Q1 (i) Full wave bridge rectifier.

(ii) Diodes D3 and D1 conduct when B +ve w.r.t. A.

(iii) The capacitor maintains a voltage V_o which is approximately V_p. The worst case condition for $D_3 + D_1$ is when V_{A-B} is at it's +ve peak → $D_2 + D_4$ are then conducting so $V_{anode\,D_4} = V_B + 0.7$ and $V_{cathode\,D_2} = V_A - 0.7$

$$\left.\begin{aligned} \therefore\ V_{D3} &= V_A - 0.7 - V_B. \\ V_{D1} &= V_A - (V_B + 0.7). \end{aligned}\right\} = \text{reverse bias in both cases}$$

$V_A - V_B$ = peak voltage of V_s

$\therefore$ max reverse voltage $\approx V_s\sqrt{2} = \underline{\underline{495\text{V}}}$.

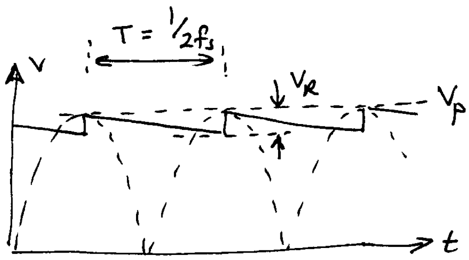
Same argument can be used for diodes 1 + 3 when V_B +ve w.r.t. V_A.

(iv)

(a) $I = C\dfrac{dV}{dt}$

$0.35 = 68 \times 10^{-6} \times \dfrac{\Delta V}{10\text{ms}}$.

or $\Delta V = V_R = 51.5\text{V}$.



$\therefore\ V_o\ dc \approx V_p - V_R/2 = (495 - 26)\text{V} = \underline{\underline{469\text{V}}}$.

(b) $V_R = 51.5\text{V}$.

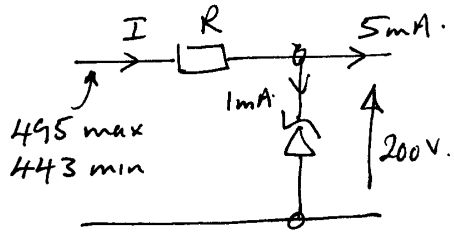
assumes – C discharges for whole charging interval
– 0.7V diode drops are negligible

(v) minimum input voltage $= V_p - V_R = 495 - 52$
$= 443\text{V}$.

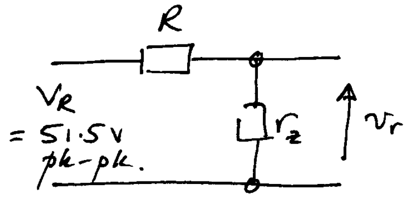
$I = 1\text{mA} + 5\text{mA} = \dfrac{443 - 200}{R}$

$6 \times 10^{-3} = \dfrac{243}{R}$

or $\underline{\underline{R = 40.5\,k\Omega}}$.



(VI) ripple equivalent circuit



$$v_r = V_R \frac{r_z}{R + r_z}$$

$$= 51.5 \times \frac{25}{40.5k\Omega + 25\Omega}$$

$$= 51.5 \times 617 \times 10^{-6} = \underline{\underline{32\,mV}}\ \text{pk-pk}.$$

(VII) Normal conditions for R ....

$$P = \frac{(V_{odc} - 200)^2}{R} = \frac{(469 - 200)^2}{40.5k\Omega} = \underline{\underline{1.8W}}.$$

assumes that Vodc can be used to estimate power in R — not strictly accurate.

[If someone used Vi max to calculate P that would be acceptable.].

Normal conditions for Dz are I_Z = 2mA and V_Z = 200

$$\therefore I_Z = \frac{469-200}{R} - 5mA = 1.64\,mA.$$

$$\therefore P_Z = 200V \times 1.64\,mA = \underline{\underline{330\,mW}}.$$

[again, if someone uses Vimax, ~~that would~~ be acceptable

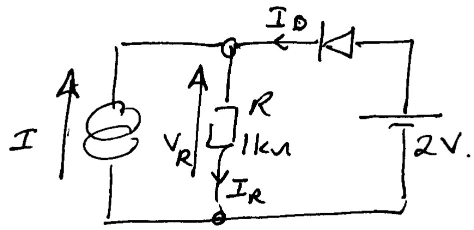
$$I_Z = \frac{495-200}{R} - 5mA = 2.28\,mA.$$

$$\therefore P_Z = 200V \times 2.28\,mA = \underline{\underline{457\,mW}}$$
]

Q2(a)(i) Diode will be on the point of conduction when $V_R = 1{\cdot}3V$ and all of I goes through R.

ie when $I \times 1k\Omega = 1{\cdot}3V$.

or $\underline{I = 1{\cdot}3\,mA}$



(ii) If $I > 1{\cdot}3\,mA$, diode will be non-conducting
if $I < 1{\cdot}3\,mA$, diode will conduct.

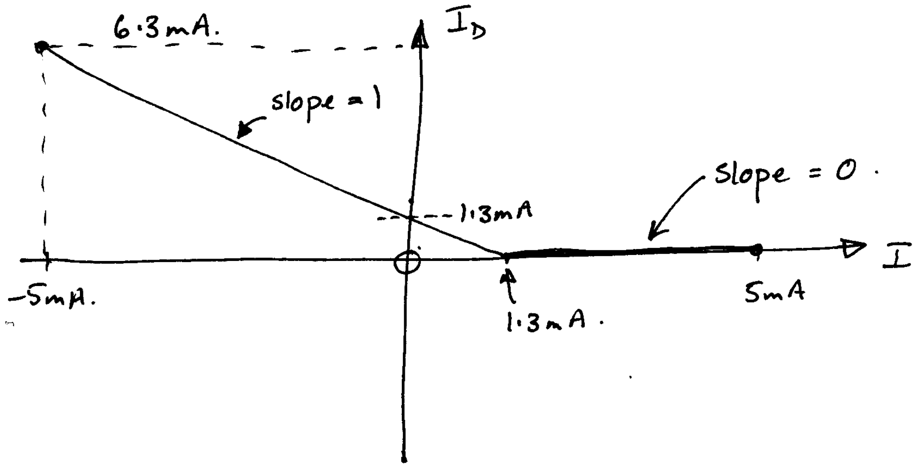
For $I = 5\,mA$, $\underline{I_D = 0}$ $V_D = 2 - 5mA \times 1k\Omega$
$= \underline{-3V}$.

For $I = -5\,mA$, $I_D + (-5mA) = I_R = \frac{1{\cdot}3V}{1k\Omega} = 1{\cdot}3\,mA$.

$I_D = 1{\cdot}3\,mA - (-5mA) = \underline{6{\cdot}3\,mA}$.

and $V_D = \underline{0{\cdot}7V}$.

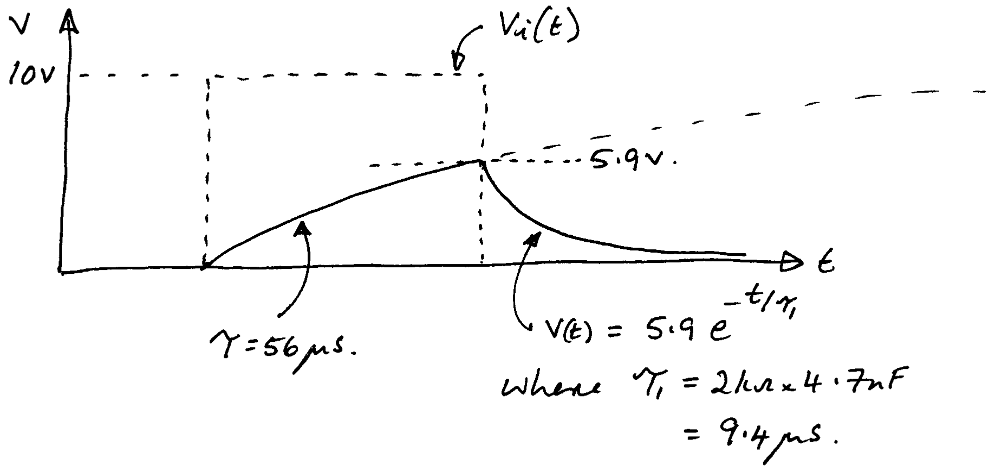
(iii)



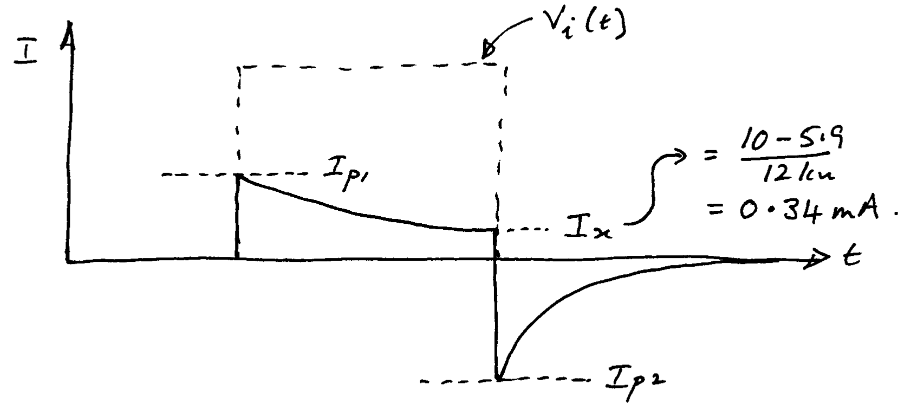
(b) (i) rising edge response is $V(t) = 10\left(1 - e^{-t/\tau}\right)$

where $\tau = 12k\Omega \times 4.7nF = 56\mu s$.

$\therefore V(50\mu s) = 10\left(1 - e^{-50/56}\right) = \underline{\underline{5.9V}}$



(ii)



$I_{p1} = \frac{10V}{12k\Omega} = \underline{\underline{0.83mA}}$. $\quad I_{p2} = -\frac{5.9V}{2k\Omega} = \underline{\underline{-2.95mA}}$.

(iii) With $18k\Omega$ in parallel with C, aiming level becomes $10 \times \frac{18k\Omega}{18k\Omega + 12k\Omega} = 6V$ and $\tau = (18k\Omega // 12k\Omega) \times 4.7nF = 33.8\mu s$.

$V(50\mu s) = 6\left(1 - e^{-50/33.8}\right) = \underline{\underline{4.63V}}$.

Q3 (a) (i) $I_c = I_L = \frac{24\text{V}}{6\,\Omega} = \underline{\underline{4A}}$; $I_s = \underline{\underline{0A}}$.

($V_{CE\,ON}$ ignored).

(ii) in "on" state, $P_D = V_{CE\,ON} \times I_c = 4A \times 0.2V = \underline{\underline{0.8W}}$.

(iii) $I_{C\,ON} = 4A$ so required $I_B = \frac{4A}{h_{FE}} = \frac{4A}{30} = 133\,mA$

$$I_{B\,ON} = \frac{V_2 - V_{BE\,ON}}{R_B} = \frac{10 - 0.7}{R_B} = 133\,mA$$

$$\text{or } R_B = \frac{9.3\text{V}}{0.133\,A} = \underline{\underline{70\,\Omega}}.$$

(iv) immediately after switch off ....

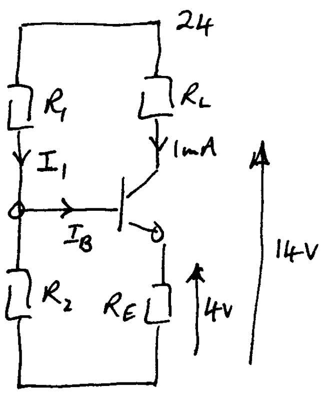
$I_c = 0$ $\quad I_L$ = unchanged

$\therefore$ $\underline{\underline{I_c = 0}}$ $\quad I_L = I_s = \underline{\underline{4A}}$.

(v) immediately after switch off

$$V_{CE} = 24 + I_s R_s + 0.7 = 24 + 48 + 0.7$$
$$= \underline{\underline{72.7\,V}}.$$

(b) (i) Since $h_{FE} \gg 1$, $I_c \approx I_E$



$\therefore R_E = \frac{4\text{V}}{1\,mA} = \underline{\underline{4\,k\Omega}}$.

$R_L = \frac{24-14}{1\,mA} = \underline{\underline{10\,k\Omega}}$.

$I_B = I_c / h_{FE} = \frac{1\,mA}{200} = 5\,\mu A$.

$I_1 = \frac{24}{R_1 + R_2}$ must be at least $10 \times I_B$ in order to justify ignoring I_B — ie $I_1 = 50\,\mu A$.

$\therefore R_1 + R_2 = 24\text{V}/50\,\mu A = 480\,k\Omega$

and $\frac{24 \cdot R_2}{R_1 + R_2} = V_B = V_E + 0.7 = 4.7$

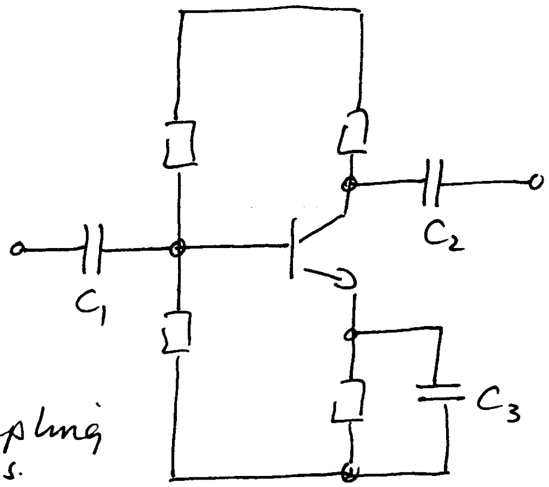
so $24R_2 = 4.7R_1 + 4.7R_2$

or $19.3R_2 = 4.7R_1$

$$\frac{R_1}{R_2} = \frac{19.3}{4.7} = 4.1$$

$$\therefore \quad R_1 + \frac{R_1}{4.1} = 480k\Omega \longrightarrow \underline{\underline{R_1 = 386\,k\Omega.}} \quad \underline{\underline{R_2 = 94\,k\Omega.}}$$

(ii)



$C_1 + C_2$ are coupling capacitors.

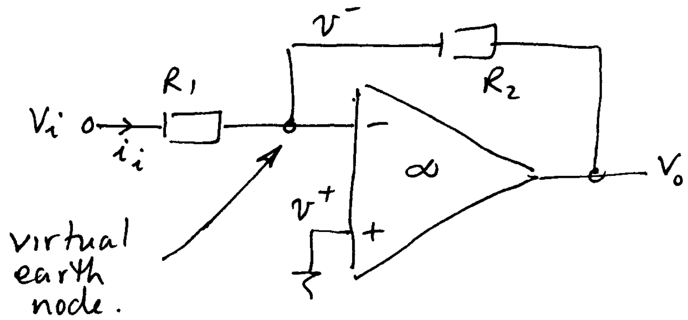
C_3 is a decoupling capacitor.

Q4 (a) (i) "inverting amplifier"

(ii) $\frac{V_o}{V_i} = -\frac{R_2}{R_1}$

suitable values $R_2 = 10k\Omega$ $R_1 = 1k\Omega$.

(iii)



The output voltage of the amplifier is given by..... $V_o = A_v(v^+ - v^-)$.

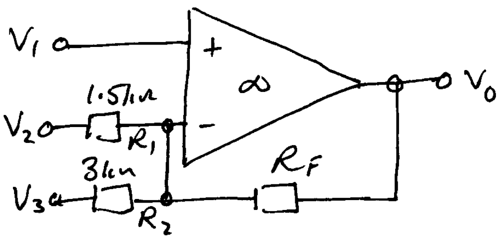
If $A_v \Rightarrow \infty$, $(v^+ - v^-) \approx 0$ for finite V_o and hence $v^+ \approx v^-$. If $v^+ = 0$ then $v^- \approx 0$ also.... ie, v^- = virtual earth.

(iv) The input resistance of the circuit is R_1 (or whatever particular value has been chosen for R_1). Input resistance is defined as $\frac{v_i}{i_i}$ (in diag above)

$$i_i = \frac{v_i - v^-}{R_1} = \frac{v_i - 0}{R_1} = \frac{v_i}{R_1}$$

$$\text{or } \frac{v_i}{i_i} = r_i = R_1$$

(b)



Amplifier requirements ...

(i) Sinusoidal amplitude to be increased from 1.5V to 2.5V

$\therefore$ gain of $\frac{2.5}{1.5} = 1.67$ is needed

(ii) dc component of sinusoid to be changed from 0V at input to 2.5V at output — ie component of 2.5V to be added at output.

Gain first ....

$$\left.\frac{V_0}{V_1}\right|_{a.c} = 1.67 = \frac{R_F + R_1//R_2}{R_1//R_2} = \frac{R_F + 1k\Omega}{1k\Omega}.$$

$$\therefore \underline{\underline{R_F = 0.67k\Omega}}.$$

DC offset ...

amplifier is inverting for V_2 and inverting input is a virtual ground

$$\therefore \left.\frac{V_0}{V_2}\right|_{dc} = -\frac{R_F}{R_1} = -\frac{0.67k\Omega}{1.5k\Omega} = -0.44$$

$$\therefore \frac{2.5}{V_2} = -0.44 \quad \text{or} \quad V_2 = -\frac{2.5}{0.44}$$

$$= \underline{\underline{-5.68V}}$$