# HW 2 Solutions

**2.2** $N_D = n_n = 10^{17}/cm^3$

$$p_n \cdot n_n = n_i^2$$

$$p_n = \frac{n_i^2}{n_n} = \frac{(1.5\times10^{10}/cm^3)^2}{10^{17}/cm^3}$$

$$= 2.25\times10^{3}/cm^3$$

Electron Conc.: $10^{17}/cm^3$

Hole Conc.: $2.25\times10^{3}/cm^3$

**2.3** (a) $\rho = \frac{1}{q\cdot(\mu_n \cdot n + \mu_p \cdot p)}$

$$= \frac{1}{1.6\times10^{-19}(1350\times1.5\times10^{10} + 480\times1.5\times10^{10})}$$

$$= \frac{1}{1.6\times10^{-19}\times2745\times10^{10}}$$

$$= 2.27\times10^{5}\ \Omega\cdot cm$$

(b) $N_D = n_n = 10^{15}/cm^3$

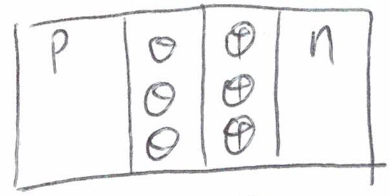
$$p_n = \frac{n_i^2}{n_n} = \frac{(1.5\times10^{10})^2}{(10^{15})^2}$$

$$= 2.25\times10^{5}/cm^3$$

$$\rho = \frac{1}{1.6\times10^{-19}(1000\cdot10^{15} + 400\cdot2.25\times10^{5})}$$

$$= \frac{1}{1.6\times10^{-19}\cdot1000\cdot10^{15}} = 6.25\ \Omega\cdot cm$$

**2.4** (1)



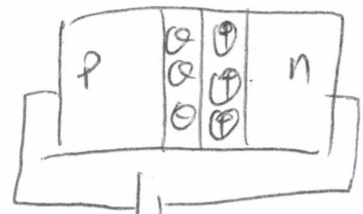

$\rightarrow$ $I_D$: Diffusion current

$\leftarrow$ $I_S$: Saturation current (Drift current)

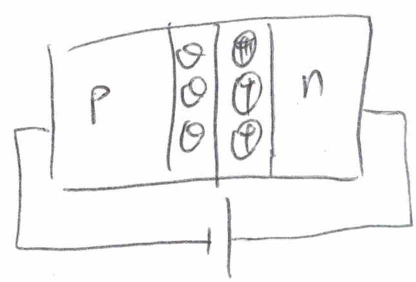
$I_D$: Caused by concentration gradient

$I_S$: Caused by Electric Field.

(2)




Forward Bias, depletion region thinner.



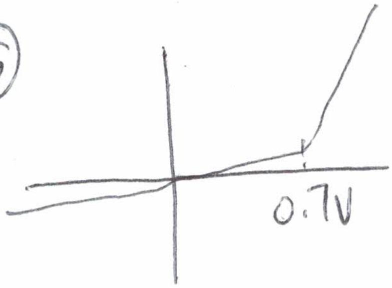

Reverse Bias, depletion region thicker.

(3) Forward Bias: capacitance increases.

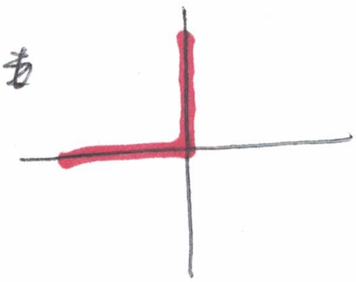
Reverse Bias: Capacitance decreases.

(4) $I_S$ is larger than $I_D$ when a diode is reverse biased.

(5)

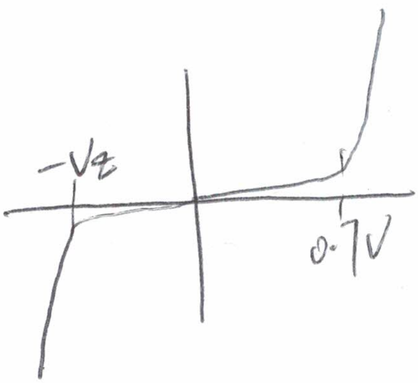



real diode

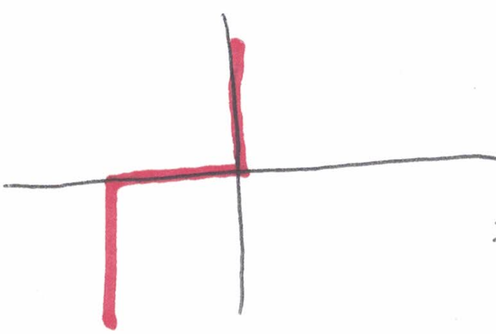


Ideal Diode

(6)




Real zener



Ideal zener

(7) (a) V=-3V

$I = \frac{6V}{10k} = 0.6mA$

(b) V=3V

I=0A

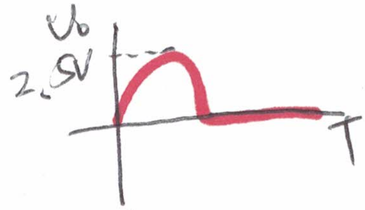
(c) V=3V.

$I = \frac{6V}{10k} = 0.6mA$

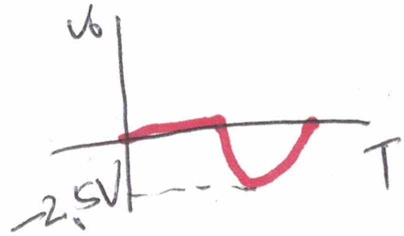
(d) V=-3V

I=0A

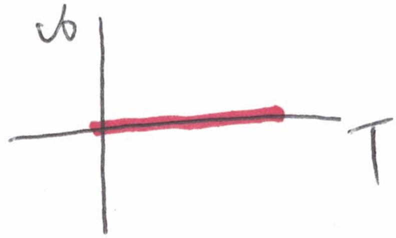
2.6.1(a)



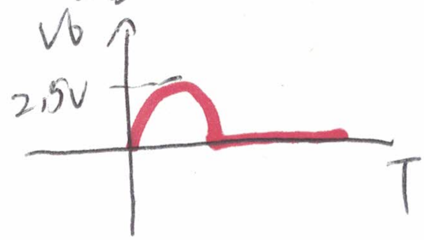

(b)



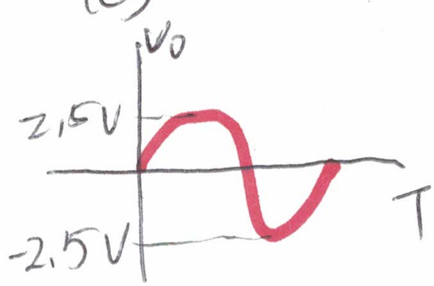

(c)



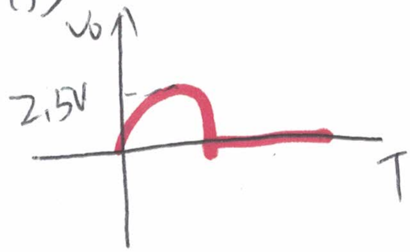

(d)



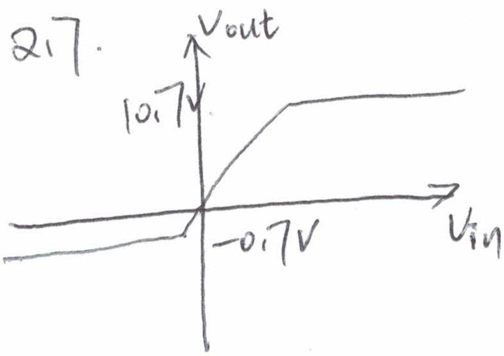

(e)



(f)




2.7.




2.8. $I_C = I_s e^{V_{BE}/V_T}$

$$\begin{cases} 1mA = I_s e^{0.7/25m} \\ 10mA = I_s e^{x/25m} \end{cases}$$

$\frac{1}{10} = e^{(0.7-x)/25m}$

$\ln 0.1 = (0.7-x)/25m$

$x = V_{BE} =$ ~~0.642V~~ $0.76V$

2.9. $\alpha = \frac{\beta}{1+\beta}$

$\beta = 50 \sim 150$

$\alpha = 0.98 \sim 0.99$

2.10. $\beta = \frac{\alpha}{1-\alpha}$

when $\alpha = 0.99$, $\beta = 99$

when $\alpha = 0.98$, $\beta = 49$

$I_{B1} = \frac{10mA}{99} = 0.101 mA$

$I_{B2} = \frac{10mA}{49} = 0.204 mA$

2.11. (a) Assume it is biased in the linear region,

$I_B = \frac{8V - 0.7}{300k} = 24 uA$

$I_C = \beta I_B = 100 \cdot 24 uA = 2400 uA$

$V_{RC} = I_C \cdot R_C = 2.4mA \cdot 1K = 2.4V$

$V_{CE} = V_{CC} - V_{RC} = 8V - 2.4V$
$= 5.6V > V_{BE}$.

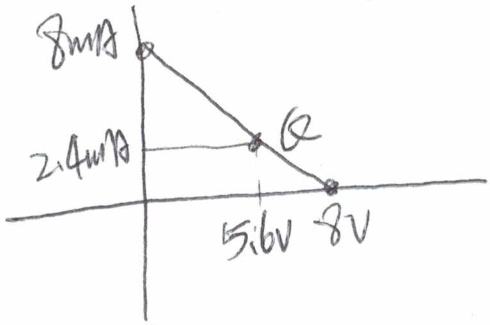
so the BJT is biased in the linear region.

(b). $I_{CQ} = 2.4mA$

$V_{CEQ} = 5.6V$.

(c) $I_{Cmax} = \frac{V_{CC}}{R_C} = \frac{8V}{1K} = 8mA$

$V_{CE(cutoff)} = V_{CC} = 8V$




(a) $I_{cpeak} = 2.4mA$

$$I_{Bpeak} = \frac{I_{cpeak}}{\beta} = \frac{2.4mA}{100}$$

$$= 24\mu A$$

2.12. $$I_{cmax} = \frac{V_{CC} - 1V}{R_L}$$

$$= \frac{14V}{2K} = 7mA$$

$$I_{CQ} = \frac{I_{cmax}}{2} = 3.5mA$$

$$I_{BQ} = \frac{I_{CQ}}{\beta} = \frac{3.5mA}{100} = 35\mu A$$

$$I_{R2} = 10 I_B = 350\mu A$$

$$I_{R1} = 11 I_B = 385\mu A$$

$$R_1 = \frac{V_{CC} - V_B}{I_{R1}} = \frac{15 - 1.7}{385\mu A}$$

$$= 34.5k\Omega$$

$$R_2 = \frac{1.7V}{I_{R2}} = \frac{1.7V}{350\mu A} = 4.86k\Omega$$

$$R_E = \frac{V_{RE}}{I_E} = \frac{1V}{(1+\beta)I_B}$$

$$= \frac{1V}{101 \cdot 35\mu A} = 282.9\Omega$$