Quiz-2 Answer Keys

Sol. 1) Given, $N_A = 2\times10^{16} / cm^3$

$t_{ox} = 80\ nm$

$Q_{ox} = 2\times10^{-8} / cm^2$

$\phi_{ms} = -0.90\ V$

$\varepsilon_{SiO_2} = 3.9$

$$|V_f| = \frac{Q_{ox}}{C_{ox}} = \frac{Q_{ox}}{\varepsilon_{ox}/t_{ox}}$$

$$\Rightarrow |V_f| = \frac{2\times10^{-8}}{3.9\times8.85\times10^{-14}/80\times10^{-7}}$$

$$\Rightarrow |V_f| = 0.463\ V$$

$$\therefore V_{FB} = -V_f - \phi_{MS}$$

$$\Rightarrow \boxed{V_{FB} = -1.363V}$$

Sol. 2 Given, $t_{ox} = 100\ \mathring{A}$

$N_A = 10^{17} / cm^3$

a) $$V_s = 2KT \ln\left(\frac{N_A}{n_i}\right)$$

$$= 2 \times 0.026 \ln\left(\frac{10^{17}}{1.5\times10^{10}}\right)$$

$$\Rightarrow \boxed{V_s = 0.817\,V}$$

b) $$W = \sqrt{\frac{2\varepsilon_s}{qN_A} V_s} = \sqrt{\frac{2\times 11.8\times 8.85\times10^{-4}}{1.6\times10^{-19}\times 10^{17}}\times 0.817}$$

$$\boxed{W = 1.032\times10^{-5}\,cm}$$

c) $$C_{ox} = \frac{\varepsilon_{ox}}{t_{ox}} = \frac{3.9\times 8.85\times10^{-14}}{100\times10^{-8}}$$

$$\Rightarrow \boxed{C_{ox} = 34.515\times10^{-8}\,F/cm}$$

d) $$V_{th} = V_{ox} + V_s$$

$$= \frac{qN_AW}{C_{ox}} + V_s$$

$\Rightarrow$ V [illegible] V

$\Rightarrow \boxed{V_{Th} = 1.295\,V}$

e) $I_D = \frac{\overline{\mu}_n C_{ox} Z}{2L} \left(V_{GS} - V_{Th}\right)^2$ [under saturation]

$\Rightarrow 1\times10^{-3} = \frac{150 \times 34.515\times10^{-8} \times 150}{10} \left(V_{GS} - 1.295\right)^2$

$\Rightarrow \boxed{V_{GS} = 0.3\,V}$

Sol. 3 a) $V_{0,EB} = KT \ln\left(\frac{N_E N_B}{n_i^2}\right) = 0.817\,V$

b) $V_{0,CB} = KT \ln\left(\frac{N_C N_B}{n_i^2}\right) = 0.637\,V$

c) $W_{CB} = \sqrt{\frac{2\varepsilon}{q}\left(V_{0,CB} + V_R\right)\left(\frac{1}{N_C} + \frac{1}{N_B}\right)}$

$\therefore \boxed{W_{CB} = 6.632\,\mu m}$

Hence, the effective base width,

$W_B' = W_B - W_{CB}$

$$\Rightarrow \boxed{W_B' = 0.368\,\mu m}$$

Ans. 4) The current gains are expressed as follows:

$$\alpha = \frac{I_c}{I_E} \quad \& \quad \beta = \frac{I_c}{I_B}$$

$$\beta = \frac{I_c / I_E}{I_B / I_E} ,$$

we know, $I_E = I_c + I_B$

$$\therefore \quad I_B = I_E - I_c$$

$$\Rightarrow \beta = \frac{I_c / I_E}{(I_E - I_c) / I_E}$$

$$= \frac{\alpha}{1 - \frac{I_c}{I_E}}$$

$$\Rightarrow \boxed{\beta = \frac{\alpha}{1-\alpha}}$$