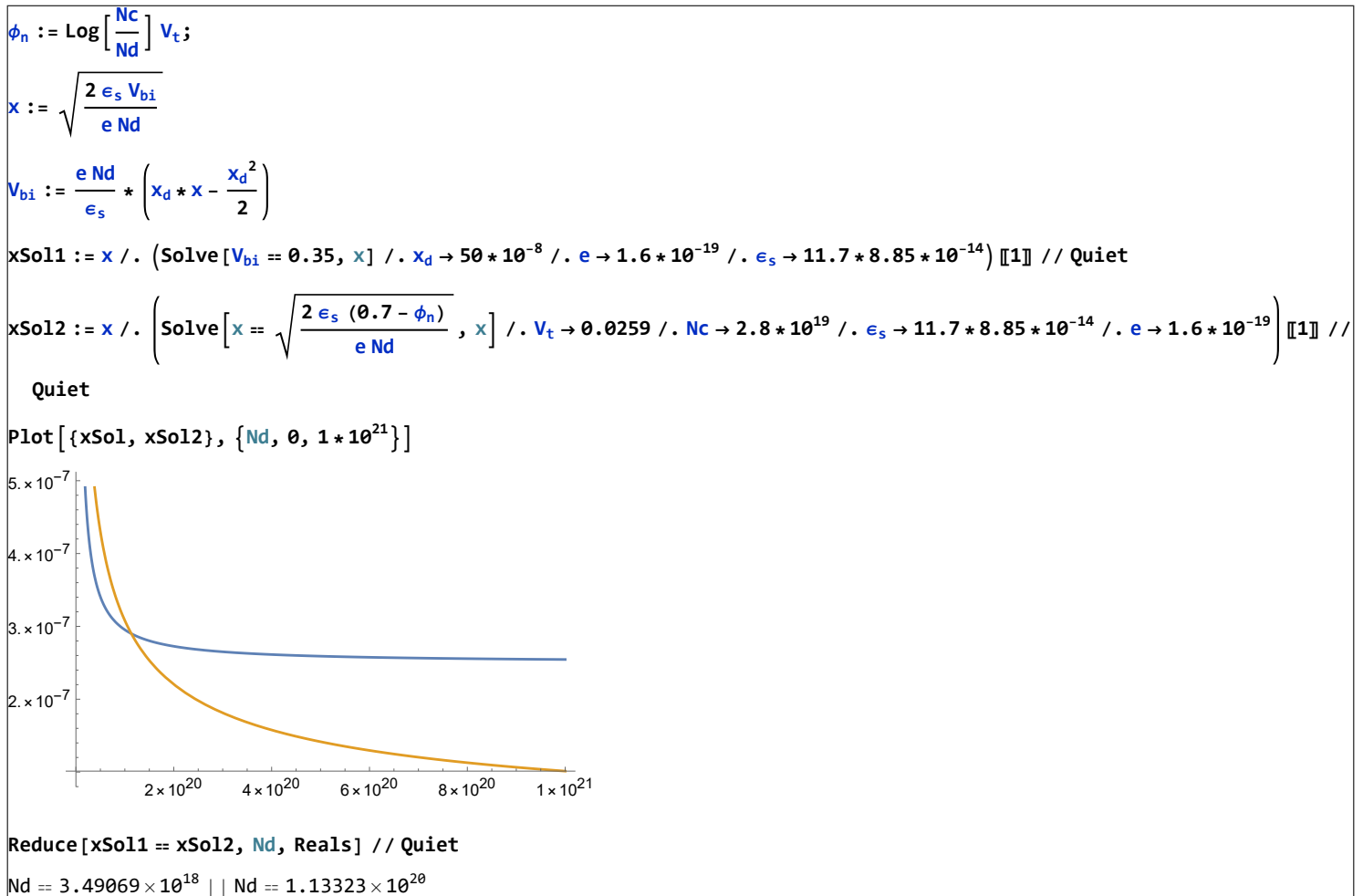# Q 2:

$$\phi_n = V_t \ln \frac{N_c}{N_d}$$

$$V_{bi} = \phi_{B0} - \phi_n$$

$$x_n = \left[\frac{2\epsilon_s V_{bi}}{e N_d} \right]^{1/2}$$

$$V_{bi} = \frac{\left(x_n \cdot x_d - \frac{x_d^2}{2} \right)(e N_d)}{\epsilon_s}$$

Now, using Mathematica to plot N_d from the two equations, we can see a solution in the region of $1 * 10^{20}$, finding that root yields:

```
φn := Log[Nc/Nd] Vt;

x := √(2 εs Vbi / e Nd)

Vbi := e Nd/εs * (xd * x - xd²/2)

xSol1 := x /. (Solve[Vbi == 0.35, x] /. xd → 50 * 10⁻⁸ /. e → 1.6 * 10⁻¹⁹ /. εs → 11.7 * 8.85 * 10⁻¹⁴)〚1〛 // Quiet

xSol2 := x /. (Solve[x == √(2 εs (0.7 - φn) / e Nd), x] /. Vt → 0.0259 /. Nc → 2.8 * 10¹⁹ /. εs → 11.7 * 8.85 * 10⁻¹⁴ /. e → 1.6 * 10⁻¹⁹)〚1〛 //
  Quiet

Plot[{xSol, xSol2}, {Nd, 0, 1 * 10²¹}]
```



```
Reduce[xSol1 == xSol2, Nd, Reals] // Quiet

Nd == 3.49069 × 10¹⁸ || Nd == 1.13323 × 10²⁰
```

Figure 1: Mathematica code used to obtain the results for N_d

$$\therefore N_d = 3.49 \times 10^{18} \, cm^{-3}$$

Q 3:

n p n p n p

E_c E_c E_c

E_F E_v E_F E_v E_F E_v

0-Biased   Reverse-Biased   Forward-Biased

I

V