1. BJT

A.

i) $\alpha_F = \dfrac{q A_E F_{n,B}(W_b)}{I_E}$

$I_E = q A_E \left[F_{n,B}(0) + \int_{EB.dep} u\,dx + F_{p,E}(0) \right]$

$= q A_E \left[1.01\, F_{n,B}(0) + 10^{20} \right]$

$= q A_E \left[1.01 \times 10^{23} + 0.001 \times 10^{23} \right]$

$= q A_E \times 1.011 \times 10^{23}$

$\therefore \alpha_F = \dfrac{0.99 \times 10^{23}}{1.011 \times 10^{23}} = \dfrac{0.99}{1.011}$ $\longleftarrow$ (5)

ii) $I_{CBO} = q A_E \left[\int G\,dx + F_{p,C}(0) \right]$

$= q A_E \left[5 \times 10^{18} + 1 \times 10^{17} \right]$

$= 1.6 \times 10^{-19} \times 10^{-8}\,cm^2 \times 5.1 \times 10^{18}$

$= 8.16 \times 10^{-9}\,A$ $\longleftarrow$ (5)

B.

i) Collector current $\simeq q A_E F_{n,B}(W_b)$

$\left(F_{n,B}(W_b) = v_{sat} \times N_{DC} = 1 \times 10^{7}\,cm/sec \times 6 \times 10^{16}/cm^3 \right.$

$\left. = 6 \times 10^{23} / cm^2 \cdot sec \right)$

$\therefore$ Collector Current $\simeq 1.6 \times 10^{-19} \times 10^{-8}\,cm^2 \times 6 \times 10^{23} / cm^2 \cdot sec$

$= 9.6 \times 10^{-4}\,A = 0.96\,mA$ $\longleftarrow$ (5)

ii) V_{BE}

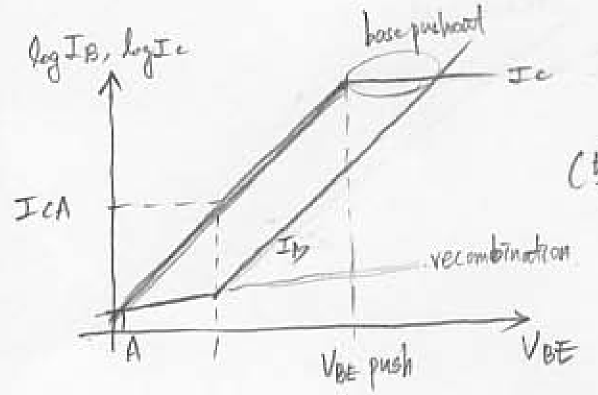
$$\frac{F_{n,B}(0)}{F_{n,B}(W_b)} = \frac{e^{0.7/V_t}}{e^{V_{BE}/V_t}}$$

$$\Rightarrow \quad V_{BE} = 0.7 + V_t \ln \frac{F_{n,B}(W_b)}{F_{n,B}(0)} = 0.7 + 0.024 \ln 6$$

$\longleftarrow$ (5)

$$\cong 0.743\,V$$

C.



(5)

$$I_C = I_{C0}\, e^{V_{BE}/V_t}$$

$$\left(I_{C0} = qA_E\, 0.99\, F_{n,B}(W_b)\, e^{-0.7/V_t}\right)$$

$$I_B = I_{B0}\, e^{V_{BE}/2V_t}$$

$$\left(I_{B0} = qA_E\, R_{ec}(BE)\, e^{-0.7/2V_t}\right)$$

$$I_C = I_B$$

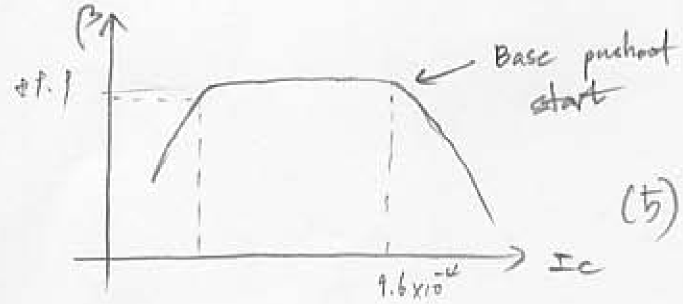
$$V_{BE} = 2V_t \ln \frac{I_{B0}}{I_{C0}}$$

$$= 2V_t \ln \frac{10^{20} \times 10^{-0.7/2V_t}}{0.99 \times 10^{23} \times e^{-0.7/V_t}}$$

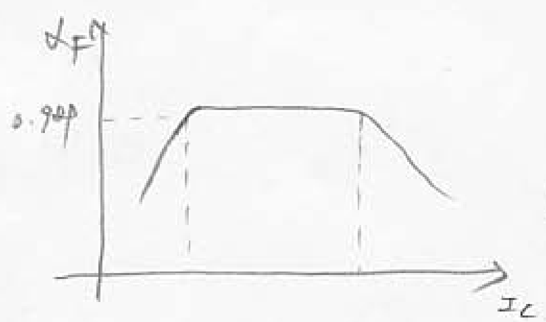
$$= 2V_t \ln \frac{10^{20}}{0.99 \times 10^{23}} + 0.7$$

$$= \underline{0.369\,V} \Leftarrow A$$

(5)



(5)



(5)

D.

1) $$I_{CEO} = \frac{I_{CBO} M}{1 - \alpha M} = -1.545 \times 10^{-8} A \qquad (5)$$

$$\left(\begin{array}{l} M = \dfrac{1}{1-\left(\dfrac{V_{CB}}{BV_{CBO}}\right)^4} = \dfrac{1}{1-\left(\frac{6}{7}\right)^4} = 2.17 \\ \alpha \simeq \alpha_F = \dfrac{0.98}{1.011} \end{array} \right)$$

2) $$\frac{1}{1-\left(\dfrac{BV_{CEO}}{BV_{CBO}}\right)^4} \simeq \frac{1}{\alpha}$$

$$\Rightarrow BV_{CEO} = BV_{CBO} \sqrt[4]{1-\alpha} = 7 \times (1-0.988)^{1/4}$$

$$= 2.657 \quad (5)$$

3) $I_{CEO} \uparrow \rightarrow \alpha \uparrow \rightarrow M \downarrow \rightarrow BV_{CEO} \downarrow$

(5)

4) $$I_{CEO} \simeq I_C \big|_{\text{Base pushout}} = q V_{sat} \times N_{DC} \times A_E$$

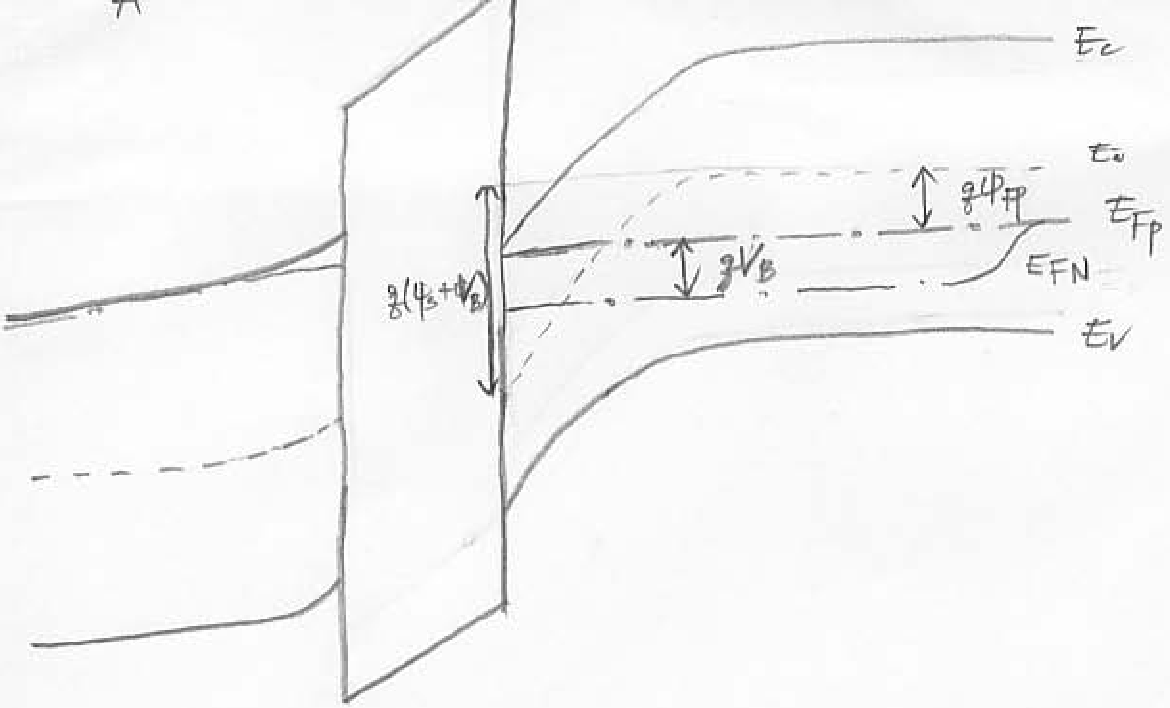
$$\simeq 9.6 \times 10^{-4} A$$

$\Rightarrow$ As base push out starts, BV_{CEO} Increase to make high electric field in B-C Junction.

(5)

2.

A



B. $V_G - V_{FB} = r\sqrt{\varphi_s + V_B} + \varphi_s$

$V_T(V_B) = V_{FB} + r\sqrt{2\varphi_F + V_B} + 2\varphi_F$

$(V_G = V_T)$

$V_T - V_{FB} = r\sqrt{\varphi_s + V_B} + \varphi_s$

$\Rightarrow r\sqrt{2\varphi_F + V_B} + 2\varphi_F = r\sqrt{\varphi_s + V_B} + \varphi_s$

$\Rightarrow \underbrace{r\sqrt{2\varphi_F + V_B} + 2\varphi_F + V_B}_{t} = r\sqrt{\varphi_s + V_B} + \varphi_s + V_B$

$\rightarrow \left(\sqrt{\varphi_s + V_B}\right)^2 + r\sqrt{\varphi_s + V_B} - t = 0$

CONT.

$\therefore \sqrt{\varphi_s + V_B} = \dfrac{-r + \sqrt{r^2 + 4t}}{2}$

$$\varphi_s = \left(\frac{-r + \sqrt{r^2 + 4t}}{2} \right)^2 - V_B$$

$$r = \frac{\sqrt{2 q N_a \varepsilon_{si}}}{C_{ox}} \quad \left(C_{ox} = \frac{\varepsilon_{ox}}{t_{ox}} \right)$$

$$= 0.5276$$

$\therefore t = 2.267$

$\therefore \underline{\varphi_s = 0.59\ V}$ //

c.

$$|Q_{dmax}| = \sqrt{2 q N_a \varepsilon_{si} (\varphi_s + V_B)}$$

$$= \sqrt{2 \times 1.6 \times 10^{-19} \times 10^{17} \times 11.7 \times 8.85 \times 10^{-14} \times 1.6}$$

$$= \underline{2.3 \times 10^{-7}\ c/cm^2}$$ //