Q2b)

$$N_D = N_C e^{-(E_C - E_F)/kT}$$

$$E_C - E_F = q\phi_N$$

$$\Rightarrow \phi_N = \frac{E_C - E_F}{q} = V_T \ln\left(\frac{N_C}{N_D}\right) = 0.242\,eV$$

$$N_C = 2.8 \times 10^{19}\ cm^{-3}$$

Now ϕ_S OR $\phi_N = 0.242 + \chi$ mark

$$= 4.252\ V$$

$$\phi_B = \phi_M - \chi$$

$$\phi_{B0} \rightarrow given = 0.55$$

$$\Rightarrow \phi_M = 0.55 + 4.01$$

$$= 4.56\ V \quad - \quad 1\ mark$$

Now $V_{bi} = \phi_M - \phi_S = 4.56 - 4.252$

$$= 0.308\ V$$

$$\quad \longleftarrow 1\ mark$$

6) Now if $N_D = 3 \times 10^{16}$

ϕ_M & χ dont change

$\Rightarrow \phi_{B0}$ also remains the same

ϕ_S changes

$$N_D = N_c e^{-(E_c - E_F)/kT}$$

$$\Rightarrow \quad E_c - E_F = 26 \times 10^{-3} \times \ln\left(\frac{2.8 \times 10^{19}}{3 \times 10^{16}}\right)$$

$$= 0.1770 \text{ eV}$$

$$\Rightarrow$$

$$q\phi_s = \chi + \frac{g}{8}(E_c - E_F)$$

$$\Rightarrow \quad \phi_s = \frac{4.01 \text{ eV} + 0.177 \text{ eV}}{2}$$

$$\phi_s = 4.187 \text{ V} \quad - 1 \text{ mark}$$

$$\Rightarrow \quad V_{bi} = \phi_M - \phi_s = 4.56 - 4.187$$

$$= 0.373 \text{ V}$$

$$\rightarrow 1 \text{ mark}$$

$$\Rightarrow \text{By doping more donors} \rightarrow V_{bi}$$

$$\text{increased}$$

$$\text{Change in } V_{bi} = 0.373 - 0.308$$

$$= 0.065 \text{ V}$$

$$\rightarrow 1 \text{ mark}$$