6) $V_D = ?$

$I_D = 1\,mA$

(a) $I_S = 10^{-11}\,A$ $\qquad I_D = I_S\left(e^{\frac{V_D}{V_T}} - 1\right)$

$n = 1$

$$\frac{I_D}{I_S} + 1 = e^{V_D/V_T}$$

$$\frac{V_D}{V_T} = \ln\left(\frac{I_D}{I_S} + 1\right) \Rightarrow V_D = V_T \ln\left(\frac{I_D}{I_S} + 1\right)$$

$\underline{V_T = 0,026\,V}$; $V_D = 0,026 \cdot \ln\left(\frac{1\times10^{-3}}{10^{-11}} + 1\right) = 0,479\,V$

(b) $I_S = 10^{-13}\,A$

$$V_D = 0,026 \ln\left(\frac{1\times10^{-3}}{10^{-13}} + 1\right) = 0,599\,V$$

(c) $I_S = 10^{-15}\,A$

$$V_D = 0,026 \ln\left(\frac{1\times10^{-3}}{10^{-15}} + 1\right) = 0,718\,V$$