Mid Spring 2023-24

1) A) $R \downarrow$, (iv)

$I = neAv_d$

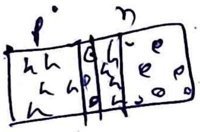
B) $v_d = \mu E = \frac{1000 \times 0.5}{1000} = 0.5\ cm/s$ — (ii)

C) (ii)

13 14 15
B C N O F Ne
Al Si P
Ga Ge As

D) (iii)

• Al



E) $\alpha_{DC} = 0.98$, $I_B = 100\,\mu A$, $I_C = 4.9\,mA$

$I_C = \alpha_{DC} I_E \Rightarrow I_E = \frac{4.9}{0.98}\,mA$

$= 5\,mA$

$\beta_{DC} = \frac{4.9 \times 1000}{100}$

$= 49$

2) ✓

3) (A) $I = neAv_d = neA\mu E$

$I = (n_e eA\mu_e + n_h eA\mu_h)\frac{V}{l}$

$\Rightarrow V = I\left[\frac{l}{(n_e\mu_e + n_h\mu_h)eA}\right]$

$= IR$

$R = \frac{l}{(n_e\mu_e + n_h\mu_h)eA}$

$R = \frac{0.1}{1.5 \times 10^{10} \times 1.6 \times 10^{-19} \times 0.1 \times 0.1 \times 0.1 \times 2000}$

$= \frac{10^9}{1.5 \times 1.6 \times 0.1 \times 0.1 \times 2000}$

$0.0208 \times 10^9\ \Omega$

$\boxed{R = 2.08 \times 10^7\ \Omega}$

$\boxed{\frac{1}{R} = 48 \times 10^{-9}\ \mho}$

B) $n_e n_h = n_i^2$

$\Rightarrow n_h = \dfrac{1.5^2 \times 10^{20}}{8 \times 10^{13}} = 0.28125 \times 10^7$

$R = \dfrac{l}{(n_e \mu_e + n_h \mu_h) e A}$

$= \dfrac{0.1}{(8\times10^{13} \times 1500 + 0.28125\times10^7 \times 500) \times 1.6\times10^{-19} \times 0.1\times0.1}$

$= \dfrac{10^{14}}{(8\times10^6 \times 1500 + 0.28125\times 500) \times 1.6} \ \Omega$

13
7
60

7 − 19 − 2

7 − 21

21
7
14

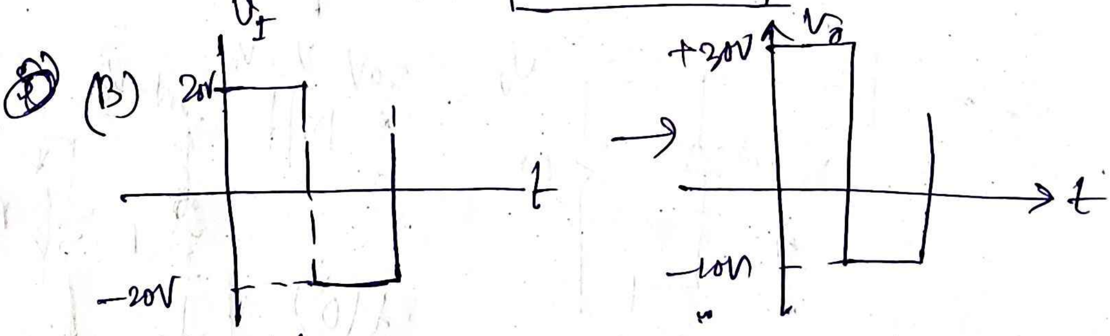
$\Rightarrow \boxed{R = 5.208\ k\Omega}$

$\left(\frac{1}{R} = 1.92\times10^{-4}\ \mho\right)$

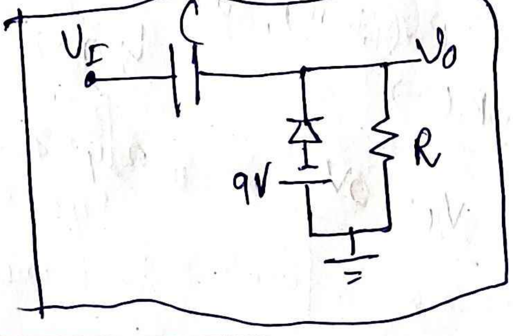
6) (A) $R_i = \dfrac{24-16}{40+400} = \dfrac{8}{440} \times 10^3\ \Omega$

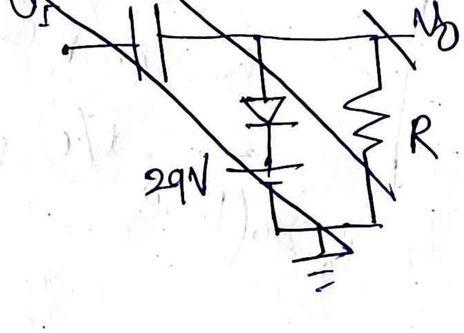
$= \boxed{18.18\ \Omega}$

(B)



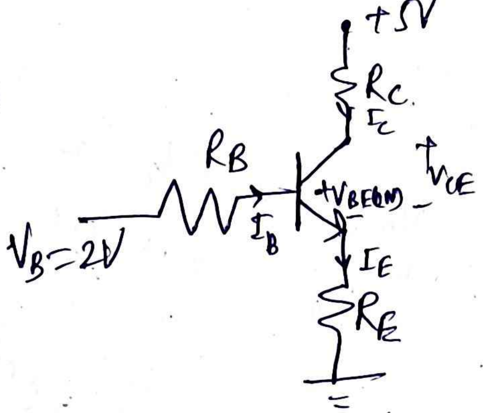
$V_\gamma = 1V$





7)

(i)



$R_B = R_E = 1k\Omega$
$R_C = 2k\Omega$
$\beta = 100$

Let us assume forward active mode,

$2 - I_B R_B - 0.7 - (\beta+1) I_B R_E = 0$

$\Rightarrow I_B = \dfrac{1.3}{1+101\times 1}$ mA

$\Rightarrow \boxed{I_B = 12.75\,\mu A}$, $\boxed{I_C = 1.27\,mA}$

$5 - I_C R_C - V_{CE} - I_E R_E = 0$

$\Rightarrow V_{CE} = 5 - \dfrac{100\times 12.75\times 2}{1000} - \dfrac{101\times 12.75\times 1}{1000}$

$\boxed{V_{CE} = 1.16\,V} > V_{CE(sat)} = 0.2V$

So our assumption is valid

(ii) $\beta = 120$

$I_B = \dfrac{1.3}{1+121\times 1}$ mA $= 10.66\,\mu A$

$V_{CE} = 5 - \dfrac{120\times 10.66\times 2}{1000} - \dfrac{121\times 10.66\times 1}{1000}$

$= 1.15174\,V > V_{CE(sat)}$

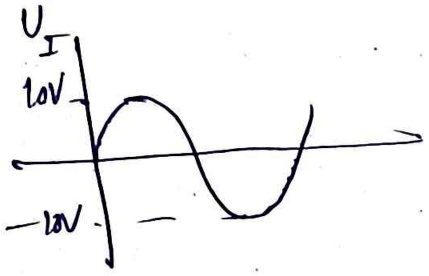
$\dfrac{\Delta I_B}{I_B} = \dfrac{12.75 - 10.66}{12.75}\times 100\% = \boxed{16.4\%}$ decrease

$\dfrac{\Delta I_C}{I_C} = \cancel{\dfrac{\left|1.2745 - \frac{120\times 10.66}{1000}\right|}{1.27}\times 100\%}$

$= \dfrac{1.27869 - 1.2745}{1.2745}\times 100\% = \cancel{0.7\%}$ ~~increase~~ $= \boxed{0.33\%}$ increase

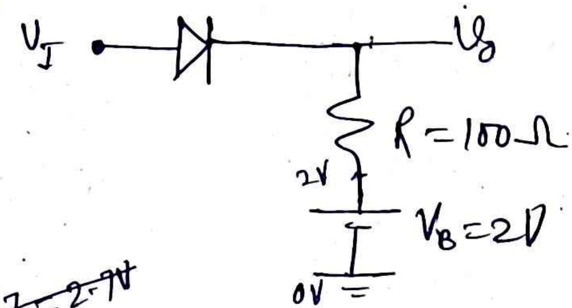
$\dfrac{\Delta V_{CE}}{V_{CE}} = \dfrac{1.16225 - 1.15174}{1.16225}\times 100\% = \boxed{0.9\%}$ decrease

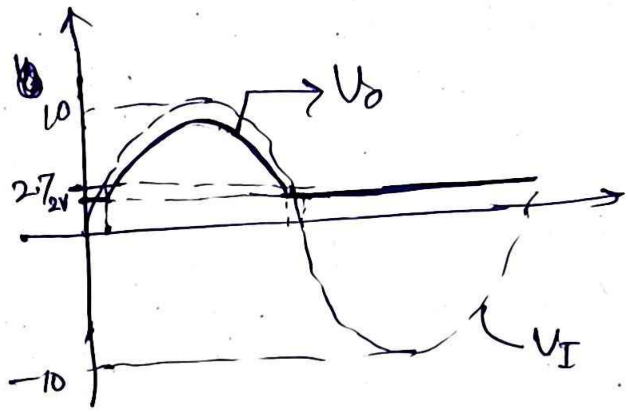
5)



$V_\gamma = 0.7V$

(i)



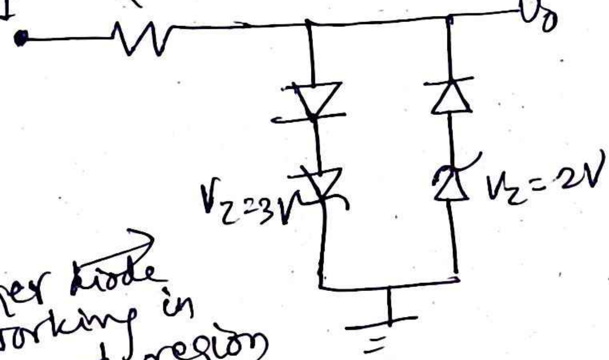


~~2+0.7=2.7V~~

for $V_I < 2.7V$, $V_o = 2V$

for $V_I > 2.7V$, $V_o = V_I - 0.7V$

(ii)

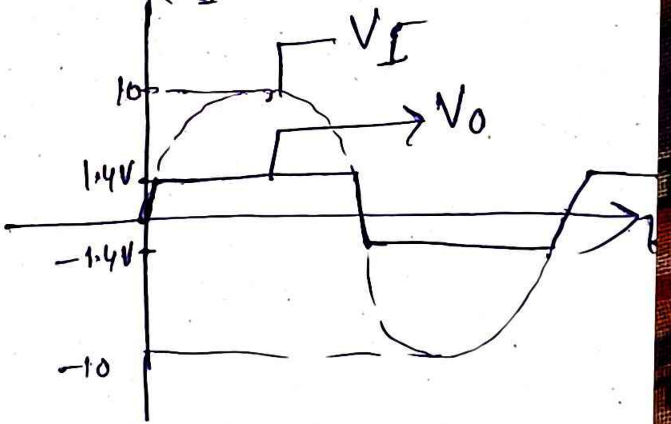


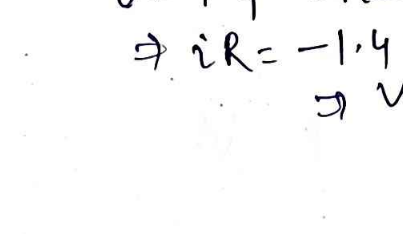
for, $V_I \geq 1.4V$, $V_o = 1.4V$

for $V_I \leq -1.4V$, $V_o = -1.4V$

for $-1.4V \leq V_I \leq 1.4V$, $V_o = V_I$

Zener diode is working in forward region here.





$0 - 1.4 - iR = V_I$

$\Rightarrow iR = -1.4 - V_I \geq 0$

$\Rightarrow V_I \leq -1.4$