1. An MOS device has the following high-frequency C-V curve. Draw the band diagrams (include the gate electrode and the gate oxide, label the Fermi levels) at bias points A and B. The interface charge is negligible.

\[\text{P-type substrate} \]

A. Accumulation

\[E_F - - - - - \]

B. Inversion

\[E_F \]

\[E_F - - - - - \]
2. Consider an nMOSFET with a gate oxide thickness of 15 nm and p-type substrate doping of $5 \times 10^{16}/\text{cm}^3$. The interface charge is negligible. What is the potential drop across the oxide?

(a) at the threshold condition?

(b) at a gate voltage of 2.0 V above the threshold?

(c) at the new threshold condition with a 2.0 V reverse bias on the substrate?

\[ V_{ox} = \frac{Q_{si}}{C_{ox}} \]

(a) \[ Q_{si} = Q_d = \sqrt{2 \epsilon_{si} \frac{q}{n_{i}} N_a (2 q V_B)} \]

\[ q V_B = \frac{k T}{\theta} \ln \frac{N_a}{n_i} = 0.39 \text{ V} \]

\[ Q_d = 1.14 \times 10^{-7} \text{ C/cm}^2 \]

\[ V_{ox} = 0.49 \text{ V} \]

(b) \[ Q_{si} = Q_d + C_{ox} (V_{gs} - V_T) \]

\[ V_{ox} = 0.49 + V_{gs} - V_T = 2.49 \text{ V} \]

(c) \[ Q_{si} = Q_d = \sqrt{2 \epsilon_{si} \frac{q}{n_{i}} N_a (2 q V_B + V_2)} \]

\[ = 2.15 \times 10^{-7} \text{ C/cm}^2 \]

\[ V_{ox} = 0.93 \text{ V} \]