —

$10 \times 0.99 \times 10^{-2} + 0.7 = 5 - V_E$

$\Rightarrow V_E = 5 - 0.7 - 0.099 = 4.201\, V$

$\therefore$ (i) $\Rightarrow V_{CE} = 10 - 9.9 - 4.201 = -4.101 \leq V_{sat_{CE}}$

$\therefore$ active assumption wrong.

Assuming saturation —

KVL in (2) —

$10 I_c + V_{CE}(sat) = 10 - V_E$ [upto node E] $\Rightarrow 10 I_c + V_E = 9.8$ — (i)

KVL in (1) upto node E —

$$10I_B + V_{BE}(sat) = 5 - V_E \Rightarrow 10I_B + V_E = 4.2 \quad \text{(ii)}$$

also we know, $I_E = I_B + I_c \Rightarrow I_B + I_c = 1$ —— (iii)

Solving (i), (ii) & (iii), we get,

$I_B = 0.22$ mA

$I_c = 0.78$ mA

$V_{CE} = 2V$

$$\therefore \frac{I_c}{I_B} = 3.54 = \beta_{forced} < \beta$$

$\therefore$ assumption correct

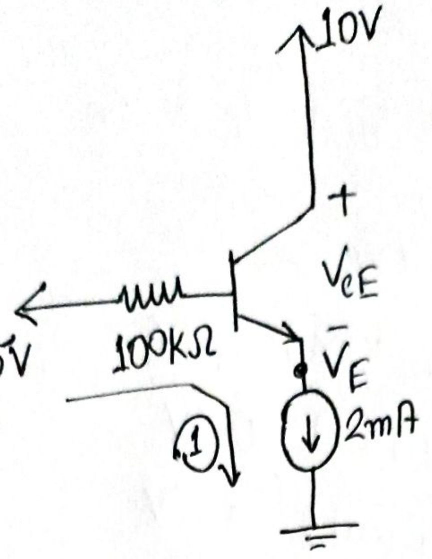
required quantities $\longrightarrow$ $I_B = 0.22$mA

$I_c = 0.78$mA

$I_E = 1$mA

$V_{CE} = 0.2V$

(3)



Find I_B, I_C, I_E & V_{CE}

$\beta = 100$

$V_{BE}(active) = 0.7V$

$V_{BE}(sat) = 0.8V$

$V_{CE}(sat) = 0.2$

Assuming active —

$I_E = 2mA \quad \therefore I_B = \frac{2}{\beta+1} = 0.0198mA \quad \therefore I_C = 1.98mA$

KVL in (1) —

$100 \times 0.0198 + V_{BE}(active) = 5 - V_E$ [upto node E]

$\Rightarrow V_E = 5 - 1.98 - 0.7 = 2.32V$

$\therefore V_{CE} = 10 - V_E = 10 - 2.32 = 7.68V > V_{CE}(sat)$

$\therefore$ assumption correct

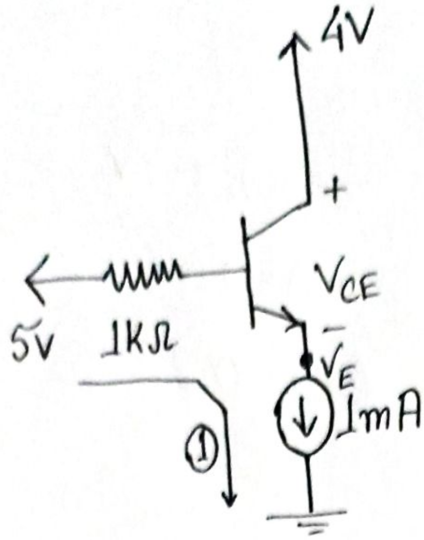
Required quantities $\longrightarrow$ $I_B = 0.0198mA$

$I_C = 1.98mA$

$I_E = 2mA$

$V_{CE} = 7.68V$

④



Find I_B, I_C, I_E & V_{CE}

$\beta = 100$

$V_{BE}(active) = 0.7V$

$V_{BE}(sat) = 0.8V$

$V_{CE}(sat) = 0.2V$

Assuming active mode —

$I_E = 1mA \quad \therefore I_B = \frac{1}{\beta+1} = 0.0099mA$

KVL in ① —

$0.0099 + V_{BE}(active) = 5 - V_E$ (upto node E)

$\Rightarrow V_E = 5 - 0.7 - 0.0099 = 4.29V$

$\therefore V_{CE} = 4 - 4.29 = -0.29 \leq V_{CE}(sat)$

So, assumption is wrong

Assuming saturation —

$\because V_{CE}(sat) = 0.2V \quad \therefore V_E = 4 - 0.2 = 3.8V$

KVL in ① —

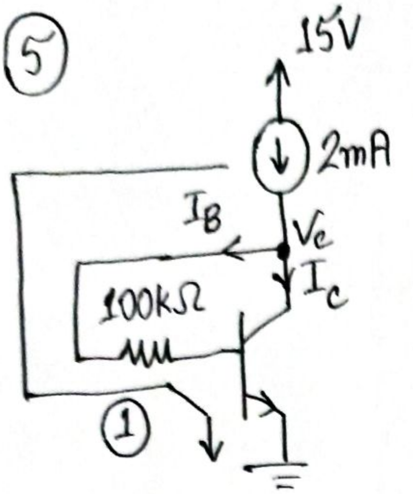
$I_B + V_{BE}(sat) = 5 - V_E$ [upto node E] $\Rightarrow I_B = 5 - 3.8 - 0.8 = 0.4mA$

$\because I_E = I_B + I_C \quad \therefore I_C = 0.6mA$

$\therefore \beta_{forced} = \frac{I_c}{I_B} = \frac{0.6}{0.4} = 1.5 < \beta$ [assumption correct]

$\therefore$ required quantities $\rightarrow I_B = 0.4mA ; I_c = 0.6mA ; I_E = 1mA ; V_{CE} = 0.2V$

(5)



Find I_B, I_c, I_E & V_{CE}

$\beta = 100$

V_{BE} (active) $= 0.7V$

V_{CE} (sat) $= 0.2V$

V_{BE} (sat) $= 0.8V$

Assuming active —

KCL @ node C — $I_B + I_c = 2 \Rightarrow I_B + 100 I_B = 2$ [$\because I_c = \beta I_B$ in active]

$\Rightarrow I_B = 0.0198 mA$

KVL in line (1) starting from node C —

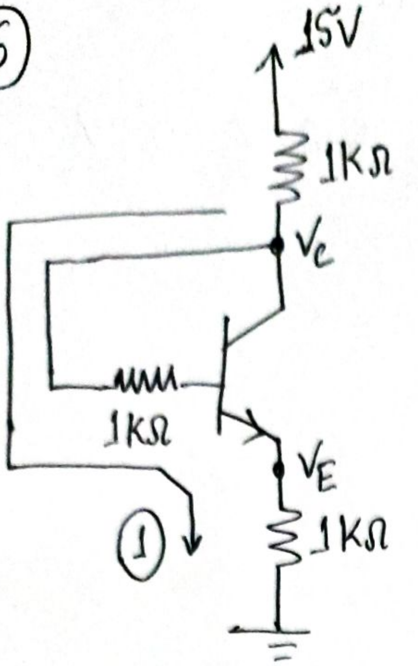
$100 \times 0.0198 + V_{BE}(active) = V_c - 0 \Rightarrow V_c = 1.98 + 0.7 = 2.68V$

$\therefore V_{CE} = V_c - V_E = 2.68V > V_{CE}(sat)$ [assumption correct]

Required quantities —

$I_B = 0.0198 mA ; I_c = 1.98 mA \; I_E = 2mA ; V_{CE} = 2.68V$

(6)



Find I_B, I_C, I_E & V_{CE}

$\beta = 100$

$V_{BE}(active) = 0.7V$

$V_{BE}(sat) = 0.8V$

$V_{CE}(sat) = 0.2V$

Assuming active —

$I_C = \beta I_B \Rightarrow 100 I_B - I_C = 0$ —(i)

applying KCL @ node C—

$$\frac{15 - V_C}{1} = I_B + I_C \Rightarrow I_B + I_C + V_C = 15 \text{ —(ii)}$$

applying KVL in line (1) starting @ node C —

$$I_B + V_{BE}(active) + I_E = V_C - 0 \Rightarrow I_B + I_E - V_C = -0.7$$

$$\Rightarrow 2I_B + I_C - V_C = -0.7 \; [I_E = I_B + I_C] \text{ —(iii)}$$

Solving (i), (ii) & (iii) we get,

$I_B = 0.07044$ mA ; $I_C = 7.044$ mA ; $V_C = 7.885$ V

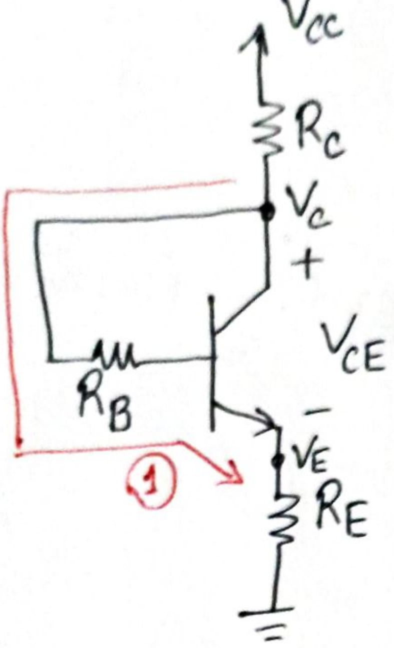
$V_{CE} = V_C - V_E = 7.885 - 1 \times I_E = 7.885 - 7.044 - 0.07044$

$= 0.77056 V > V_{CE}(sat)$ [correct]

required quantities → $I_B = 0.07044$mA; $I_C = 7.044$mA; $I_E = 7.114$ mA

$V_{CE} = 7.885V$

Note — This type of connection as in problem 5 & 6 will always be in active mode, if the BJT is ON.



KVL in line 1 from node C to E —

$$I_B R_B + V_{BE} = V_C - V_E$$

$$\Rightarrow V_{CE} = V_{BE} + I_B R_B$$

When BJT is ON — V_{BE} is at least 0.7V & $I_B > 0$

$\therefore$ V_{CE} must be greater than 0.7V

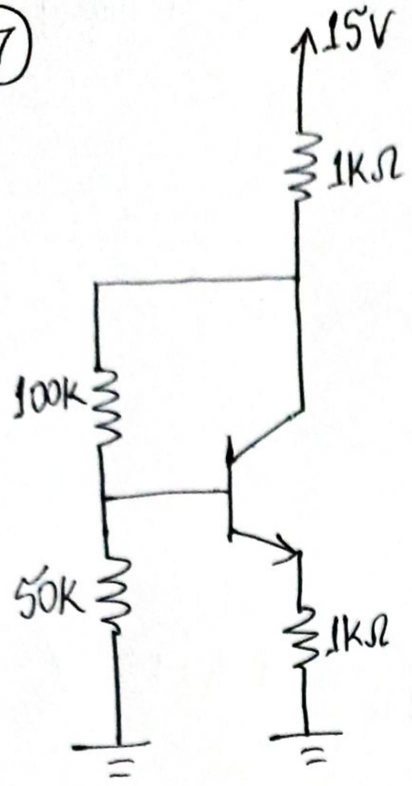
$\because$ $V_{CE}(sat) = 0.2 \sim 0.3V$

The BJT must be in active mode

V_{cc} must be large enough to ensure $I_B > 0$ which implies $V_{BE} \nless 0.7V$

PS — You still have to find values and verify

7



Find I_c, I_B, I_E & V_{CE}

$\beta = 100$

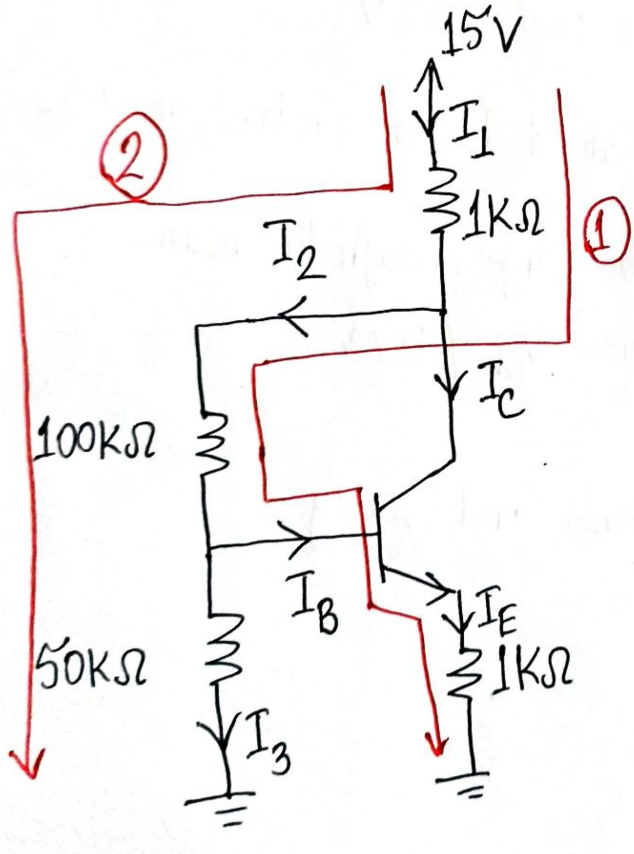
$V_{BE} = 0.7V$ (active)

$0.8V$ (saturation)

$V_{CE}(sat) = 0.2V$

High difficulty. Will probably not be set in exam

Labelling some circuit variables —



Assuming active —

KVL in 1 —

$I_1 + 100I_2 + V_{BE}(active) + I_E = 15 - 0$

$\Rightarrow I_2 + I_c + 100I_2 + I_B + I_c = 15 - 0.7$

$\Rightarrow I_2 + 100I_2 + I_B + I_c + I_c = 14.3$

$\Rightarrow 101I_2 + I_B + 2\times 100I_B = 14.3$ [∵ $I_c = \beta I_B$]

$\Rightarrow 101I_2 + 201I_B = 14.3$ — (i)

KVL in 2 —

$I_1 + 100I_2 + 50I_3 = 15 \Rightarrow I_2 + I_c + 100I_2 + 50I_2 - 50I_B = 15$

$\Rightarrow 151I_2 + 50I_B = 15$ — (ii) [∵ $I_c = \beta I_B$]

Solving (i) & (ii) —

$I_2 = 0.0909\,mA$

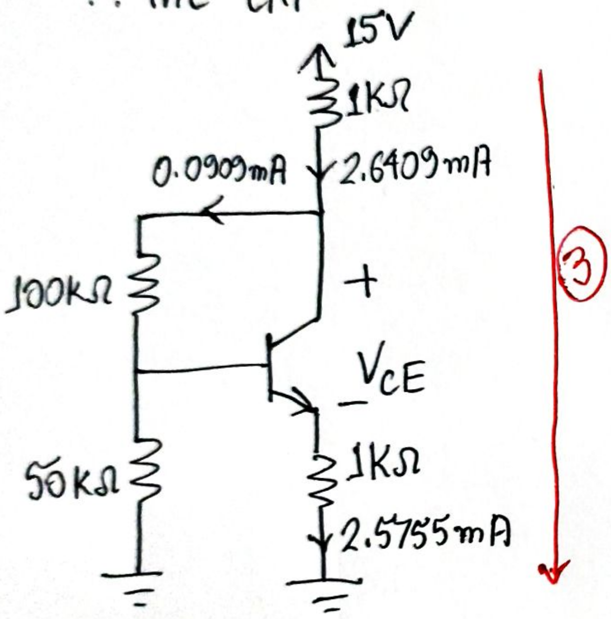
$I_B = 0.0255\,mA$

$\therefore I_C = 2.55\,mA$

$\therefore I_1 = I_2 + I_C = 2.6409\,mA$

& $I_E = I_B + I_C = 2.5755\,mA$

∴ the ckt —



To verify assumption —

Applying KVL in (3) —

$2.6409 + V_{CE} + 2.5755 = 15 - 0$

$\Rightarrow V_{CE} = 15 - 5.2164$

$= 9.7836\,V > V_{CE}(sat)$

∴ assumption is correct

Required quantities — $I_B = 0.0255\,mA$

$I_C = 2.55\,mA$

$I_E = 2.5755\,mA$

$V_{CE} = 9.7836\,V$