Quiz 10

(1) For a ~~Al Mos~~ N-MOSFET with $t_{ox} = 5nm$

$N_A = 10^{16}\ cm^{-3}$

Find

(A) V_T (assume $\phi_{ms} = 0$).

Sol^n $\phi_F = \frac{KT}{q} \ln\left(\frac{N_A}{n_i}\right) = 0.0259 \ln\left(\frac{10^{16}}{10^{10}}\right)$

$\phi_F = 0.36V$

$$V_T = V_{FB} + 2\phi_F + \frac{\sqrt{2q\epsilon_{Si} N_A 2\phi_F}}{C_{ox}}$$

$$= 0 + 2\times 0.36 + \frac{\sqrt{2\times 1.6\times 10^{-19}\times 11.8\times 8.85\times 10^{-14}\times 10^{16}\times 2\times 0.36}}{3.9\times 8.854\times 10^{-14}/5\times 10^{-7}}$$

$$= 0.72 + 0.071$$

$$\boxed{V_T = 0.791\ V}$$

(B) Find the threshold voltage when $\phi_M = 4.2\ eV$ (with the same doping & t_{ox})

Sol^n $\phi_M = 4.2\ eV$ $\qquad \phi_S = (4.05 + 0.56 + 0.36)\ eV$

$\phi_S = 4.97\ eV$

$\phi_{MS} = 4.2 - 4.97$

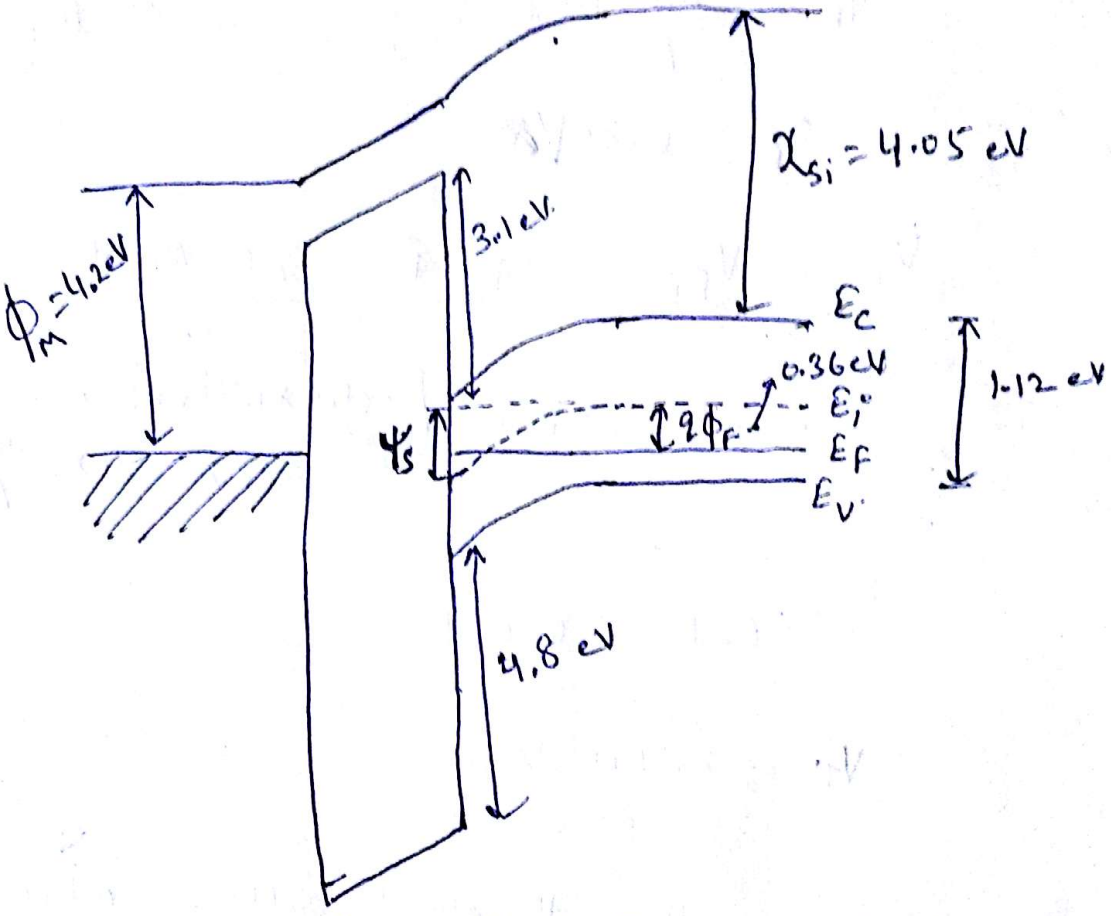
$= -0.77\ eV.$

$V_T' = V_T + \frac{\phi_{MS}}{e} = 0.791 - 0.77 = 0.021\ eV$

$\boxed{V_T' = 0.021\ V.}$

(C) Draw the energy band Diagram at $V_G = 0$ for the above case.

Sol^n.



(D) For the MOSFET in (B) estimate the threshold voltage if a sheet of charge $Q = 2 \times 10^{11}$ cm^{-2} is placed at a distance 2 nm from metal/oxide interface.

Sol^n

$$\Delta V_{FB} = -\frac{Q x_o}{\epsilon_{ox}} = \frac{-1.6 \times 10^{-19} \times 10^{11} \times 2 \times 10^{-7}}{3.9 \times 8.854 \times 10^{-14}}$$

$$\Delta V_{FB} = -0.0093 \text{ V}.$$

$$V_T'' = V_T' + \Delta V_{FB} = 0.021 - 0.0093$$

$$\boxed{V_T'' = 0.0117}$$