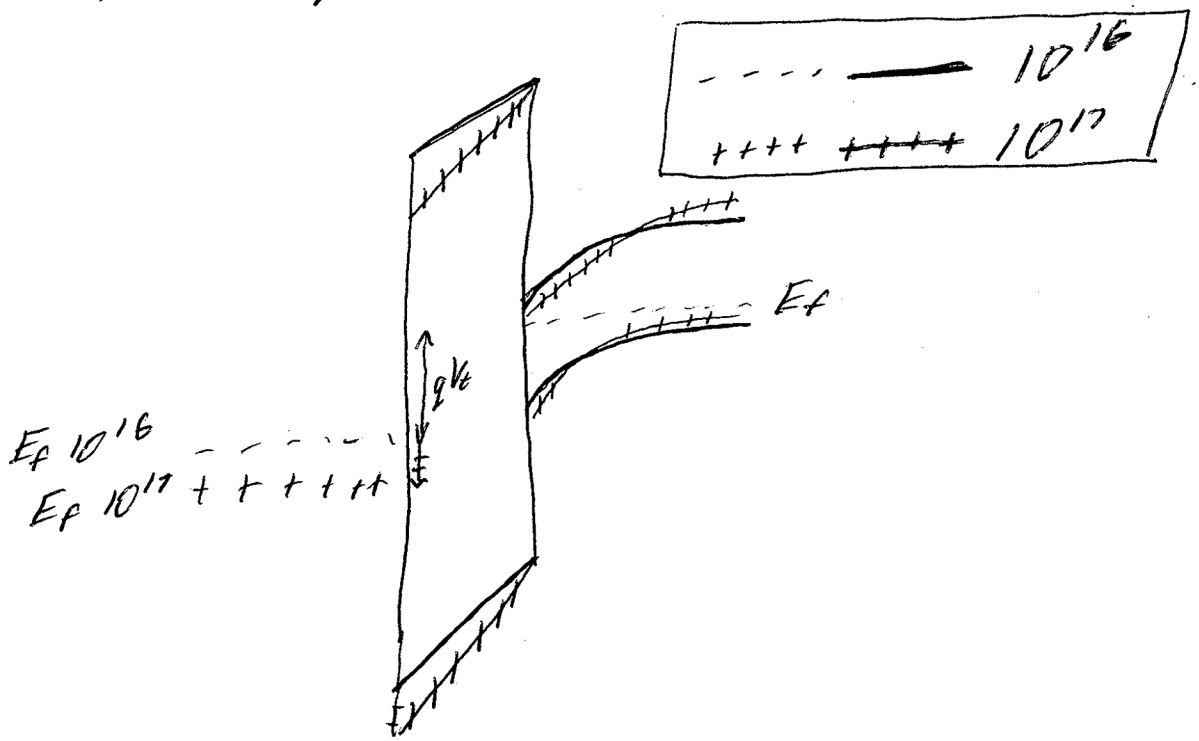
1.

a.) Band Diagram at threshold.

At $N_a = 10^{17}$, $\phi_s = 2\phi_f$ will increase over the 10^{16} case. Thus the substrate energy bands bend a little more. In addition, the band bending in the oxide increases because of a dependence on $2\phi_f$, and qV_t will increase as well.



b.) $V_t = 2\phi_f + \frac{t_{ox}}{\epsilon_{ox}}\sqrt{2q\epsilon_{si}N_a 2\phi_f}$ → voltage dropped across oxide, $\Delta\phi_{ox}$

$\phi_f = kT \ln \frac{N_a}{n_i} = .42$

$2\phi_f = .84$

$$V_t = .84 + \frac{400\times10^{-8}\,cm}{(3.9)\,8.854\times10^{-14}\,\frac{F}{cm}}\sqrt{2(1.6\times10^{-19}\,Ca.1)(11.7)\epsilon_0(10^{17})(.84)}$$

$$V_t = 2.77\,V = .84 + 1.93$$

$$= \Delta\phi_s + \Delta\phi_{ox}$$

$$\mathcal{E}_{ox} = \frac{\Delta\phi_{ox}}{t_{ox}} = 4.8\times10^5\,\frac{V}{cm}$$

c.) $V_g = 5\,V$

Beyond V_t, the surface potential remains clamped at $\phi_s = 2\phi_f$, therefore all voltage above V_t is dropped across the oxide.

$$\mathcal{E}_{ox} = \frac{(\Delta\phi_{ox})_{threshold}}{t_{ox}} + \frac{V_g - V_t}{t_{ox}}$$

$$\mathcal{E}_{ox} = \frac{1.93\,V}{400\,\text{Å}} + \frac{5 - 2.77\,V}{400\,\text{Å}}$$

$$\boxed{\mathcal{E}_{ox} = 1.04\times10^6\,V/cm}$$

(2.) a.) $C_{ox} = \frac{\epsilon_{ox}}{t_{ox}} = 1.15 \times 10^{-7} \frac{F}{cm^2}$

b.) position "a" p-type substrate

$$V_t = 2\phi_f + \frac{t_{ox}}{\epsilon_{ox}} \sqrt{2q\epsilon_{si} N_a 2\phi_f}$$

$$= .84 + \frac{3000\text{Å}}{\epsilon_{ox}} \sqrt{2q\epsilon_{si}(10^{17})(.84)}$$

$$\boxed{V_t = 2.29V}$$

position "b" n-type substrate

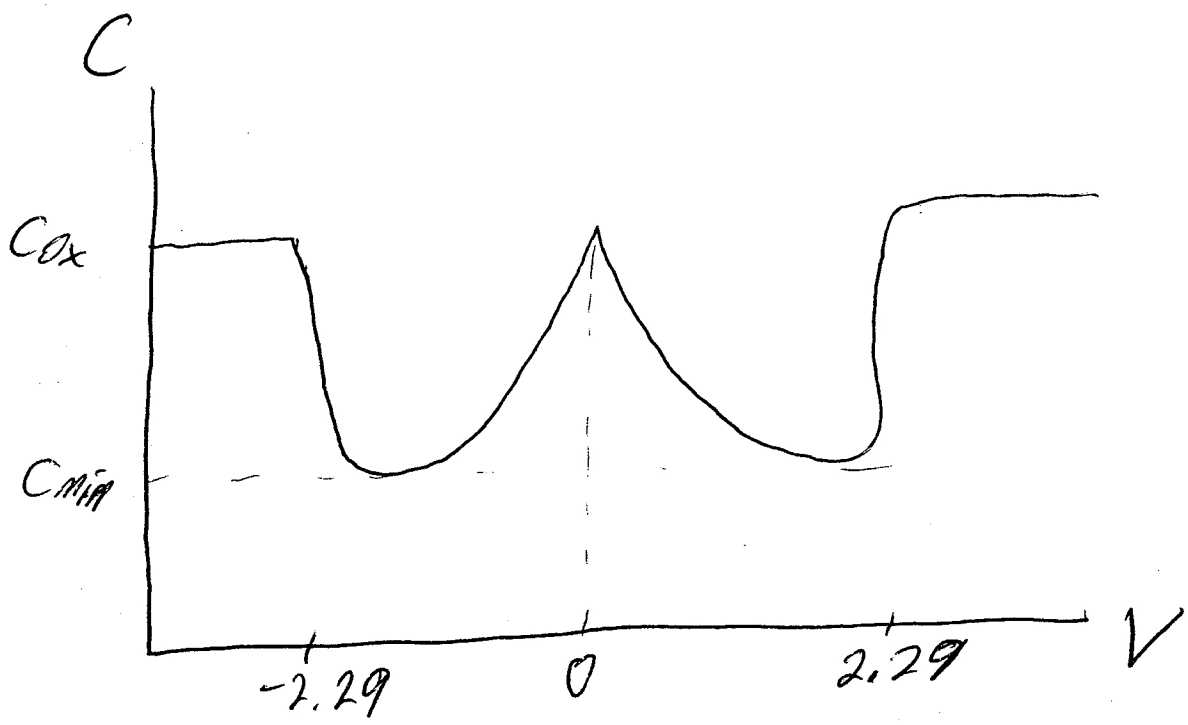
$$V_t = -2|\phi_f| - \frac{t_{ox}}{\epsilon_{ox}} \sqrt{2q\epsilon_{si} N_a 2|\phi_f|}$$

$$\boxed{V_t = -2.29V}$$

c.) $W_{max} = \sqrt{\frac{4\epsilon_{si}|\phi_f|}{qN}} = \sqrt{\frac{4(11.7)(8854 \times 10^{-14} \frac{F}{cm})(.42)}{(1.6 \times 10^{-19})(10^{17})}}$

$W_{max} = .10\,\mu m$ for both n-type & p-type

d.)



The n-side can supply electrons to the p-region's inversion layer & vice-versa. Thus this is a transistor-like low frequency curve.