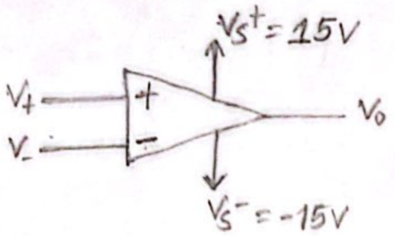
OP-Amp

Q-1



(i) $V_d = V_+ - V_- = (10 \times 10^{-6}) - (5 \times 10^{-6})$

$= 5 \times 10^{-6} V$

$\therefore V_o = AV_d = 2105 \times 5 \times 10^{-6}$

$= 0.012 V$ (Ans)

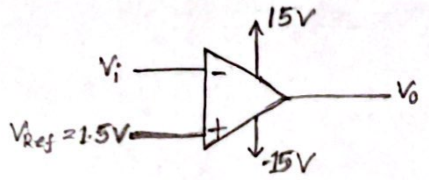
(ii) $V_d = V_+ - V_- = (1 \times 10^{-3}) - (0.2 \times 10^{-3})$

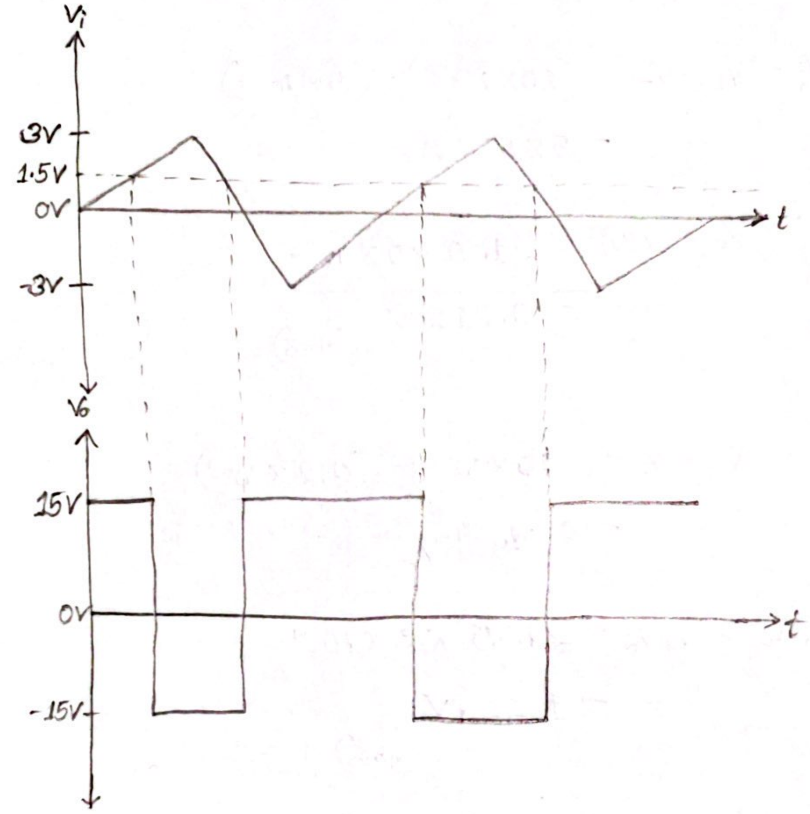
$= 8 \times 10^{-4} V$

$\therefore V_o = AV_d = 2105 \times 8 \times 10^{-4}$

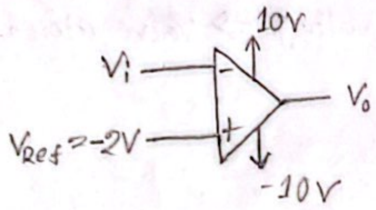
$= 1.684 V$ (Ans)

Q-2





Q-3



Q-5

(i) Here,

$$P = h\rho g$$
$$= 10 \times 1000 \times 9.8$$
$$= 98000 \text{ Pa}$$

In atm,

$$\frac{98000}{101325}$$
$$= 0.967 \text{ atm}$$

Voltage difference,

for 1 atm pressure change ΔV is $\cancel{2.5V}$ $\frac{2.5}{0.5}$ V

$\therefore$ " $(0.967 - 0.5)$ atm " " " " $\frac{2.5 \times (0.967 - 0.5)}{0.5}$

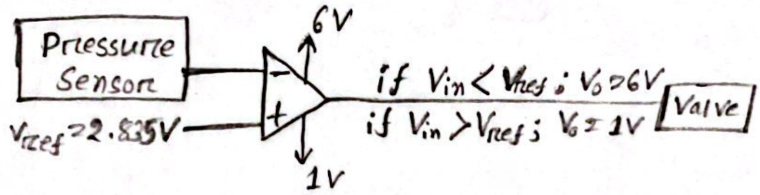
$$= 2.335 \text{ V}$$

$\therefore$ Voltage at 0.967 atm $= (2.335 + 0.5)$ V

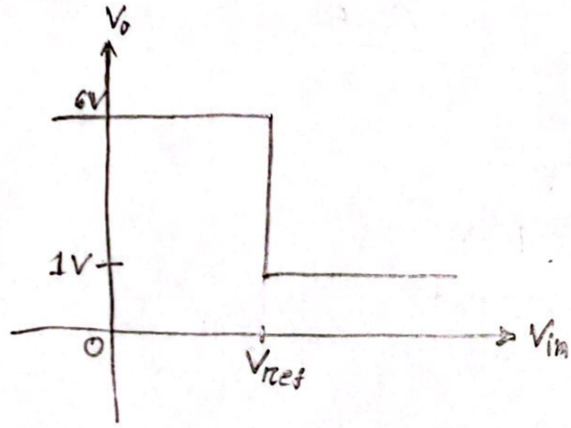
$$= 2.835 \text{ V}$$

High pressure ⇒ High input voltage ⇒ Valve open, $V_o^- = 1V$

Low pressure ⇒ Low input voltage ⇒ Valve closed, $V_o^+ = 6V$



(ii)



Q-6

(i) We know,

$$V_o = AV_d$$

$$\Rightarrow V_d = \frac{V_o}{A}$$

$$\Rightarrow V_d = \frac{V_o}{\infty}$$

$$\Rightarrow V_+ - V_- = 0$$

$$\therefore V_+ = V_-$$

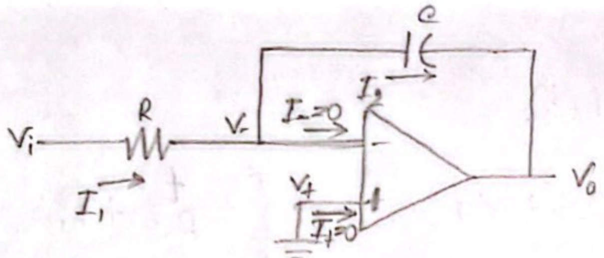
As, $V_+ = 0V$ (Grounded)

$$\therefore V_- = 0V$$

This is called virtual ground

(Ans)

(ii)



Here,

$$I_+ = I_- = 0$$

$$\therefore I_1 = I_2$$

$$\Rightarrow \frac{V_i - V_+}{R} = C\frac{d(V_- - V_0)}{dt}$$

$$\Rightarrow \frac{V_i}{R} = -C\frac{dV_0}{dt} \quad [\because V_- = 0V]$$

(Ans)

(iii) That's an integrator circuit.

$$\therefore I_+ = I_- = 0$$

$$\therefore I_1 = I_2$$

$$\Rightarrow \frac{V_i - V_+}{R} = \frac{C \cdot d(V_- - V_0)}{dt}$$

$$\Rightarrow \frac{V_i}{R} = -C\frac{dV_0}{dt} \quad [\because V_- = 0V]$$

$$\Rightarrow \frac{d}{dt}V_0 = -\frac{V_i}{RC}$$

$$\Rightarrow V_0 = -\int \frac{V_i}{RC}\,dt$$

$$\therefore V_0 = -\frac{1}{RC}\int V_i\,dt$$

(Ans)

From Fig. 1(b),

$$V_i = \begin{cases} 1, & 0 \leq t < 1 \\ -1, & 1 \leq t < 2 \\ 1, & 2 \leq t < 3 \\ -1, & 3 \leq t < 4 \end{cases} \qquad V_o = \begin{cases} -\frac{t}{RC} + k_1 \\ \frac{t}{RC} + k_2 \\ -\frac{t}{RC} + k_3 \\ \frac{t}{RC} + k_4 \end{cases}$$; [k's are constant]

(iv) Here,

$R = 10k\Omega$

$C = 0.1\mu F$

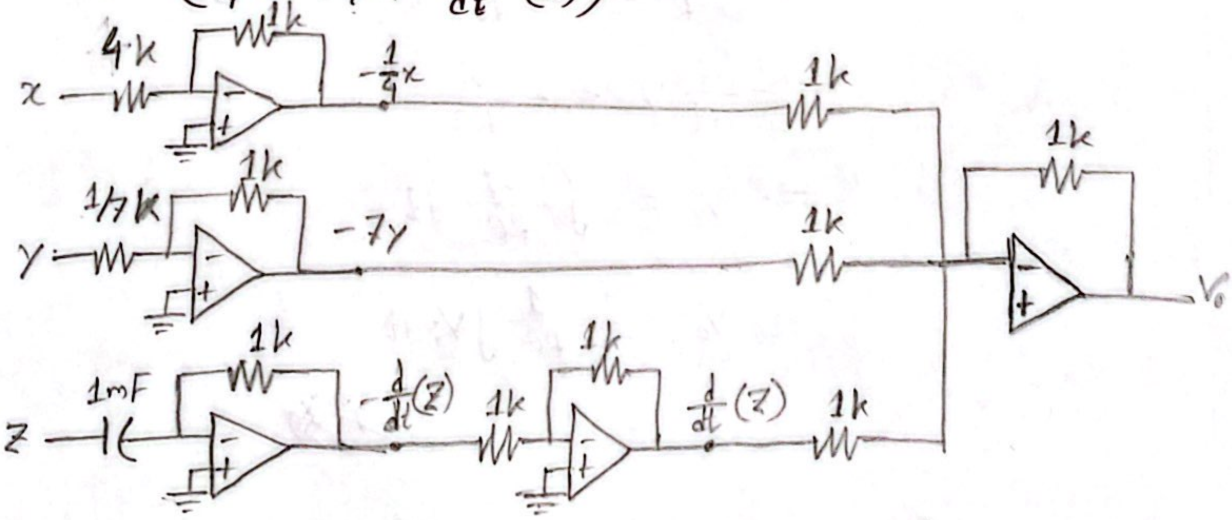
$t = 1ms$

$$\therefore V_o = \frac{-1\times10^{-3}}{10\times10^3\times0.1\times10^{-6}} + k_1$$

$$= -1 + k_1$$ (Ans)

(v) $f = \frac{1}{4}x + 7y - \frac{d}{dt}(z)$

$= -\left(-\frac{1}{4}x - 7y + \frac{d}{dt}(z)\right)$



$\therefore V_o = -(-\frac{1}{4}x) - (-7y) - \frac{d}{dt}z$

$= \frac{1}{4}x + 7y - \frac{d}{dt}z$ (Ans)

Q-7

ⓐ We know,

$$V_o = AV_d$$

$$\Rightarrow V_d = \frac{V_o}{A}$$

$$\Rightarrow V_d = \frac{V_o}{\infty}$$

$$\Rightarrow V_+ - V_- = 0$$

$$\therefore V_+ = V_-$$

As, $V_+ = 0V$

$$\therefore V_- = 0V$$

(Ans)

ⓑ Here, $I_+ = I_- = 0$

$$\therefore i_2 = i_D$$

From the circuit,

$$i_2 = -\frac{V_o}{R}$$

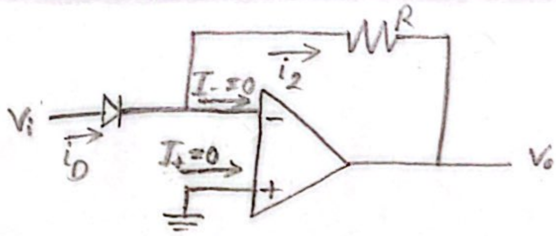
$$i_D = I_s e^{\frac{V_o}{V_T}}$$

$$\therefore -\frac{V_o}{R} = I_s e^{\frac{V_o}{V_T}}$$

This indicates that the current through the resistor R is the same as the current through the diode, which follows an exponential relationship with the output voltage V_o.

(Ans)

(c)



$$i_D = i_2$$

$$\Rightarrow I_S e^{\frac{V_i}{V_T}} = \frac{0 - V_o}{R}$$

$$\therefore V_o = -I_S R e^{\frac{V_i}{V_T}}$$

(Ans)

(d) Expression is not given.

Q-8

ⓐ $V_{I_1} = -RC \cdot \frac{d}{dt} V_i$

$= -(1\times10^6 \times 1\times10^{-6}) \cdot \frac{d}{dt} y$

$= -\frac{d}{dt} y$

$V_{I_2} = -\frac{R_2}{R_1} V_i$

$= -\frac{5}{5}\left(-\frac{d}{dt} y\right)$

$= \frac{d}{dt} y$

$V_{I_3} = -\frac{1}{RC} \int V_i \, dt$

$= -\frac{1}{1\times10^6 \times 1\times10^{-6}} \int x \, dt$

$= -\int x \, dt$

$\therefore f = -5\left(\frac{-\int x\,dt}{5} + \frac{\frac{d}{dt} y}{5}\right)$

$= \int x\,dt - \frac{d}{dt}(y)$

(Ans)

ⓑ We know,

$$V_o = -\frac{R_2}{R_1} V_i$$

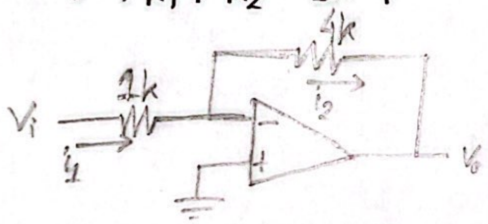
Here,

$$\text{Gain}, k = -\frac{R_2}{R_1}$$

$$\therefore -\frac{R_2}{R_1} = -4$$

$$\Rightarrow \frac{R_1}{R_2} = \frac{1}{4}$$

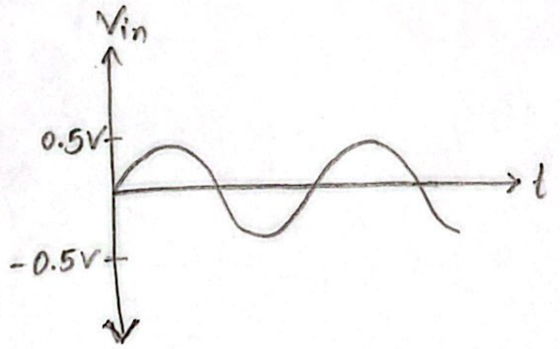
$$\therefore R_1 : R_2 = 1:4$$

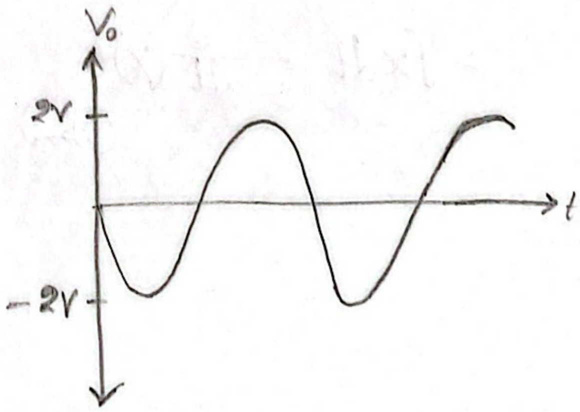


ⓒ Output Amplitute = |gain| × input amplitude

$= |-4| \times 0.5$

$= 2\text{ V}$ ~~(peek to peek)~~





(d) Here,

$i_1 = 0.5\mu A$

$V_{in} = 0.5V$

Now,

$$i_1 = \frac{V_{in} - 0}{R_1}$$

$$\Rightarrow R_1 = \frac{0.5V}{0.5\mu A} = \frac{0.5}{0.5 \times 10^{-6}}$$

$$\therefore R_1 = 1 \times 10^6 \Omega$$
$$= 1M\Omega$$

$\therefore$ We need to set, $R_1 = 1M\Omega$ instead of $1k\Omega$

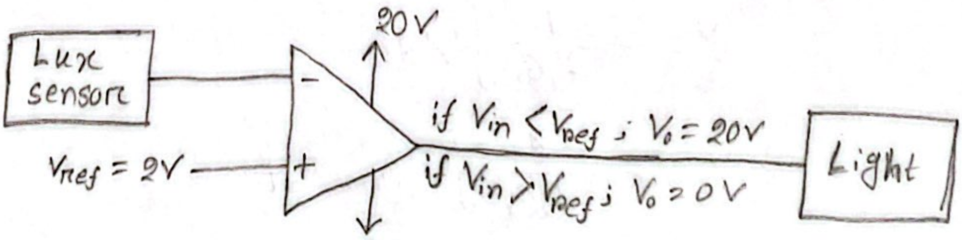
$R_2 = 4M\Omega$ " " $4k\Omega$

(Ans)

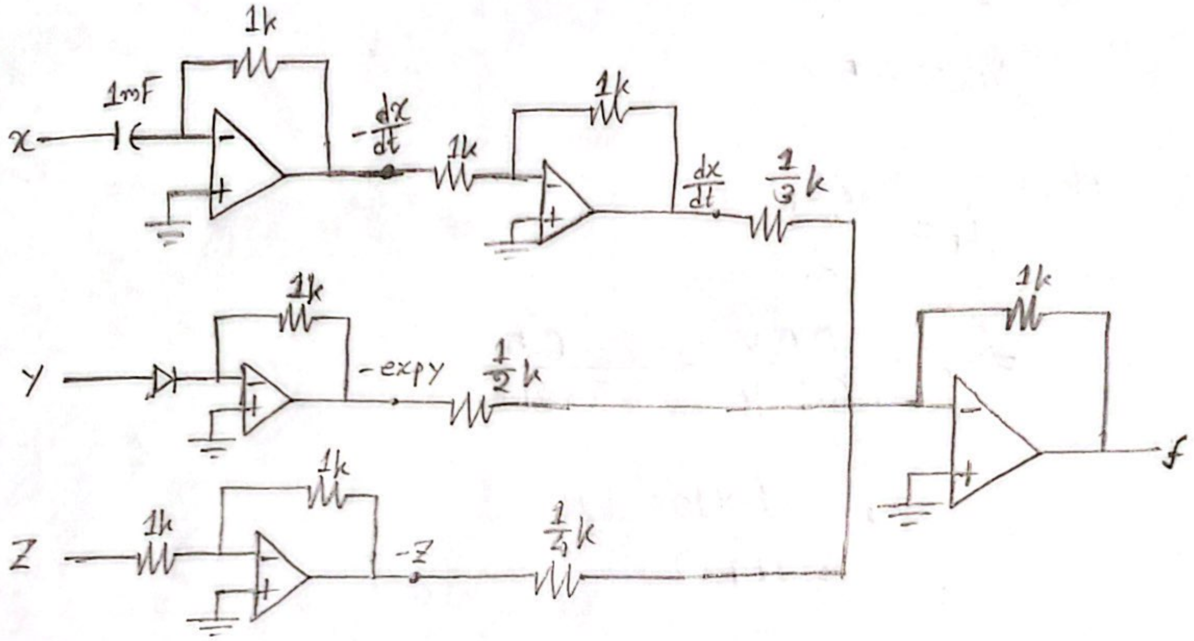
Q-9

(a) High brightness $\Rightarrow$ High input voltage $\Rightarrow$ Light OFF, $V_S^- = 0V$

Low brightness $\Rightarrow$ Low input voltage $\Rightarrow$ Light ON, $V_S^+ = 20V$



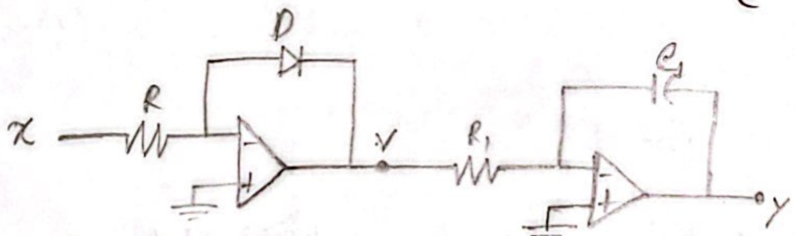
(b) $f = -3\frac{dx}{dt} + 2\exp y + 4Z$



$$\therefore f = -3\frac{dx}{dt} + 2\exp y + 4Z$$

(Ans)

(c)



$$V = -\ln x$$

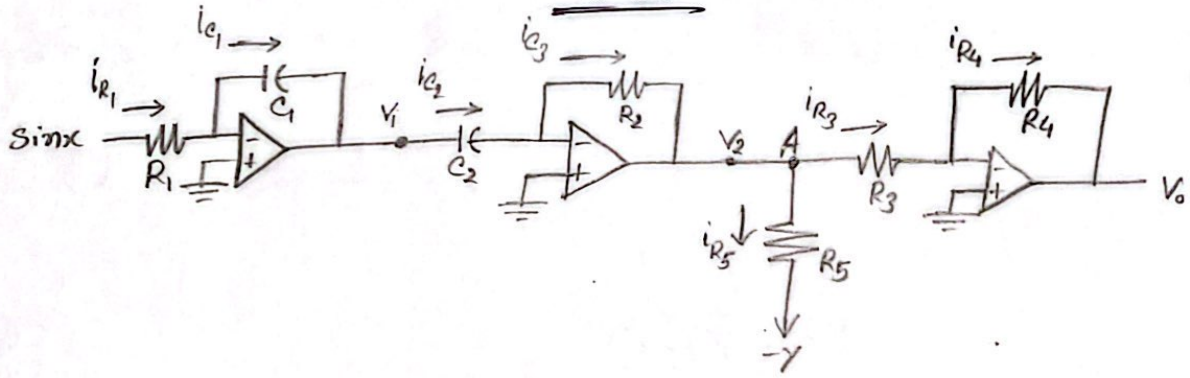
$$Y = -\frac{1}{R_1C_1}\int V\,dt$$

$$\Rightarrow Y = -\frac{1}{R_1C_1}\int -\ln x\,dt$$

$$\therefore Y = \frac{1}{R_1C_1}\int \ln x\,dt$$

(Ans)

Q-10



Here,

$$V_1 = -\frac{1}{R_1C_1}\int \sin x \, dt$$

$$V_2 = -\cancel{\frac{R_2C_2}{R_2C_2}} \cdot \frac{d}{dt}\left(-\frac{1}{R_1C_1}\int \sin x \, dt\right)$$

$$= \sin x$$

Applying KCL at node A,

$$-i_{C_3} + i_{R_3} + i_{R_5} = 0$$

$$\Rightarrow -\frac{0-\sin x}{R_2} + i_{R_4} + \frac{\sin x + Y}{R_5} = 0 \quad [\because i_{R_3} = i_{R_4}]$$

$$\Rightarrow \frac{\sin x}{R_2} + \frac{0 - V_o}{R_4} + \frac{\sin x + Y}{R_5} = 0$$

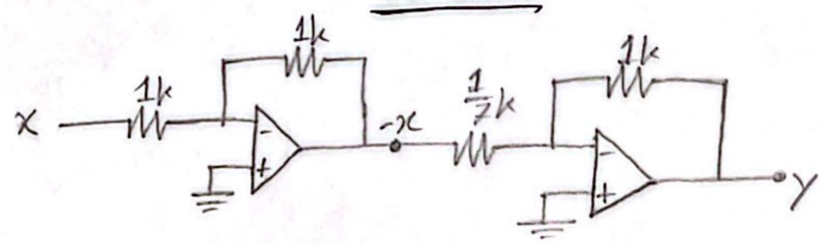
$$\Rightarrow \frac{V_o}{R_4} = \frac{\sin x}{R_2} + \frac{\sin x + Y}{R_5}$$

$$\therefore V_o = \frac{R_4}{R_2}\sin x + \frac{R_4}{R_5}(\sin x + Y)$$

(Ans)

Q-11

ⓐ

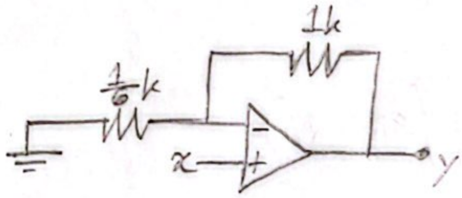


$$Y = -7(-x)$$

$$\Rightarrow Y = 7x$$

(Ans)

ⓑ



$$Y = \left(1 + \frac{1}{1/6}\right)x$$

$$\Rightarrow Y = (1+6)x$$

$$\therefore Y = 7x$$

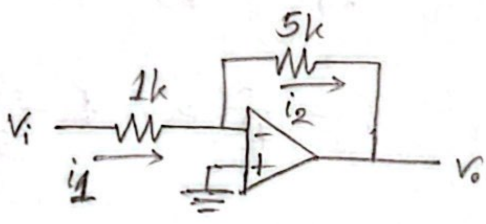
(Ans)

Q-12

ⓐ We know,

$$V_o = -\frac{R_2}{R_1} V_i$$

Here,



$$\text{Gain}_x = -\frac{R_2}{R_1}$$

$$\therefore -\frac{R_2}{R_1} = -5$$

$$\Rightarrow \frac{R_1}{R_2} = \frac{1}{5}$$

$$\therefore R_1 : R_2 = 1:5$$

(b) Here,

$i_{1max} = 5\mu A$

$V_{imax} = 0.1V$

Now,

$$i_1 = \frac{V_i - 0}{R_1}$$

$$\Rightarrow R_1 = \frac{0.1V}{5\mu A} = \frac{0.1}{5 \times 10^{-6}}$$

$$\therefore R_1 = 20 \times 10^3 \Omega$$

$$= 20k\Omega$$

Gain,

$$-\frac{R_2}{R_1} = -5$$

$$\Rightarrow \frac{R_2}{20} = 5$$

$$\therefore R_2 = 100k\Omega$$

$\therefore$ We need to set, $R_1 = 20k\Omega$ instead of $1k\Omega$

$R_2 = 100k\Omega$ " " $5k\Omega$

(Ans)

(c) Here,

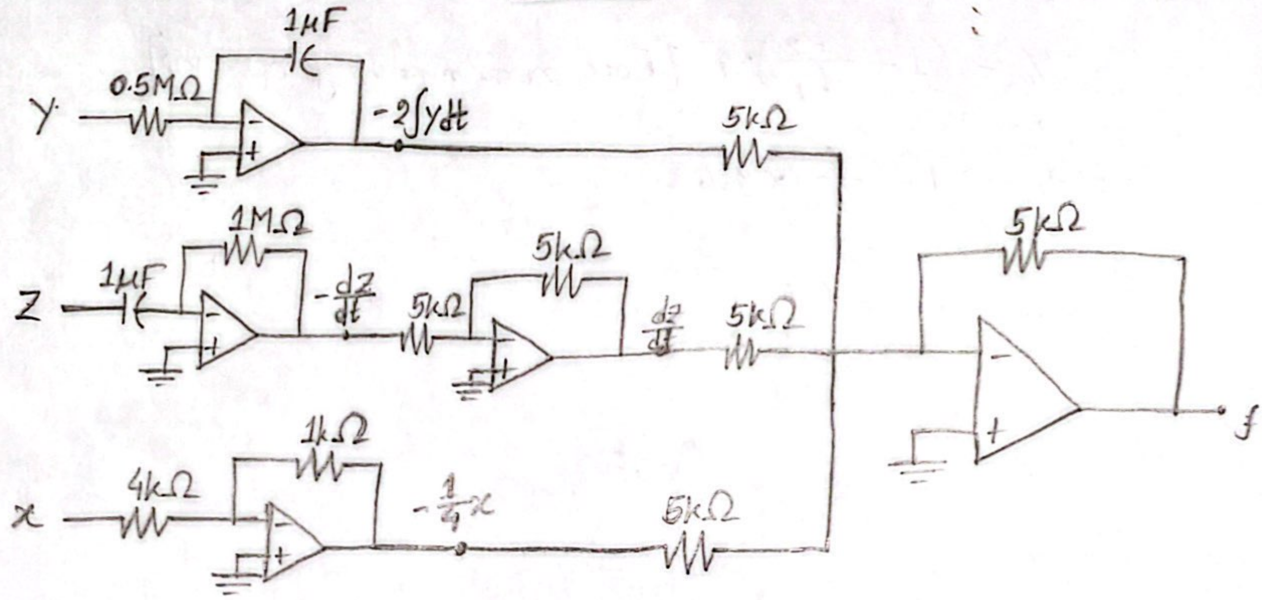
$V_1 = 1V$

$V_2 = 2V$

$V_3 = 1.5V$

$R_F = R_{in}$

Q-13

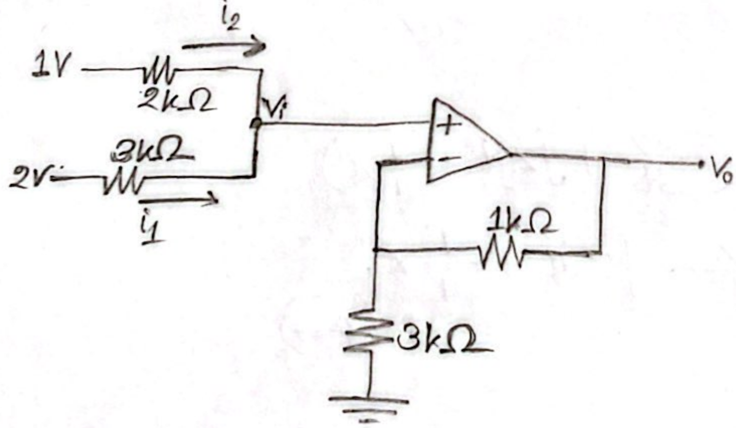


$$f = -\left(-2\int y\,dt + \frac{dz}{dt} - \frac{1}{4}x\right)$$

$$= 2\int y\,dt - \frac{dz}{dt} + \frac{1}{4}x$$

(Ans)

Q-14



Applying KCL at node V_i,

$$i_1 + i_2 = 0$$

$$\Rightarrow \frac{2-V_i}{3} + \frac{1-V_i}{2} = 0$$

$$\Rightarrow \frac{4-2V_i+3-3V_i}{6} = 0$$

$$\Rightarrow 5V_i = 7$$

$$\therefore V_i = 1.4\text{V}$$

We know,

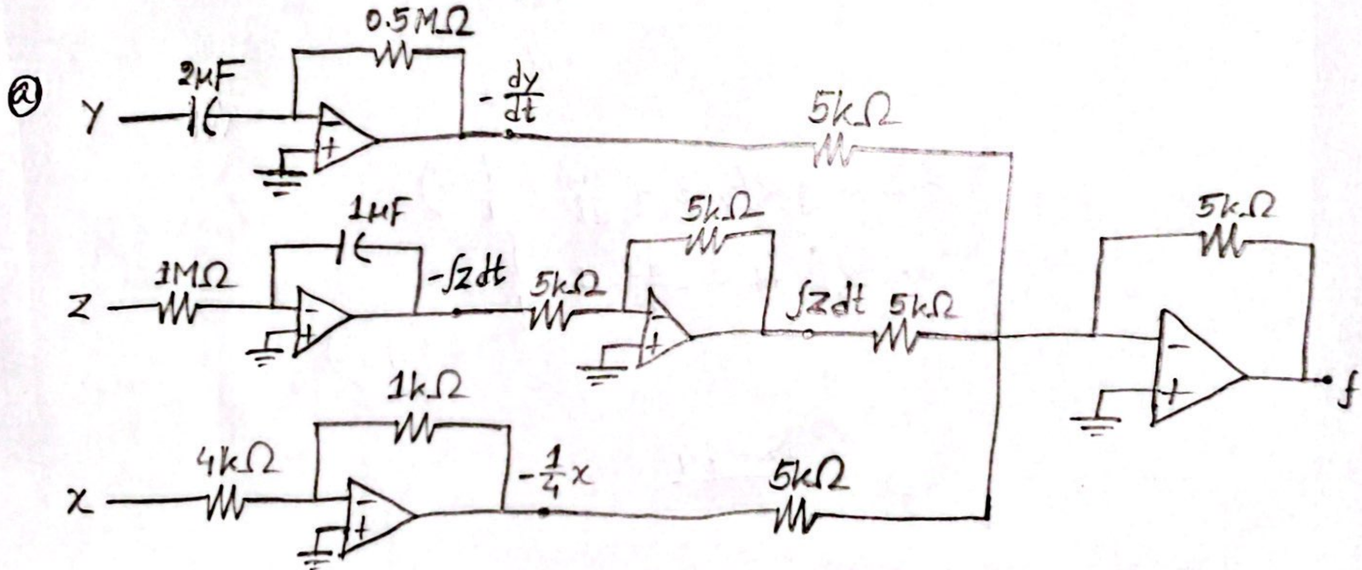
$$V_o = \left(1+\frac{R_2}{R_1}\right)V_i \quad \text{[For non-inverting op-amp]}$$

$$\Rightarrow V_o = \left(1+\frac{1}{3}\right)\times 1.4$$

$$\therefore V_o = 1.867V$$ (Ans)

Q-15

ⓐ

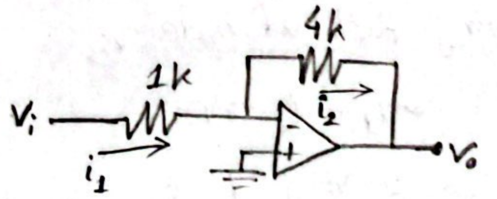


$$f = -\left(-\frac{dy}{dt} + \int z dt - \frac{1}{4}x\right)$$

$$= \frac{dy}{dt} - \int z dt + \frac{1}{4}x.$$ (Ans)

ⓑ We know,

$$V_o = -\frac{R_2}{R_1}\cdot V_i$$



Here, $\text{Gain} = -\frac{R_2}{R_1} = -4$

$$\Rightarrow \frac{R_1}{R_2} = \frac{1}{4}$$

$$\therefore R_1 : R_2 = 1:4$$

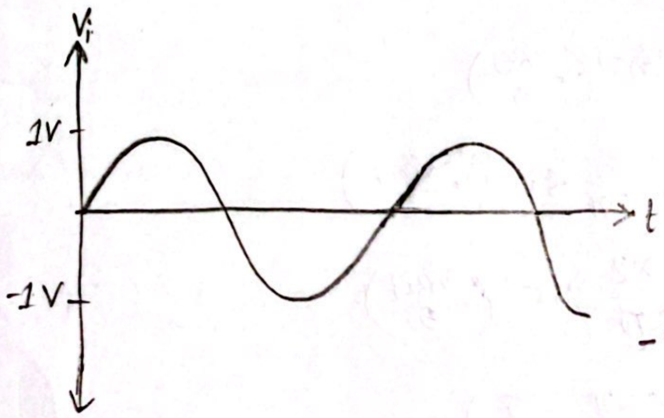
(c) Assume that,

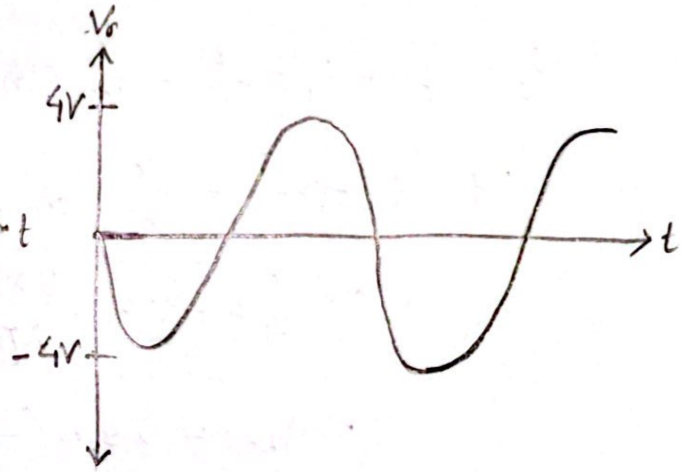
$$V_i = \sin t$$

Output amplitude $= |\text{gain}| \times$ input amplitude

$$= |-4| \times 1$$

$$= 4V$$





(d) Here,

$$i_{1max} = 4\mu A$$

$$V_{imax} = 0.1V$$

Now, $i_1 = \dfrac{V_i - 0}{R_1}$

$$\Rightarrow R_1 = \frac{0.1V}{4\mu A} = \frac{0.1}{4 \times 10^{-6}}$$

$$\therefore R_1 = 25 \times 10^3 \, \Omega$$

$$= \cancel{25k\Omega}\ 25k\Omega$$

Gain,

$$-\frac{R_2}{R_1} = -4$$

$$\Rightarrow \frac{R_2}{20} = 4$$

$$\therefore R_2 = 100k\Omega$$

$\therefore$ We need to set,

$R_1 = 25k\Omega$ instead of $1k\Omega$

$R_2 = 100k\Omega$ " " $4k\Omega$

(Ans)

Q-16

(i) $t_1 = \frac{T}{4} = \frac{5}{4} = 1.25\,ms$

$t_2 = \frac{3T}{4} = \frac{3\times5}{4} = 3.75\,ms$

(ii) $t_1 = \frac{5}{2\pi}\sin^{-1}\left(\frac{V_{Ref}}{5}\right)$

$t_2 = \frac{T}{2} - t_1 = \frac{5}{2} - \frac{5}{2\pi}\sin^{-1}\left(\frac{V_{Ref}}{5}\right)$

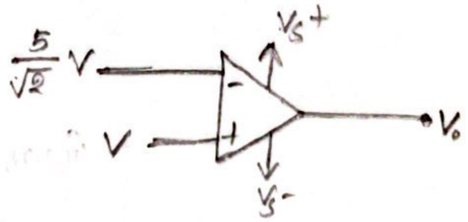
$\therefore t_2 - t_1 \Rightarrow \frac{T}{4} = \frac{5}{2} - 2\cdot\frac{5}{2\pi}\sin^{-1}\left(\frac{V_{Ref}}{5}\right)$

$\Rightarrow \frac{5}{4} = \frac{5}{2} - \frac{5\times2}{2\pi}\sin^{-1}\left(\frac{V_{Ref}}{5}\right)$

$\Rightarrow V_{Ref} = 5\sin\left(\frac{2\pi}{5}\cdot\frac{5}{8}\right)$

$\therefore V_{Ref} = \frac{5}{\sqrt{2}}\,V$

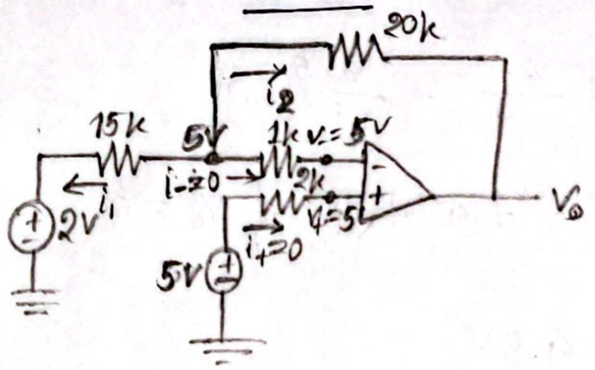
$\therefore$



(Ans)

Miscellaneous

Q-17



Here,

$$i_1 + i_2 = 0$$

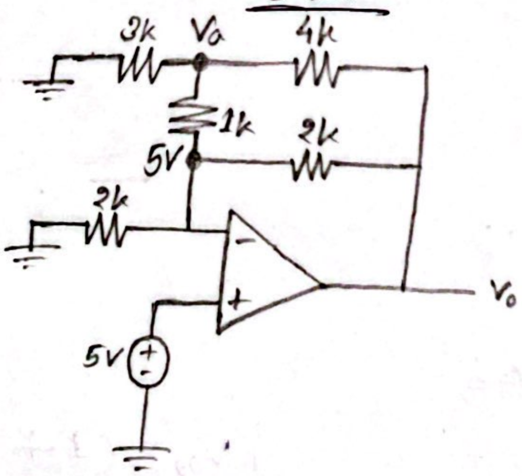
$$\Rightarrow \frac{5-2}{15} + \frac{5-V_0}{20} = 0$$

$$\Rightarrow \frac{5-V_0}{20} = -\frac{1}{5}$$

$$\Rightarrow 5 - V_0 = -4$$

$$\therefore V_0 = 9V \quad \text{(Ans)}$$

Q-18



KCL at V_-,

$$\frac{5-0}{2} + \frac{5-V_0}{2} + \frac{5-V_a}{1} = 0$$

$$\Rightarrow V_a + \frac{1}{2}V_0 = 10 \quad \ldots\ldots (i)$$

KCL at V_a,

$$\frac{V_a - 0}{3} + \frac{V_a - V_o}{4} + \frac{V_a - 5}{1} = 0$$

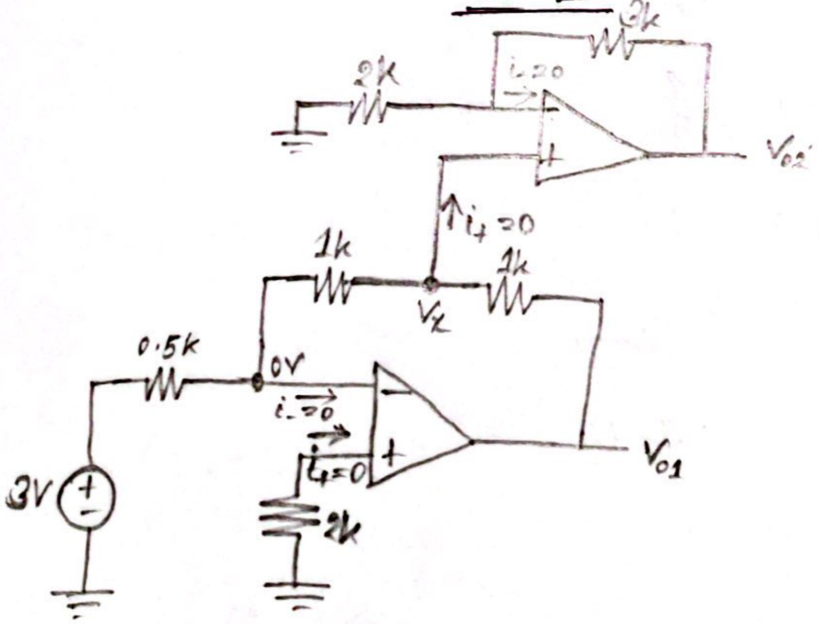
$$\Rightarrow V_a(3^{-1} + 4^{-1} + 1) - \frac{1}{4}V_o = 0$$

$$\therefore V_a = 4.8V$$

$$V_o = 10.4V$$

(Ans)

Q-19



$$V_{o1} = \left(-\frac{1+1}{0.5}\right) \cdot 3$$

$$= -12V$$ (Ans)

KCL at V_x,

$$\frac{V_x - 0}{1} + \frac{V_x + 12}{1} = 0$$

$$\Rightarrow 2V_x = -12$$

$$\therefore V_x = -6V$$

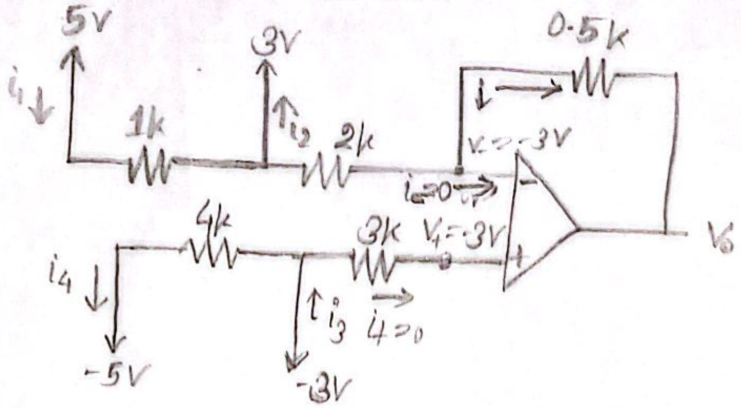
(Ans)

$$V_{o2} = \left(1 + \frac{3}{2}\right)(-6)$$

$$= -15V$$

(Ans)

Q-#20



$i_1 = \frac{5-3}{1}$

$= 2mA$

$i_2 = \cancel{\frac{-3-3}{2}}$ $\quad i_1 - i = 2 - \frac{-3+4.5}{0.5}$

$= \cancel{-3mA}$ $\quad = -1mA$

$i_3 = i_4 = \frac{-3+5}{4}$

$= 0.5mA$

(Ans)

$\cancel{i = -i_2}$

$\cancel{= 3mA}$

Now,

$\cancel{\frac{-3-V_o}{0.5} = 3}$

$\cancel{\Rightarrow -3 - V_o = 1.5}$

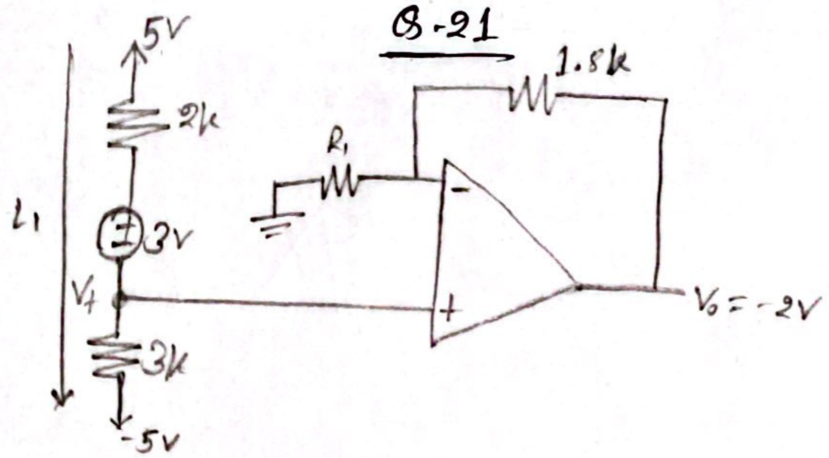
$\cancel{\therefore V_o = -4.5\,V}$ (Ans)

KCL at V_-,

$\frac{-3-V_o}{0.5} + \frac{-3-3}{2} = 0$

$\Rightarrow V_o = -4.5\,V$ (Ans)

Q-21



KVL on L_1,

$$5+5 = 2I + 3 + 3I$$

$$\Rightarrow 5I = 7$$

$$\therefore I = \frac{7}{5} mA$$

Now,

$$\frac{V_+ + 5}{3} = \frac{7}{5}$$

$$\Rightarrow V_+ = \frac{7 \times 3}{5} - 5$$

$$\therefore V_+ = -0.8V$$

We know,

$$V_0 = \left(1 + \frac{R_2}{R_1}\right) V_{in}$$

$$\Rightarrow -2 = \left(1 + \frac{1.8}{R_1}\right) \times (-0.8)$$

$$\Rightarrow \frac{1.8}{R_1} = \frac{-2}{-0.8} - 1$$

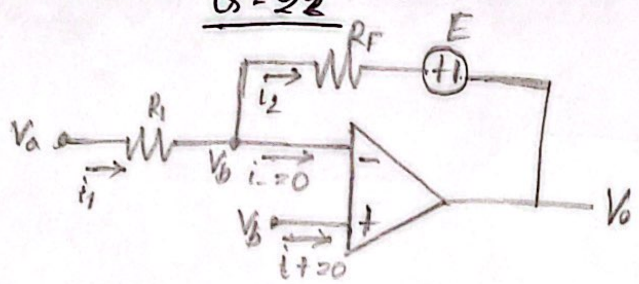
$$\Rightarrow \frac{1.8}{R_1} = \frac{3}{2}$$

$$\Rightarrow R_1 = \frac{2 \times 1.8}{3}$$

$$\therefore R_1 = 1.2 k\Omega$$

(Ans)

Q-22



$$i_1 = \frac{V_a - V_b}{R_1}$$

$$i_2 = \frac{V_b - E - V_0}{R_F}$$

$$= \frac{V_b - (E + V_0)}{R_F}$$

Now,

$$i_1 = i_2$$

$$\Rightarrow \frac{V_a - V_b}{R_1} = \frac{V_b - E - V_0}{R_F}$$

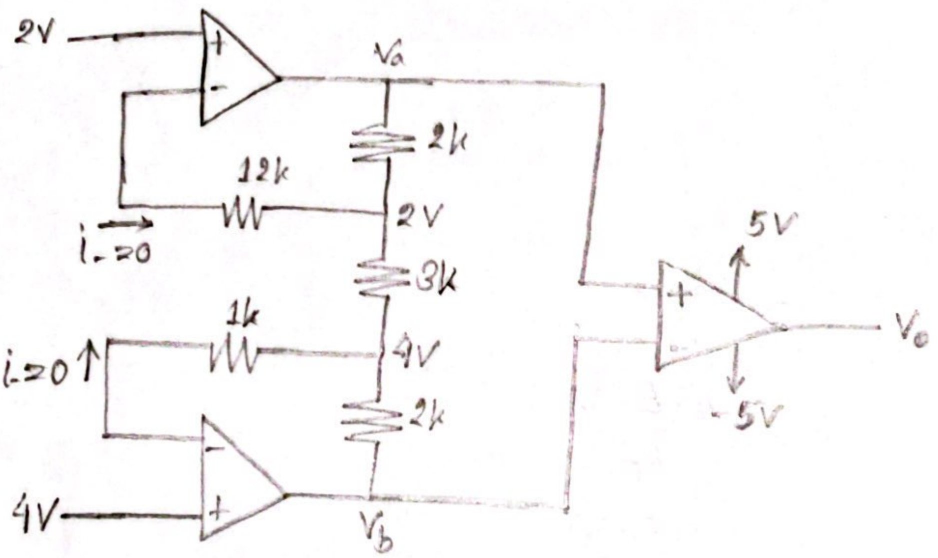
$$\Rightarrow (V_a - V_b) R_F = (V_b - E) R_1 - V_0 R_1$$

$$\Rightarrow V_0 R_1 = (V_b - E) R_1 - (V_a - V_b) R_F$$

$$\therefore V_0 = V_b - E - \frac{R_F}{R_1}(V_a - V_b)$$

(Ans)

Q-23



KCL at 2V node,

$$\frac{2-V_a}{2} + \frac{2-4}{3} = 0$$

$$\Rightarrow \frac{2-V_a}{2} = \frac{2}{3}$$

$$\therefore V_a = 0.67V$$

KCL at 4V node,

$$\frac{4-2}{3} + \frac{4-V_b}{2} = 0$$

$$\Rightarrow \frac{4-V_b}{2} = -\frac{2}{3}$$

$$\therefore V_b = 5.33V$$

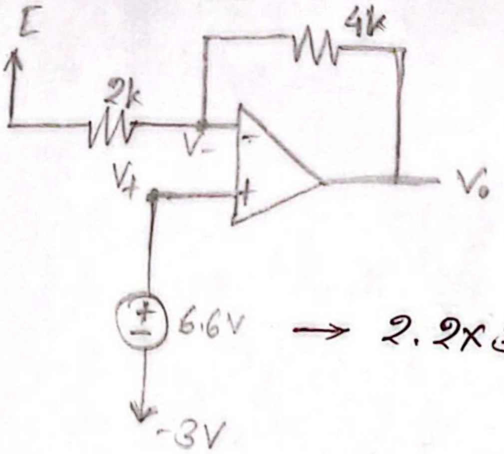
Now, $V_d = (0.67 - 5.33)V$

$= -4.66 V$

$$\therefore V_o = -5V$$

(Ans)

Q-24



$\rightarrow 2.2 \times 3 = 6.6V$

$\therefore V_+ = (6.6 - 3)V$

$= 3.6V$

$\therefore V_- = 3.6V$

When, $E = 2.2V$,

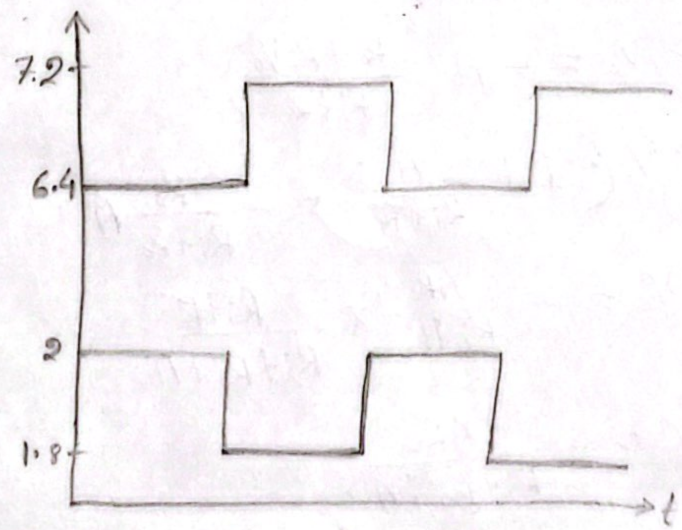
$$\frac{3.6-2.2}{2} + \frac{3.6-V_o}{4} = 0$$

$\therefore V_o = 6.4V$

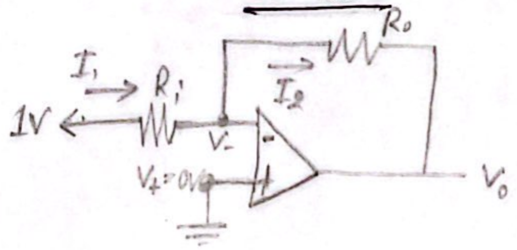
When, $E = 1.8V$,

$$\frac{3.6-1.8}{2} + \frac{3.6-V_o}{4} = 0$$

$\therefore V_o = 7.2V$



Q-25



$$I_1 = I_2$$

$$\Rightarrow \frac{1 - V_-}{R_i} = \frac{V_- - V_o}{R_o}$$

$$\Rightarrow \frac{R_o}{R_i}(1 - V_-) = V_- - V_o$$

$$\Rightarrow V_- + \frac{R_o}{R_i} V_- = V_o + \frac{R_o}{R_i}$$

$$\Rightarrow V_-\left(1 + \frac{R_o}{R_i}\right) = V_o + \frac{R_o}{R_i}$$

$$\Rightarrow V_- = \frac{V_o R_i + R_o}{\cancel{R_i}} \times \frac{\cancel{R_i}}{R_i + R_o}$$

$$\therefore V_- = \frac{R_o + R_i V_o}{R_i + R_o}$$

We know,

$$V_o = A(V_+ - V_-)$$

$$\Rightarrow V_o = -AV_-$$

$$\Rightarrow V_o = -A\left(\frac{R_o + R_i V_o}{R_i + R_o}\right)$$

$$\Rightarrow V_o\left(1 + \frac{A}{R_i + R_o}\right) = -\frac{R_o}{R_i + R_o} \cdot A$$

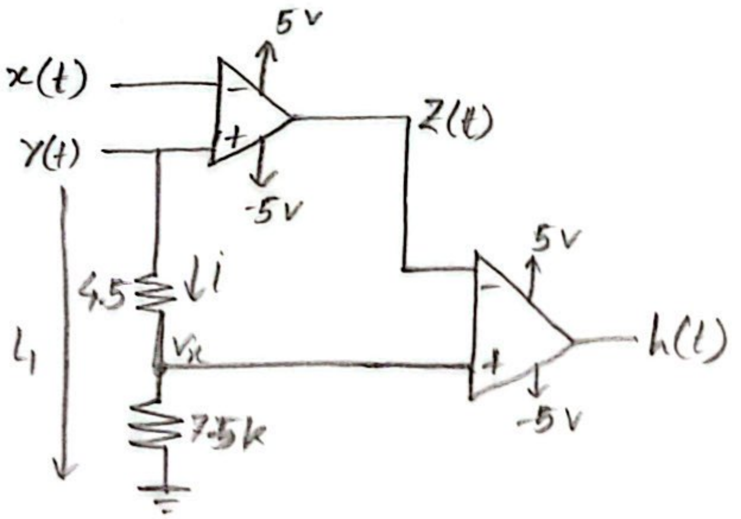
$$\Rightarrow V_o = -\frac{AR_o}{\cancel{R_i + R_o}} \times \frac{\cancel{R_i + R_o}}{R_i + R_o + A}$$

$$\therefore V_o = -\frac{AR_o}{R_i + R_o + A}$$

(Ans)

Q-26

Q-27



KVL on L_1,

$Y(t) - 0 = 4.5i + 7.5$

$\Rightarrow 12i = Y(t)$

$\therefore i = \frac{Y(t)}{12}$

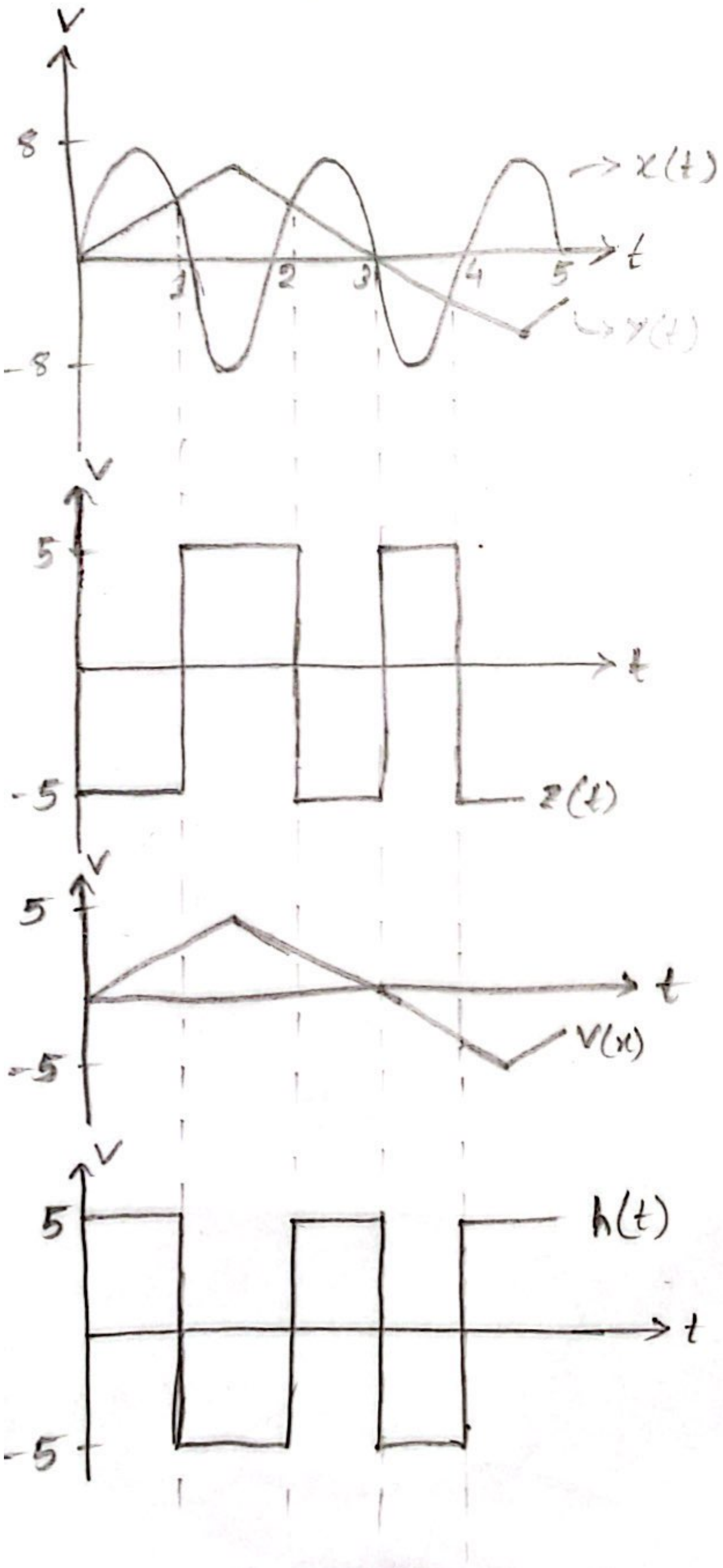
$$\frac{V_x - 0}{7.5} = \frac{Y(t)}{12}$$

$$\Rightarrow V_x = \frac{7.5}{12} Y(t)$$

$$\Rightarrow V_x = 0.625\, Y(t)$$

Y(t) has applitude 8V

$\therefore V_x$ has n of 8×0.625
$= 5V$

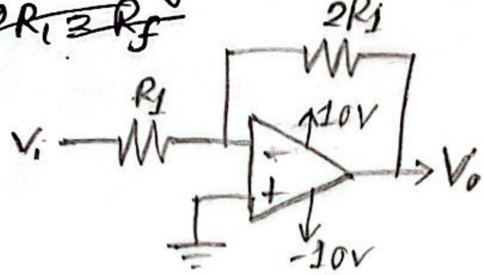


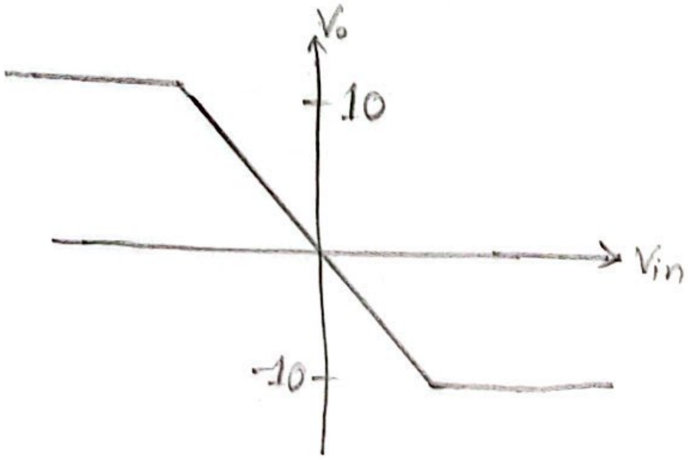
$\therefore h(t) = -z(t)$

(Ans)

Inverting Amp

~~$2R_1 = R_f$~~

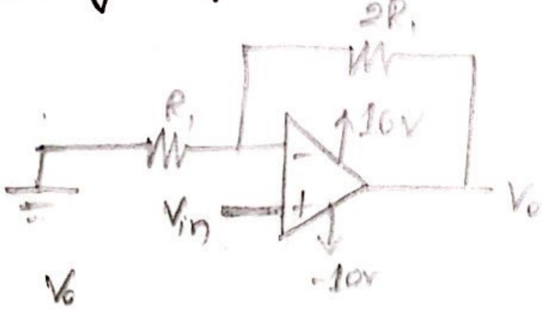


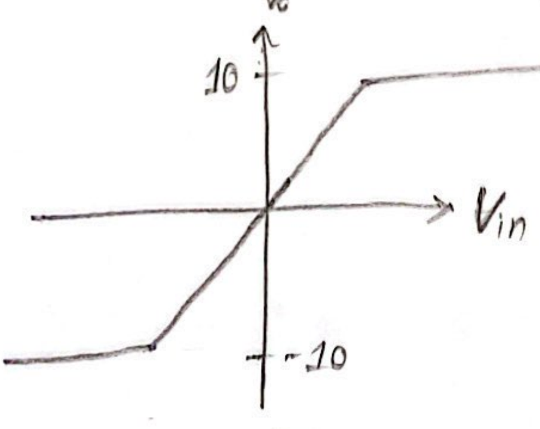


$$V_o = -\frac{2R_1}{R_1}(V_{in})$$

$$= -2V_{in}$$

Non-inverting amp





$$V_o = \left(1 + \frac{2R_1}{R_1}\right) V_{in}$$

$$= 3V_{in}$$

(Ans)

IV

Q-1

a, b & c are non-linear

d is linear

Q-2

a $|OA| < |OB| < |OC| < |OD|$

b AB & CD → slope = infinity

$\therefore |BC| < |DE| < |AB|$

Q-3

$$|AB| = \cancel{CD} = \frac{0+7}{-4+4} = \infty$$

$$|BC| = \frac{-4+7}{0+4} = 0.75$$

$$|CD| = \frac{0-0}{0-0} = \infty$$

$$|DE| = \left| \frac{\cancel{7}-0}{0-7} \right| = 1$$

(Ans)

Q-4

$C(0,-4)$

Here,

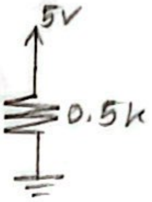
$$-\frac{V_0}{R} = I_0 = C = -4$$

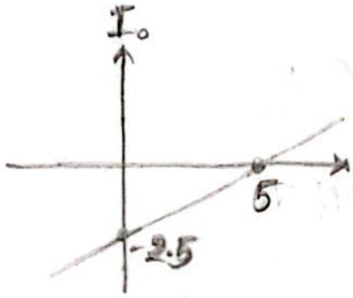
(Ans)

Q-5

(i) $V_o = 5\,V$, $m = 2/k\Omega$

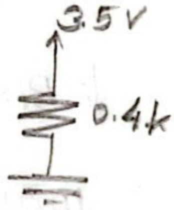
$R = \left|\frac{1}{m}\right| = \frac{1}{2}\,k\Omega$, $i = -\frac{V_o}{R} = -\frac{5}{0.5} = -2.5\,mA$

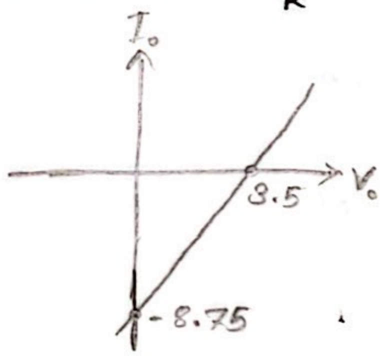




(ii) $V_o = 3.5\,V$, $m = -2.5/k\Omega$

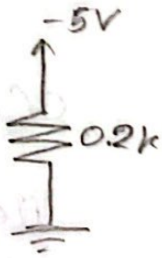
$R = \left|\frac{1}{-2.5}\right| = 0.4\,k\Omega$, $i = -\frac{V_o}{R} = -\frac{3.5}{0.4} = -8.75\,mA$

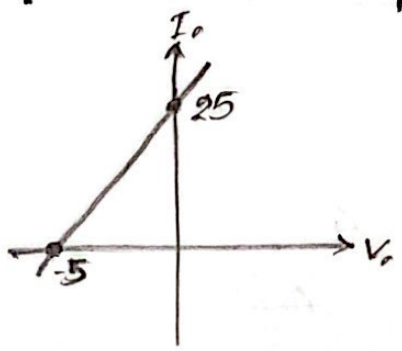




(iii) $V_o = -5\,V$, $m = 5/k\Omega$

$R = \left|\frac{1}{5}\right| = 0.2\,k\Omega$, $i = -\frac{V_o}{R} = -\frac{-5}{0.2} = 25\,mA$





Q-6

(i) $\cancel{C = -4mA}$ $C = 5\,mA$

$\cancel{V_0 = 1.5\,V}$ $-V_0 = -25$

$\Rightarrow V_0 = 25\,V$

(ii) $\cancel{C = -5mA}$ $C = -5\,mA$

V_0 $\cancel{= 2V}$ $V_0 = 1.2\,V$

(Ans)

Q-7

Same as Q-5.

Q-8

(i)

AB → Voltage Source in Series with a resistor / Current Source in parallel with a resistor.

BC → Voltage Source.

CD → Current Source.

EF → Voltage Source in series with a resistor/ Current Source in parallel with a resistor.

FG → Voltage Source.

GH → Open circuit (Not a device).

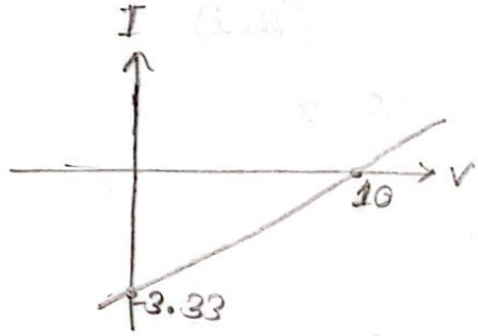
Q-9

(i) $I = \frac{1}{R} V - \frac{V_0}{R}$

(ii) $m = \left| \frac{1}{R} \right| = \frac{1}{3}$

$c = -\frac{V_0}{R} = -\frac{10}{3}$

(iii)



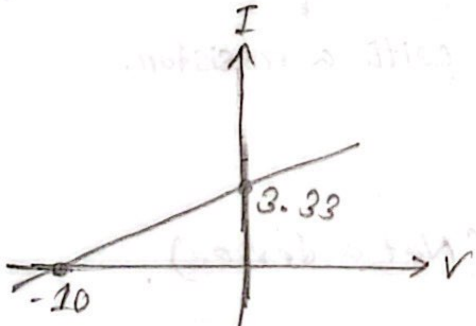
Q-10

(i) $I = \frac{1}{R} V + \frac{V_0}{R}$

(ii) $m = \left| \frac{1}{R} \right| = \frac{1}{3}$

$c = -\frac{V_0}{R} = -\frac{-10}{3} = \frac{10}{3}$

(iii)



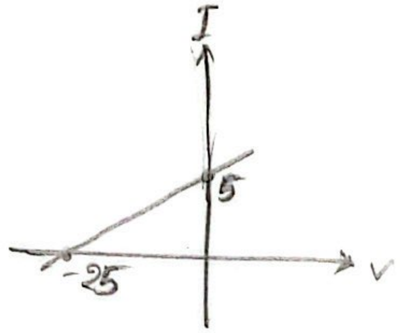
Q-11

(i) $I = I_0 + \frac{1}{R} V$

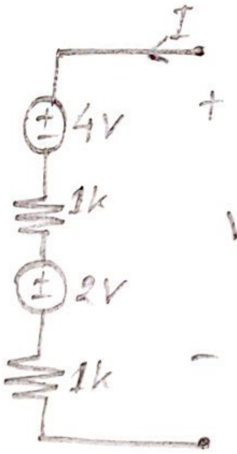
(ii) $m = \left|-\frac{1}{R}\right| = \frac{1}{5}$

$c = I_0 = 5$

(iii)



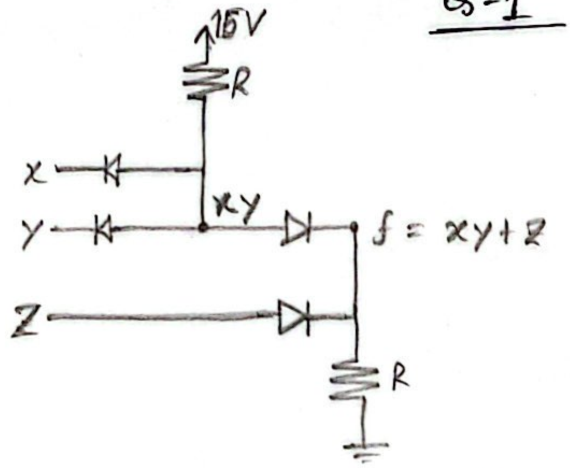
Q-12



Diode Logic Gates

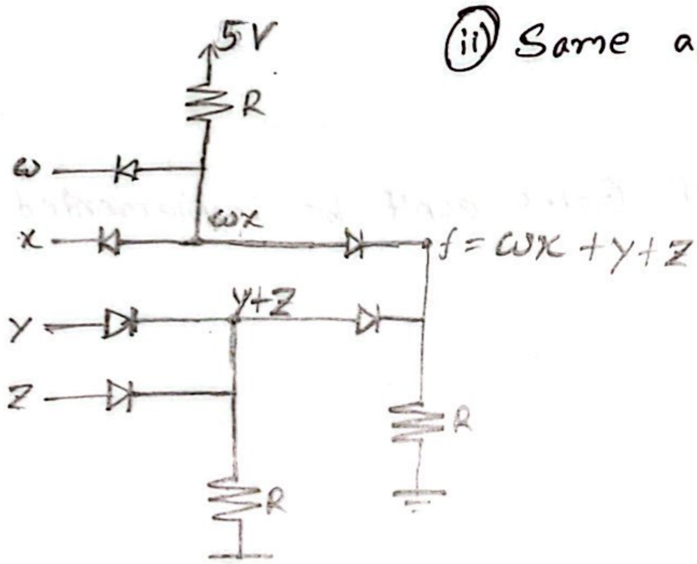
Q-1

(i)

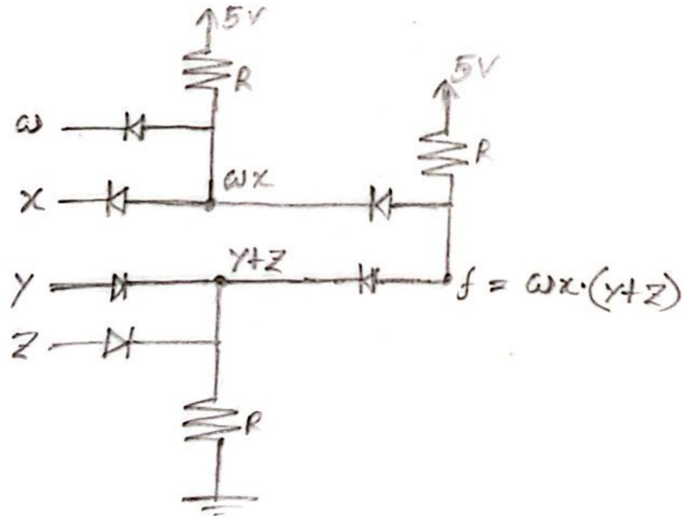


(ii) Same as (i)

(iii)

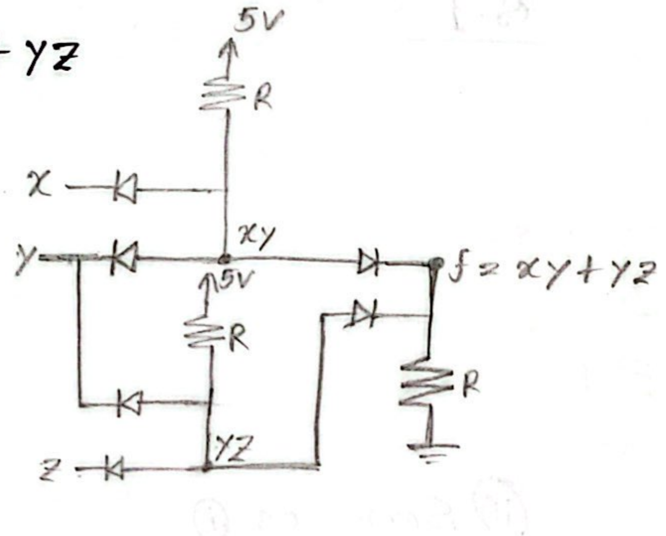


(iv)



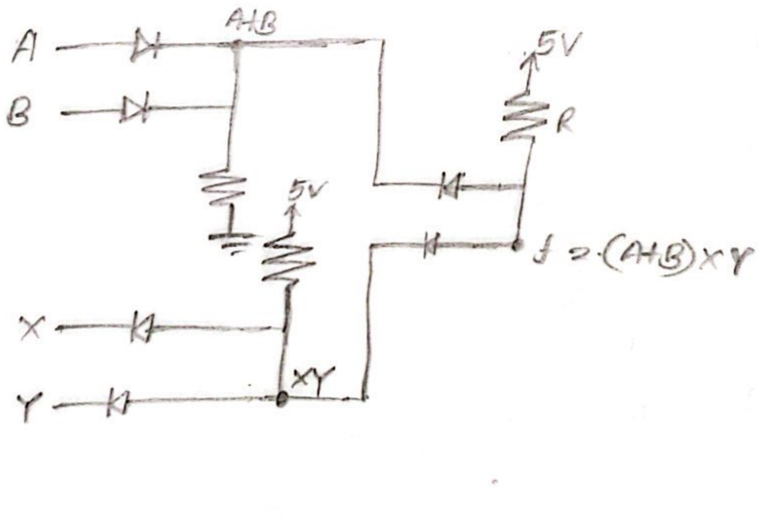
Q-2

(i) $xy + yz$

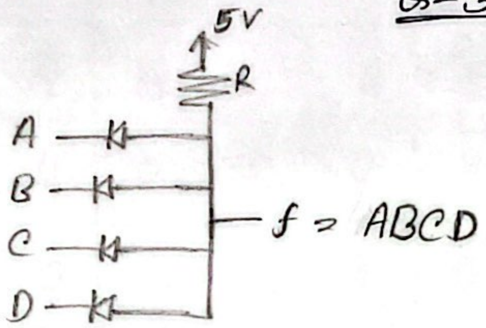


(ii) & (iii) XOR, XNOR Gates can't be implemented by diodes.

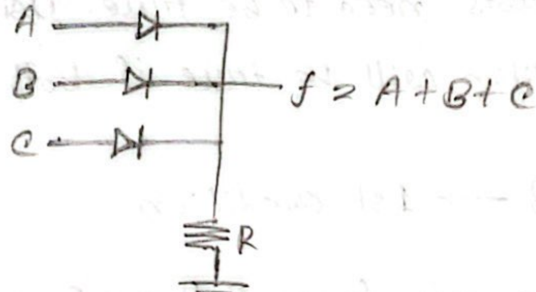
(iv) $(A+B)XY$



Q-3

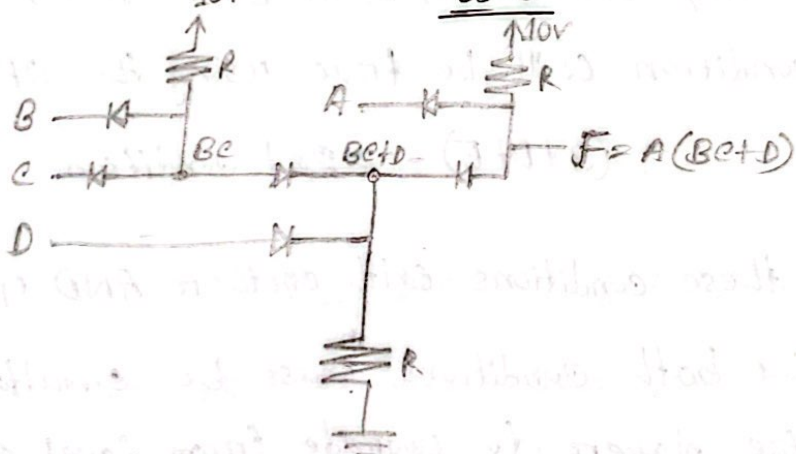


Q-4



(a)

Q-5

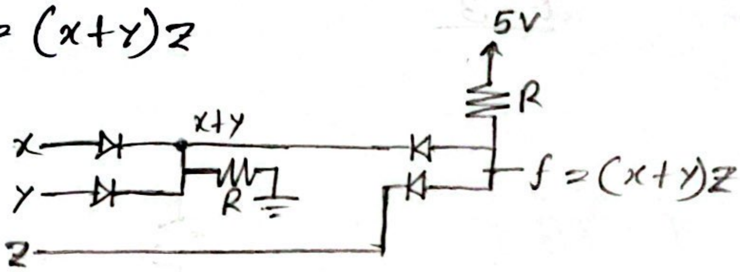


(b)

A	B	C	D	F
4V	3V	4V	6V	4V
5V	3V	4V	2V	3V
13V	3V	4V	15V	10V

→ As, F = 13 V which is greater that V_s+

ⓒ $f = (x+y)z$



Q-6

ⓐ Both the A and B quests need to be true. Using the AND gate, the first condition will be true if both A and B are true.

$\therefore$ $A.B \longrightarrow$ 1st condition

At least one of the quests from C, D, or E needs to be true. If only one of C, D, or E is true, then the second condition will be true using the OR gate.

$\therefore$ $(C+D+E) \longrightarrow$ 2nd condition

By combining these conditions with another AND operation, we ensure that both conditions must be simultaneously satisfied for the player to upgrade from level-1 to level-2.

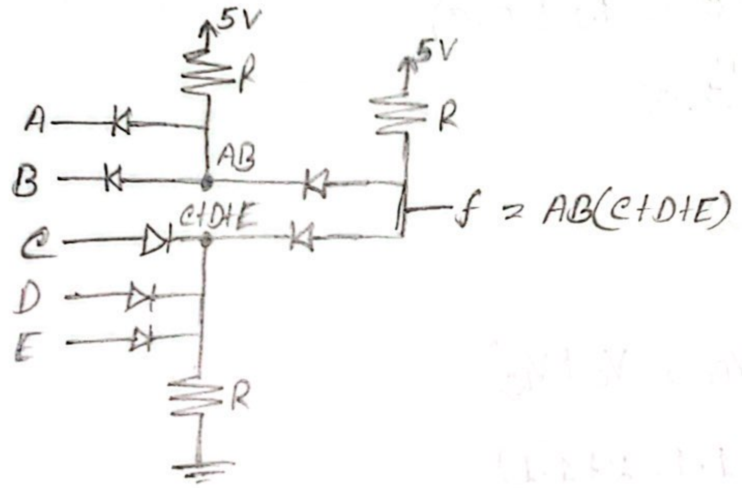
$$\therefore F = AB(C+D+E)$$

(Ans)

(b)

A	B	C	D	E	F
0	0	1	0	1	0
0	1	1	1	0	0
1	0	0	0	0	0
1	1	1	0	0	1

(c)



(D) Designing a NAND gate using si diodes alone is not achievable because diodes are passive components that can only conduct current in one direction. They lack the ability to perform the inversion or NOT operation required for the NAND gate's logic function.

Q-7

(i) $V_5 = \min(V_1 + V_{D_1}, V_2 + V_{D_2})$

$= \min(2 + 0.3, 1.7 + 0.5)$

$= \min(2.3, 2.2)$

$= 2.2V$ (Ans)

$V_6 = \min(V_3 + V_{D_3}, V_4 + V_{D_4})$

$= \min(1.5 + 0.7, 1.1 + 0.9)$

$= \min(2.2, 2.0)$

$= 2V$

(Ans)

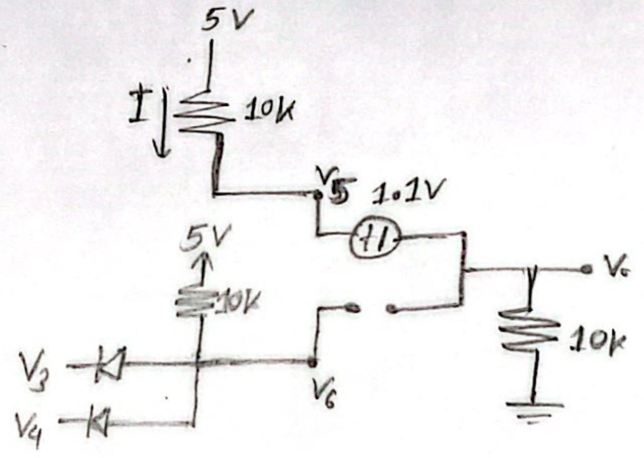
(ii) $V_0 = \max(V_5 + V_{D_5}, V_6 + V_{D_6})$

$= \max(2.2 + 1.1, 2 + 1.1)$

$= \max(3.3, 3.1)$

$= 3.3V$ (Ans)

(iii)



Assuming that V_5 is higher.

$$I = \frac{5-1.1}{10+10} = 0.195\ mA$$

$$V_5 = 5 - 10I = 3.05\ V$$

$$V_6 = 2V \quad (\text{from (i)})$$

$\therefore V_5 > V_6$. So, assumption was correct.

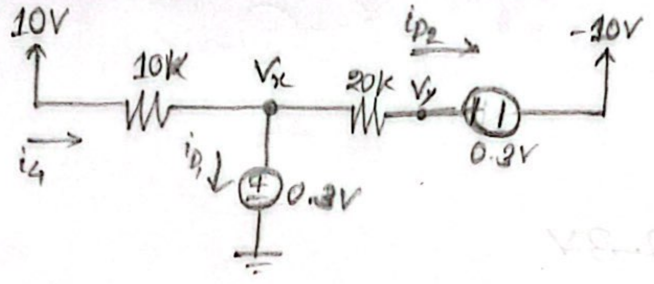
$$V_o = 3.05 - 1.1V$$
$$= 1.95V$$

(Ans)

Diode : Method of Assumed states

Q-1

(i)



Assumption:

$D_1 = ON$

$D_2 = ON$

$V_x = 0.3V$

$$i_4 = \frac{10-0.3}{10}$$

$= 0.97 mA$

$V_y + 10 = 0.3$

$\therefore V_y = -9.7V$

$$i_{D_2} = \frac{0.3+9.7}{20}$$

$= 0.5 mA$

$i_4 = i_{D_1} + i_{D_2}$

$\Rightarrow 0.97 = 0.5 + i_{D_1}$

$\therefore i_{D_1} = 0.47 mA$

Verification:

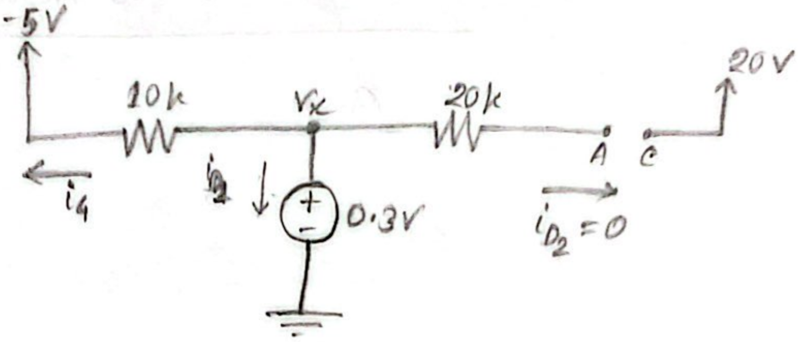
$i_{D_1} > 0$

$i_{D_2} > 0$

$\therefore$ my assumption was correct.

(Ans)

(ii)



~~$V_x = 0.3V$~~

Assumption:

$D_1 = ON$

$D_2 = OFF$

$V_x = 0.3V$

$$i_4 = \frac{0.3+5}{10}$$

$$= 0.53\,mA$$

$$i_{D_1} = i_4 = 0.53\,mA$$

$$i_{D_2} = 0\,mA$$

$$V_D = V_A - V_C = 0.3 - 20$$

$$= -19.7V$$

Verification:

$I_{D_1} > 0$

$I_{D_2} \not> 0$

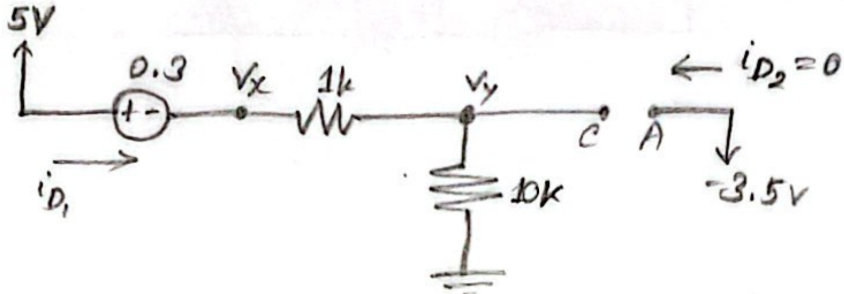
$V_D < V_{D_0}$

$\therefore$ Assumption was correct.

(Ans)

Q-2

(i)



Assumption:

$5 - V_x = 0.3$

$\therefore V_x = 4.7V$

Applying KVL,

$5 - 0 = 0.3 + I_{D_1} + 10I_{D_1}$

$\Rightarrow 11I_{D_1} = 4.7$

$\therefore I_{D_1} = 0.43 \, mA$

$\therefore V_y = 0.43 \times 10$
$= 4.3V$

$V_D = V_A - V_C = -3.5 - 4.3$
$= -7.8V$

Verification:

$I_{D_1} > 0$

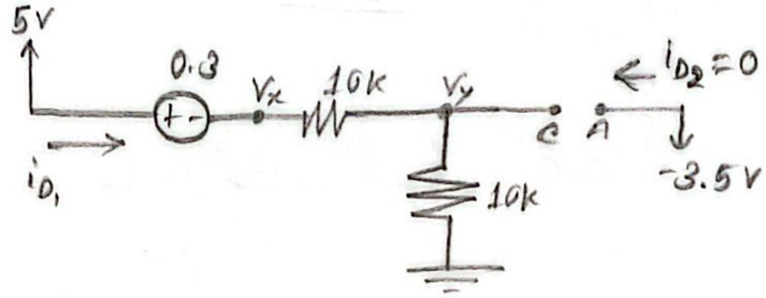
$I_{D_2} \ngtr 0$

$V_D < V_{D_0}$

$\therefore$ Assumption was correct

(Ans)

(ii)



Assumption:

$D_1 = ON$

$D_2 = OFF$

$\therefore V_x = 4.7V$

Applying KVL,

$5 - 0 = 0.3 + 10 i_{D_1} + 10 i_{D_1}$

$\Rightarrow i_{D_1} = 0.235\ mA$

$\therefore V_y = 0.235 \times 10$

$= 2.35V$

$V_D = V_A - V_C = -3.5 - 2.35$

$= -5.85V$

Verification:-

$I_{D_1} > 0$

$I_{D_2} \not> 0$

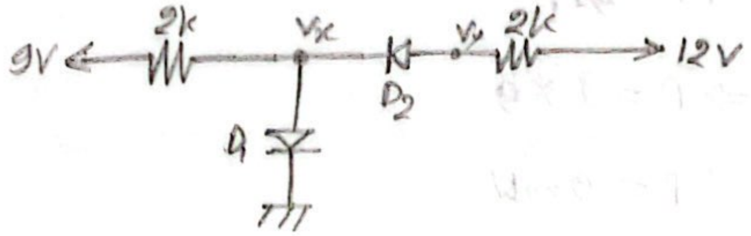
$V_D < V_{D_0}$

$\therefore$ Assumption was correct

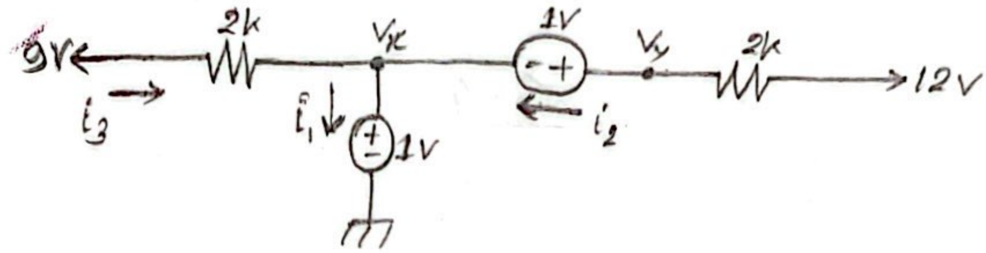
(Ans)

Q-3

(a)



(b)



Assumption:-

$D_1 = ON.$

$D_2 = ON$

$V_x = 1V$

$V_y - V_x = 1$

$\therefore V_y = 2V$

$i_2 = \frac{12-2}{2} = 5mA$

$i_3 = \frac{9-1}{2} = 4mA$

$i_1 = i_2 + i_3$

$= 5+4$

$= 9 mA$

Verification:-

$i_{D_1} > 0$

$i_{D_2} > 0$

$\therefore$ Assumption was correct

(c) We know,

$$P = V_2 I_1$$

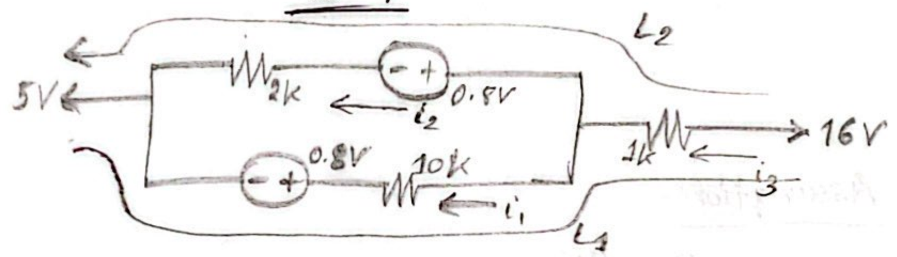
$$\Rightarrow P = 1 \times 9$$

$$\therefore P = 9\,mW$$

$\therefore$ P is consuming power

(Ans)

Q-4



Assumption:-

$D_1 = ON$

$D_2 = ON$

$$i_1 = i_3 - i_2$$

KVL on L_1,

$$16 - 5 = i_3 + 10(i_3 - i_2) + 0.8$$

$$\Rightarrow -10i_2 + 11i_3 = 10.2 \quad \ldots (1)$$

KVL on L_2,

$$16 - 5 = i_3 + 0.8 + 2i_2$$

$$\Rightarrow 2i_2 + i_3 = 10.2 \quad \ldots (2)$$

(1) & (2) $\Rightarrow$

$$i_2 = 3.19\,mA$$

$$i_3 = 3.83\,mA$$

$$\therefore i_1 = 3.83 - 3.19 = 0.64\,mA$$

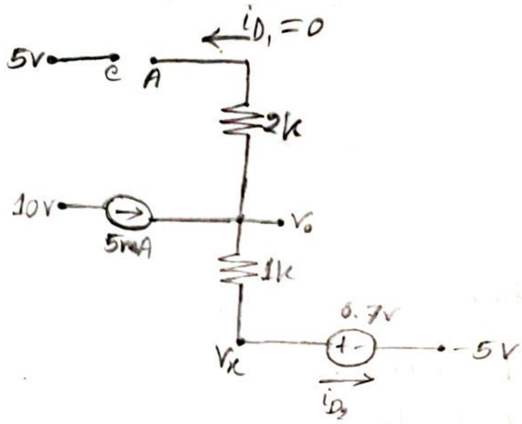
Verification:-

$i_1 > 0$

$i_2 > 0$

$\therefore$ Assumption was correct (Ans)

Q-5



Assumption:-

$D_1 = OFF$

$D_2 = ON$

$V_x + 5 = 0.7$

$\therefore V_x = -4.3V$

$i_{D_2} = 5mA$

$\Rightarrow \frac{V_0 - V_x}{1} = 5$

$\Rightarrow V_0 + 4.3 = 5$

$\therefore V_0 = 0.7V$

$V_D = V_A - V_C$

$= 0.7 - 5$

$= -4.3V$

Verification:-

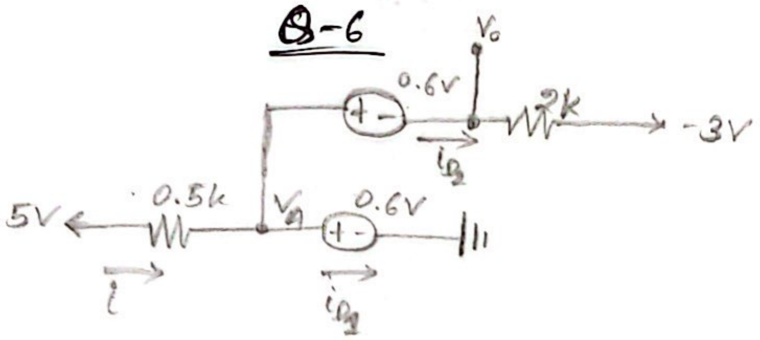
$i_{D_2} > 0$

$i_{D_2} \ngtr 0$ $\quad \therefore$ Assumption was correct

$V_D < V_{D_0}$

(~~Ans~~)

$\underline{Q-6}$



Assumption:-

$D_1 = ON$

$D_2 = ON$

$V_A = 0.6V$

$V_A - V_o = 0.6$

$\therefore V_o = 0V$

$i_{D_2} = \frac{0+3}{2} = 1.5mA$

$i_1 = \frac{5-0.6}{0.5}$

$= 8.8mA$

$i_{D_1} = 8.8 - 1.5$

$= 7.3mA$

Verification:-

$i_{D_1} > 0$

$i_{D_2} > 0$ $\quad \therefore$ Assumption was correct. (Ans)

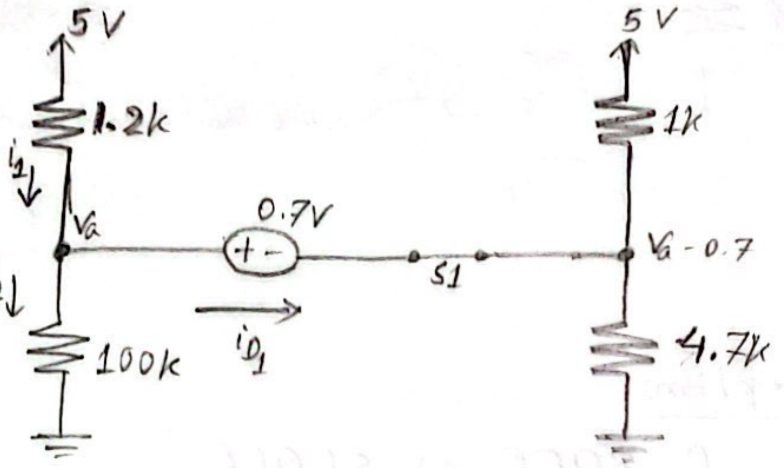
Q-7

(i)

Assumption:-

$D_1 = ON$

S2 open $\begin{cases} D_2 = OFF \\ D_3 = OFF \end{cases}$



Applying KCL,

$$\frac{V_a - 5}{1.2} + \frac{V_a - 0}{100} + \frac{V_a - 0.7 - 0}{4.7} + \frac{V_a - 0.7 - 5}{1} = 0$$

$$\therefore V_a = 4.871 V$$

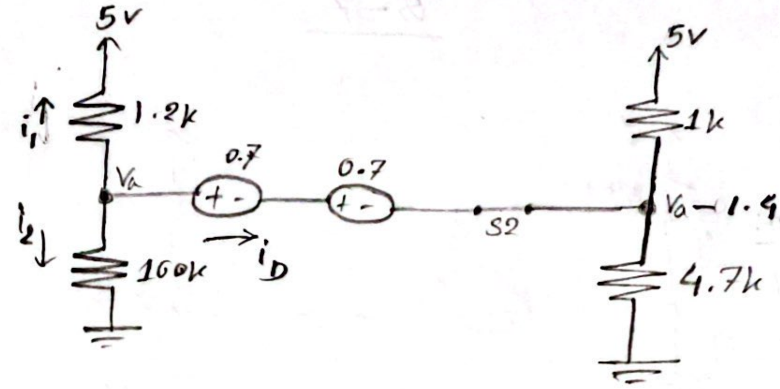
$$i_1 = \frac{5 - 4.871}{1.2} = 0.108 mA$$

$$i_2 = \frac{4.871 - 0}{100} = 0.049 mA$$

$$\therefore i_{D_1} = 0.108 - 0.049$$
$$= 0.059 mA$$

$\therefore$ 0.049 mA current is passing through the 100k Ω resistor. (Ans)

(ii)



Assumption:-

D_1 = OFF as S1 OFF

$D_2 = D_3$ = ON

Applying KCL,

$$\frac{V_a-5}{1.2} + \frac{V_a-0}{100} + \frac{V_a-1.4-5}{1} + \frac{V_a-1.4-0}{4.7} = 0$$

$$\therefore V_a = 5.284 V$$

$$\cancel{I_D = \frac{5-5.824}{1.2} + \frac{5.824-0}{100}}$$

$$\Rightarrow i_D + i_1 + i_2 = 0$$

$$\Rightarrow i_D = -\left(\frac{5.284-5}{1.2} + \frac{5.284}{100}\right)$$

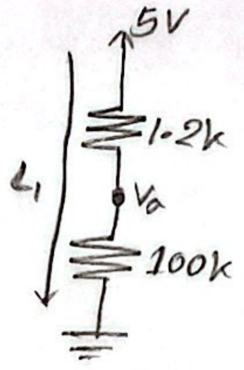
$$\therefore i_D = -0.29 mA$$

$\because i_D < 0$

$\therefore$ Assumption was wrong.

Assumption.1-

$D_2 = D_3 = OFF$



KVL on L_1,

$$5-0 = 1.2I + 100I$$

$$\therefore I = 0.049 mA.$$

$\therefore$ 0.049 mA current is passing through the 100 kΩ resistor.

(Ans)