Q 2:

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

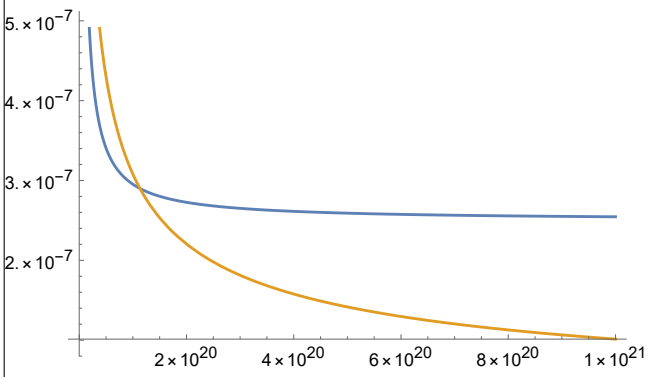
$$V_{bi} = \phi_{B0} - \phi_n$$

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

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

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 := Sqrt[2 ϵs Vbi / (e Nd)]

Vbi := (e Nd)/ϵs * (xd * x - xd^2/2)

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 == Sqrt[2 ϵs (0.7 - ϕn) / (e Nd)], x] /. Vt → 0.0259 /. Nc → 2.8 * 10^19 /. ϵs → 11.7 * 8.85 * 10^-14 /. e → 1.6 * 10^-19)[[1]] //
  Quiet

Plot[{xSol, xSol2}, {Nd, 0, 1 * 10^21}]
```

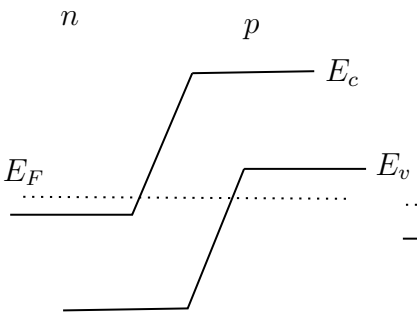



```
Reduce[xSol1 == xSol2, Nd, Reals] // Quiet

Nd == 3.49069 × 10^18 || Nd == 1.13323 × 10^20
```

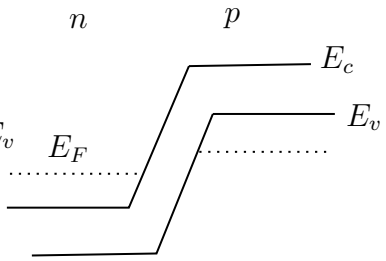
Figure 1: Mathematica code used to obtain the results for N_d

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

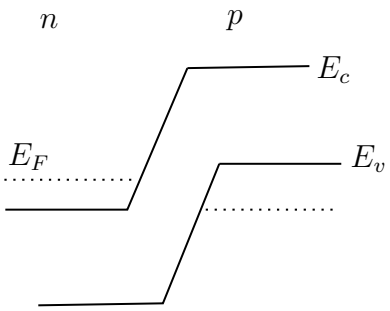
Q 3:



0-Biased



Reverse-Biased



Forward-Biased