Set: 2

Part-a

(1) a) $V_G = 0$, $i_{DS} = 2\,mA$

b) $V_D = 5 - 2i_{DS} = 5 - 2\times 2 = 5 - 4 = 1V$

c) Let, ... saturation

$$i_{DS} = \frac{1}{2} K (V_{GS} - V_T)^2$$

$$\Rightarrow 2 = \frac{1}{2} \times 4 \times (V_{GS} - 1)^2$$

$$\Rightarrow (V_{GS} - 1)^2 = 1 \qquad \therefore V_{ov} = 1V$$

$$\therefore V_{GS} = 2V \qquad \Rightarrow V_G - V_S = 2V$$

$$\therefore V_S = -2V$$

Here, $V_{DS} = V_D - V_S = 1 + 2 = 3V > V_{ov}$

$\therefore$ assumption is correct.

Part-b

$$f = \overline{\overline{A(B+C')}\,D}$$

(2) Part-a KVL: $1 - 40 i_B - V_{BE} = 0$

Let, ... active.

$$\therefore V_{BE} = 0.7V$$

$$\therefore 1 - 40 i_B - 0.7 = 0$$

$$\Rightarrow i_B = \frac{0.3}{40} = 0.0075\,mA$$

$i_C = \beta i_B = 100 \times 0.0075 = 0.75\ mA$

$\therefore i_E = i_C + i_B = 0.7575\ mA$

Here, $V_C = 12 - 4 i_C = 12 - 4 \times 0.75$
$= 12 - 3 = 9V$

$\therefore V_{CE} = V_C - V_E = 9 - 0 = 9V > V_{CE\,sat}$

$\therefore$ assumption is correct.

$\boxed{\text{Part-b}}$ BJT will be active for the valid

input range : $0.7 < V_{in} < 0.7 + \frac{V_s - 0.2}{\beta R_L} R_i$

or, $0.7 < V_{in} < 1.65 + 0.7 = 2.35$

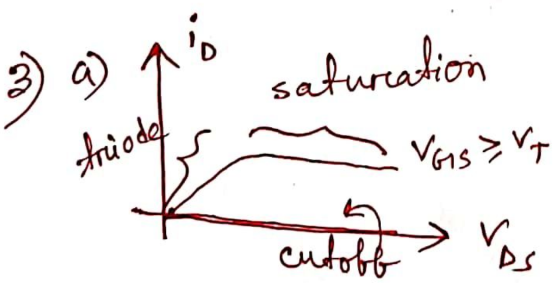
(i) $V_X = \frac{0.7 + \overset{2.35}{\cancel{1.65}}}{2} = 1.525\ V$

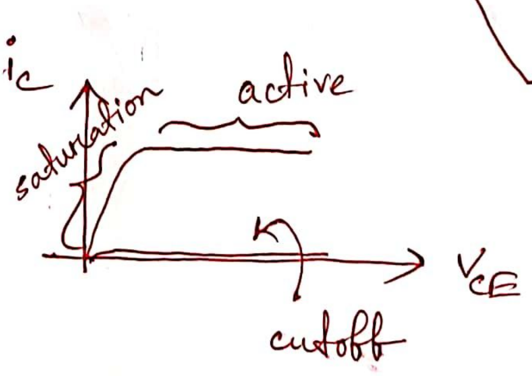
$V_Y = V_s + \frac{0.7 \beta R_L}{R_i} - \frac{\beta R_L}{R_i} V_X = 20 + 12 \times 0.7 - 12 \times \overset{1.525}{\cancel{1.175}}$
$= 10.1V$

(ii) $K = -\frac{\beta R_L}{R_i} = -\frac{60 \times 2}{10} = -6 \times 2 = -12$

swing = 1.525 − 0.7

3) a)





b)

c) $NM_0 = 3.5 - 1.5 = 2V$
$NM_1 = 5.5 - 4.7 = 0.8V$

3 (b)

Assume the following values for the inverter circuit parameters: $V_S = 5\,V, V_T = 1\,V$, and $RL = 10\,k\Omega$. Assume, further, that $\frac{1}{k_n' V_{OV}} = 5$ for the MOSFET. Determine a $\frac{W}{L}$ sizing for the MOSFET so that the inverter gate output for a logical 0 is able to switch OFF the MOSFET of another inverter.

Solution:

$$V_S \frac{R_{ON}}{R_{ON} + R_L} < V_T$$

$$\Rightarrow 5 \frac{R_{ON}}{R_{ON} + 10} < 1$$

$$\Rightarrow 5R_{ON} < R_{ON} + 10$$

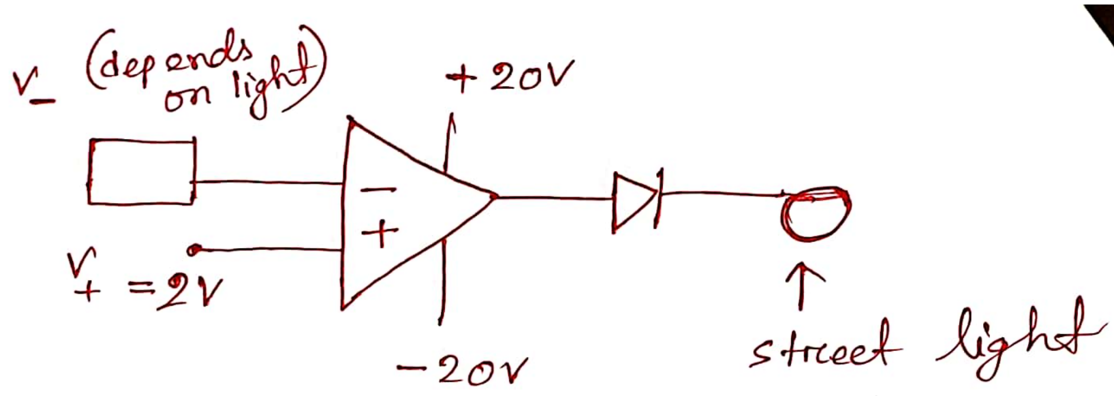
$$\Rightarrow R_{ON} < \frac{10}{4} = 2.5$$

Now, $$R_{ON} = \frac{1}{k_n' \frac{W}{L} V_{OV}} = 5 \times \frac{1}{W/L}$$

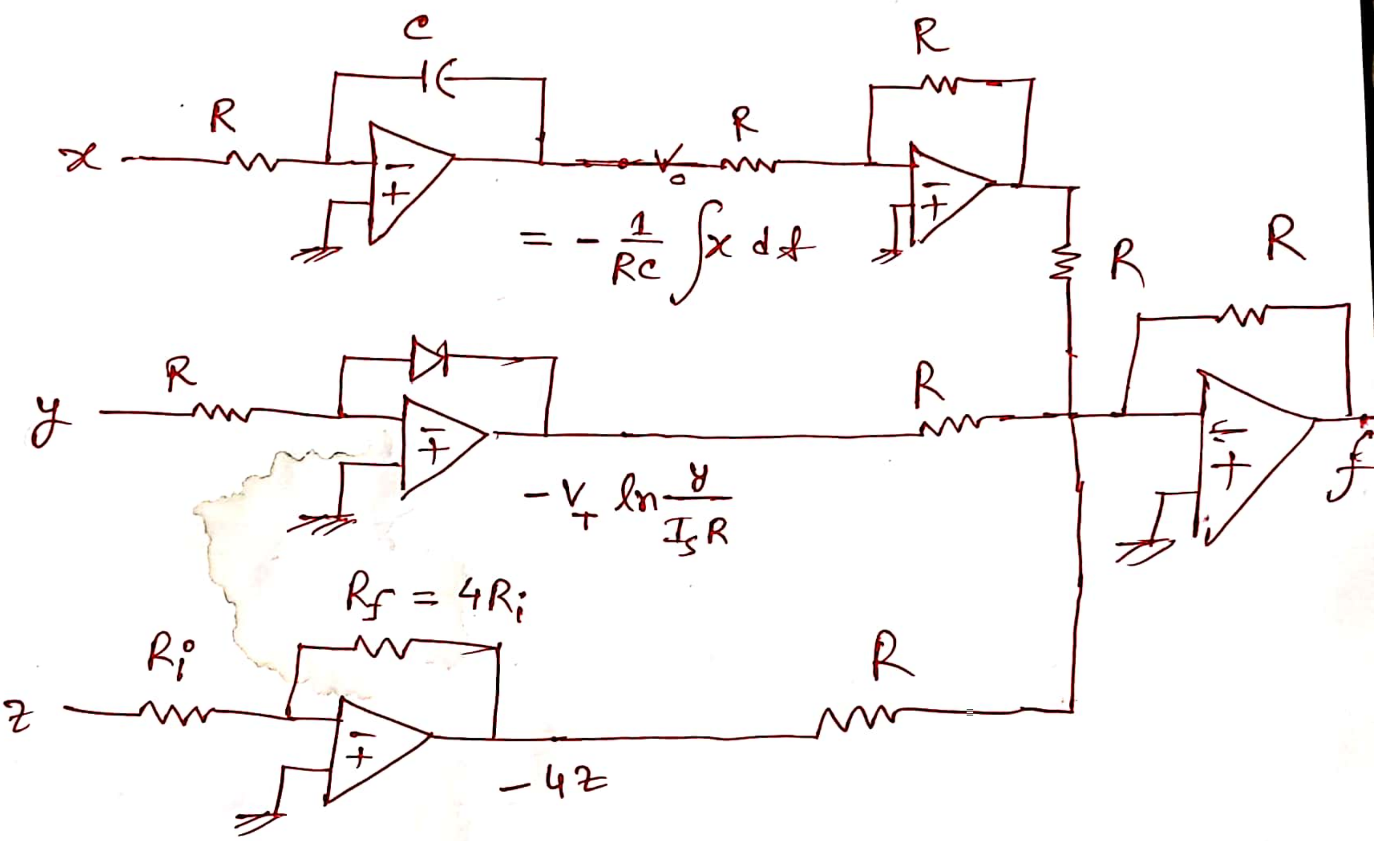
Hence $$\frac{5}{W/L} < 2.5 \Rightarrow \frac{W}{L} > \frac{5}{2.5}$$

$$\boxed{\Rightarrow \frac{W}{L} > 2}$$

4) a)



b)



Here, $RC = 3$, $I_s R = 1$, $V_T = 2$

c) $V_1 = -I_s R \exp\left(\frac{x}{V_T}\right)$

$y = -R_1 C_1 \frac{d}{dt}(V_1)$

$= -R_1 C_1 (-I_s R) \frac{d}{dt}(\exp(x))$ $[V_T = 1]$

$= R_1 C_1 \cancel{\frac{d}{dt}} \exp(x)$ $[I_s R = 1]$

Set-1

① a) $V_G = 0$, $i_{DS} = 4mA$, b) $V_D = 1V$

Part-a

b) $V_{gs} = 1 + \sqrt{2} = 2.414V$

$[V_{ov} = 1.414V]$

$\therefore V_s = -2.414V$

$V_{DS} = 1 + 2.414 = 3.414 > V_{ov}$

Part-b

$f = \overline{AB + \overline{C}D}$

② Part-a

$i_B = 0.006\ mA$

$i_c = \beta i_B = 0.6\ mA$

$i_E = 0.606\ mA$

$V_{CE} = V_C = 8 - 5i_c$

$= 5V > V_{CE\,sat}$

Part-b

$0.7 < V_{in} < 1.8$

$V_x = 1.25V$

$V_Y = ~~V_0~~ - 10.1V$

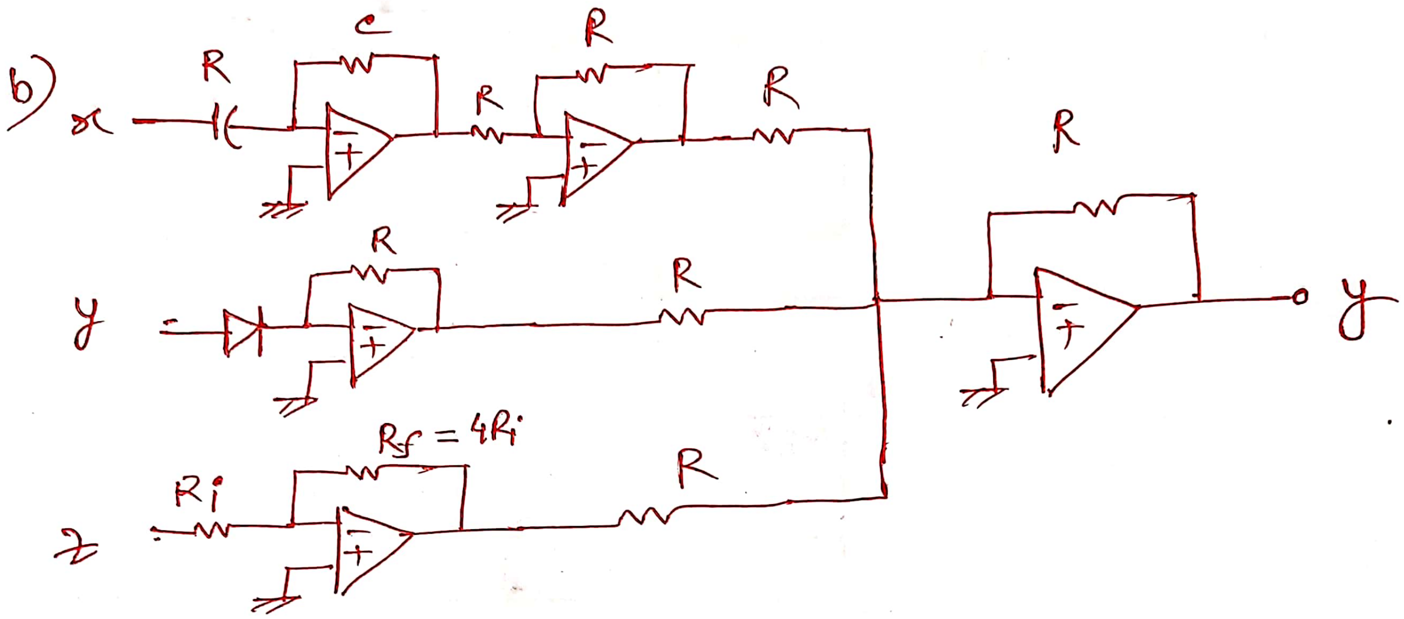
(i) maximum swing $= (1.25 - 0.7) = 0.55V$

(ii) $K = -\frac{\beta R_L}{R_I} = -\frac{120 \times 3}{20} = -18$

(3) → same as set 2

(4) a) → same as set 2

b)



$RC = 3, \quad V_T = 3$

c) $V_1 = -V_T \ln \frac{x}{I_S R}$

$$y = -\frac{1}{R_1 C_1} \int V_1 \, dt$$

$$= -\frac{1}{R_1 C_1} \int -V_T \ln \frac{x}{I_S R}$$

$$= \frac{1}{R_1 C_1} \int \ln x$$

$[V_T = 1, \quad I_S R = 1]$