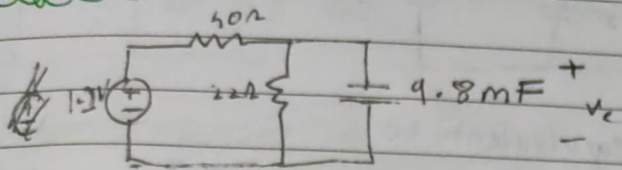
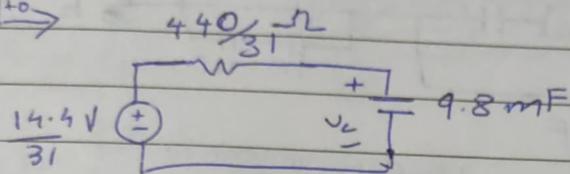
BASIC Electronics (ECE 113)

Assignment - 2

A1) (a)



equivalent $\xrightarrow{\text{to}}$



Rough calc^n

$\frac{1}{40}+\frac{1}{22}=\frac{1}{2}\left(\frac{1}{20}+\frac{1}{11}\right)$

$\frac{31}{440}$

$I_n = \frac{1.2}{40}$

$V_{Th} = I_n R_{eq}$

$= \frac{14.4}{31}$

$$\therefore \boxed{V_c = \frac{14.4}{31}\left(1-e^{-t/\tau}\right)}$$

where $\tau = \left(\frac{440}{31}\times 9.8\right)$ ms

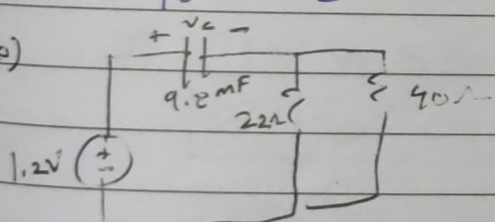
$\boxed{\tau = \frac{4312}{31} \text{ ms}}$

$$\boxed{P_{40\Omega} = \frac{(V_{40\Omega})^2}{40\Omega} = \frac{\left(1.2 - \frac{14.4}{31}\left(1-e^{-t/\tau}\right)\right)^2}{40}}$$

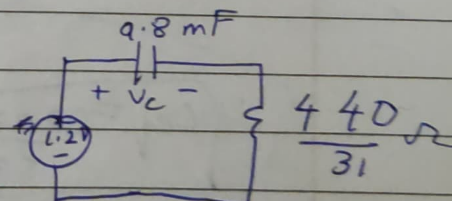
$P_{40\Omega} = 3.6\times10^{-2}\times\left(\frac{20}{31}+\frac{11}{31}e^{-t/\tau}\right)^2$ where $\tau = \frac{4312}{31}$ ms

$[\because V_{40} + V_c = 1.2V]$

(b)



equivalent $\xrightarrow{\text{to}}$



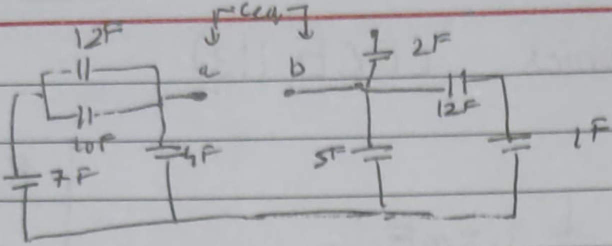
$$\therefore \boxed{V_c = 1.2\left(1-e^{-t/\tau}\right) \quad \text{where } \tau = \frac{4312}{31} \text{ ms}}$$

$$P_{40\Omega} = \frac{(V_{40\Omega})^2}{40\Omega} = \frac{\left(1.2 - 1.2\left(1-e^{-t/\tau}\right)\right)^2}{40}$$

$(\because V_{40} + V_c = 1.2V)$

$$\therefore \boxed{P_{40\Omega} = \left(3.6\times10^{-2}\times e^{-2t/\tau}\right)}$$ where $\tau = \frac{4312}{31}$ ms

A2)



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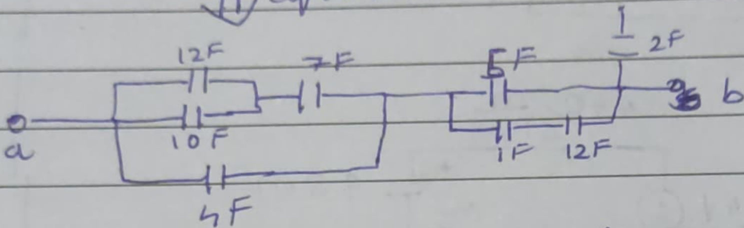

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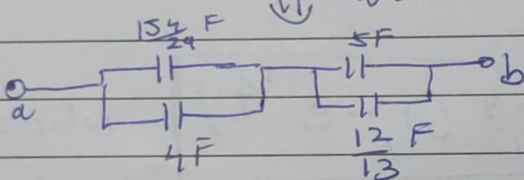

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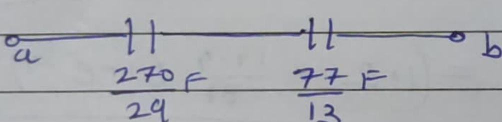

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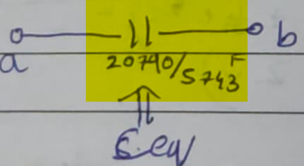


$$\therefore \boxed{C_{eq} = \frac{20790}{5743}\ F}$$

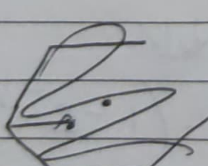
Rough Work

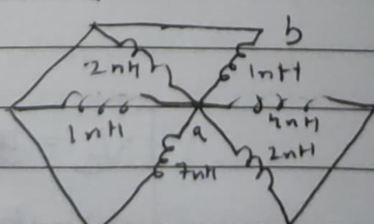
$\frac{24}{270} + \frac{13}{77}$

$2233 + 3510$

$\frac{20790}{5743}$

A3)





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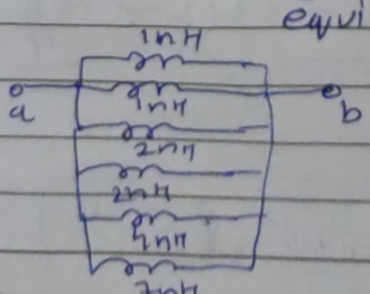
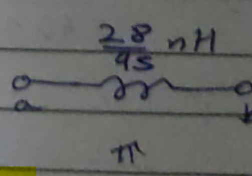


$\xrightarrow{\text{equivalent to}}$



$$\therefore \boxed{L_{eq} = \frac{28}{95}\ nH}$$

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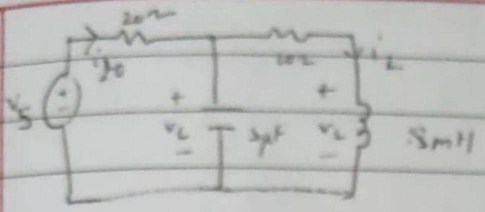
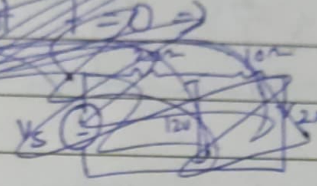
A4)

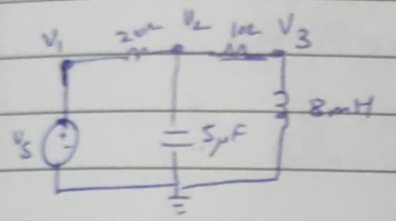


$V_c(0) = 12V$
$i_L(0) = 2A$

~~at t=0~~



$L\frac{di_L}{dt} = V_3$



$\Rightarrow V_1 = V_s$ ① —

② — $\frac{V_2 - V_1}{20} + \frac{V_2 - V_3}{10} + \frac{dV_c}{dt} \times 5\times10^{-6} = 0$

③ — $\frac{V_3 - V_2}{10} + i_L = 0$

∴ By nodal analysis we have ↓

① $\Rightarrow V_1 = V_s$
② $\Rightarrow 3V_2 - V_1 - 2V_3 + \left(\frac{dV_2}{dt}\right)\times10^{-4} = 0$

③ $\Rightarrow$

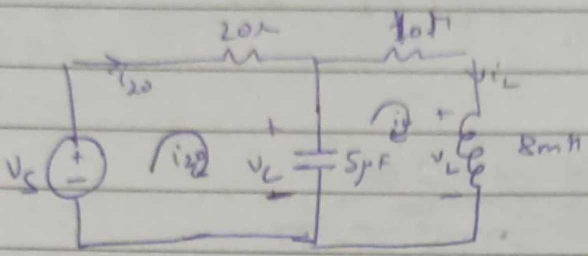
$V_3 - V_2 + 10 i_L = 0$

where $\int_2^{i_L} di_L = \int_0^{t}\left(\frac{V_3}{8\times10^{-3}}\right) dt$

$\therefore i_L = 2 + \int_0^{t}\left(\frac{V_3}{8\times10^{-3}}\right) dt$

③ $\Rightarrow V_3 - V_2 + 20 + \frac{10^4}{8}\int_0^{t} V_3\, dt = 0$

For Mesh analysis :-



$$-V_S + 20\, i_{20} + V_C = 0 \quad -(1)$$

$$10\, i_L + V_L - V_C = 0 \quad -(2)$$

$$10\, i_L + (8\times10^{-3})\frac{di_L}{dt} - V_C = 0$$

Now $V_C = \frac{q}{C}$

and $\frac{dq}{dt} = (i_{20} - i_L) \quad -(3)$

$$\frac{dV_C}{dt} = \frac{i_{20} - i_L}{C}$$

$$\therefore V_C - 12 = \frac{1}{5\times10^{-6}} \times \int_0^t (i_{20} - i_L)\, dt$$

$\therefore$ eq^n are $\Rightarrow$

(1) $\Rightarrow$ $\boxed{V_S = 20\, i_{20} + 12 + \frac{1}{5\times10^{-6}} \times \int_0^t (i_{20} - i_L).dt}$

(2) $\Rightarrow$ $\boxed{10\, i_L + (8\times10^{-3})\frac{di_L}{dt} = 12 + \frac{1}{5\times10^{-6}} \times \int_0^t (i_{20} - i_L).dt}$

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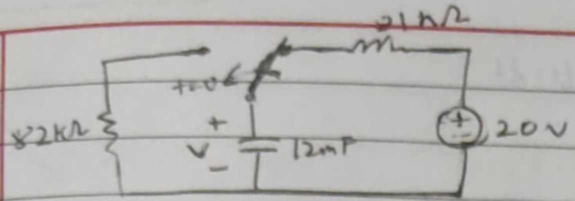
A5)



(a) at $t=0$, $V(t) = 20V$ (steady state)

$\tau = 82k\Omega \times 12mF = 984s$

$\therefore$ at $t = 984s$, $(t = \tau)$

$$V(t) = \frac{20}{e} = 7.3576\ V$$

at $t = 1236\ s$,

$$V(t) = \frac{20}{e^{(1236/984)}} = 5.6952626\,3485\ V$$

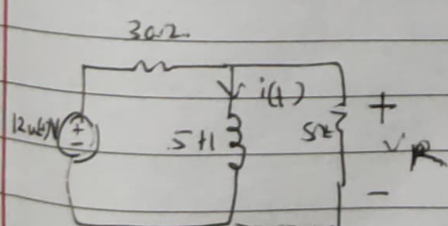
(b) at $t = 100s$,

$$E = \frac{1}{2} CV^2 = 6 \times 10^{-3} \times \left(\frac{20}{e^{-\frac{100}{984}}}\right)^2$$

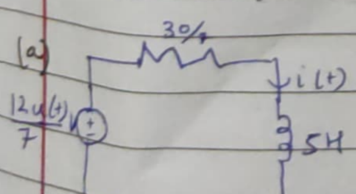
$$= \frac{2.43}{e^{200/984}}$$

$$= 1.9585740\,9285\ J$$

A6)



(a)



$$\Rightarrow \frac{30}{7} i(t) + 5\frac{di(t)}{dt} = \frac{12u(t)}{7}$$

$$30i(t) + 35\frac{di(t)}{dt} = 12u(t)$$

$$\therefore \frac{di(t)}{dt} + \frac{6}{7} i(t) = \frac{12}{35} u(t)$$

$$i(t)e^{\frac{6t}{7}} = \int e^{\frac{6t}{7}} \frac{12}{35} u(t)\,dt \Rightarrow i(t)e^{\frac{6t}{7}} = \frac{12}{35} \times \frac{7}{6} \times e^{\frac{6t}{7}} + C$$

Now, at $t=0$, $i(t) = 0$

$$\therefore i(t)e^{\frac{6t}{7}} = \frac{2}{5}\left(e^{\frac{6t}{7}} - 1\right)$$

$$\boxed{i(t) = \frac{2}{5}\left(1 - e^{-\frac{6t}{7}}\right)}$$

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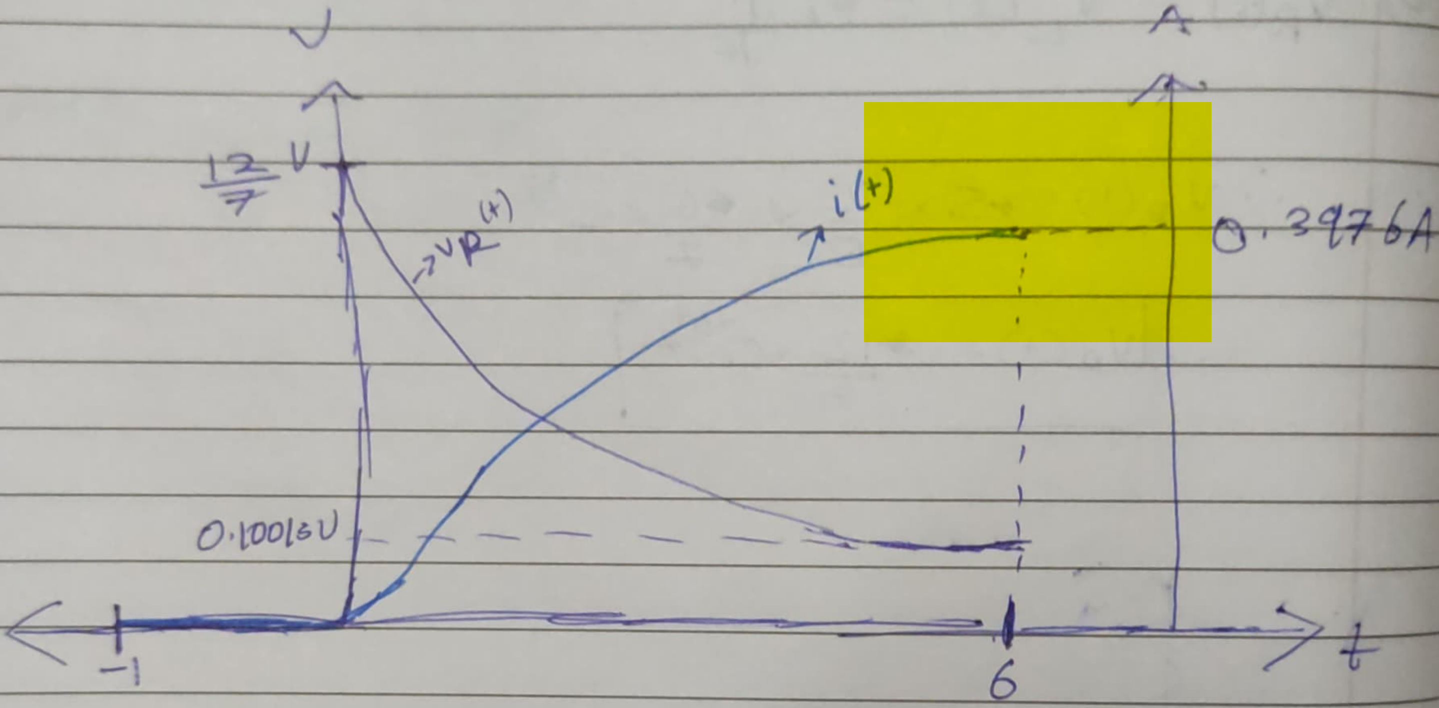
(v) $V_R(t) = V_L(t) = L\dfrac{di}{dt}$

$\therefore V_R(t) = 5 \times \dfrac{2}{5} \times \dfrac{6}{7} \times e^{-\frac{6t}{7}}$

$\therefore \boxed{V_R(t) = \dfrac{12}{7} \times e^{-\frac{6t}{7}}}$

(c)



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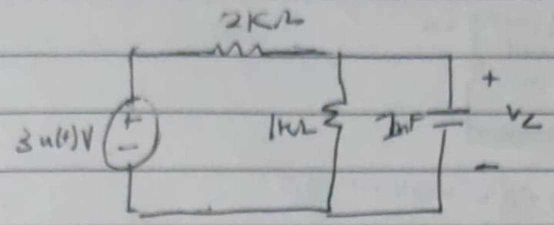
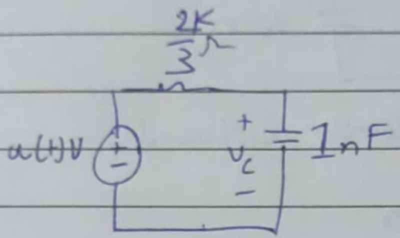
A7)



(a)

equivalent to



$$v_C \Rightarrow \frac{2\times10^3}{3}\frac{dq}{dt} + \frac{q}{1nF} = u(t)$$

$$\frac{dq}{dt} + \frac{3q}{2\times10^{-6}} = \frac{3}{2\times10^3}u(t)$$

$$q\,e^{\frac{3t}{2\times10^{-6}}} = \int \frac{3}{2\times10^{3}} e^{\frac{3t}{2\times10^{-6}}}\,dt$$

$$q\,e^{\frac{3t}{2\times10^{-6}}} = 10^{-9} e^{\frac{3t}{2\times10^{-6}}} + c$$

at $t=0$, $q=0$

$\therefore$

$$\boxed{q = 10^{-9}\left(1 - e^{\frac{-3t}{2\times10^{-6}}}\right)}$$

for $t>0$

otherwise $q=0$

$$\therefore \left[q\,e^{\frac{3t}{2\times10^{-6}}}\right]_{t=0}^{t=t} = \int_0^t \frac{3}{2} e^{\frac{3t}{2\times10^{-6}}} u(t)\,dt$$

$t=0 \Rightarrow q=0$,

$\therefore$

$$q = \left(\frac{3}{2} e^{\frac{-3t}{2\times10^{-6}}}\right) \times \int_0^t \frac{3}{2} e^{\frac{3t}{2\times10^{-6}}} u(t)\,dt$$

and $v_C = \frac{q}{1nF}$

Let 'a' be $\Rightarrow$ $\boxed{a = \frac{2}{3}\times10^{-6}}$

$\therefore$ we get

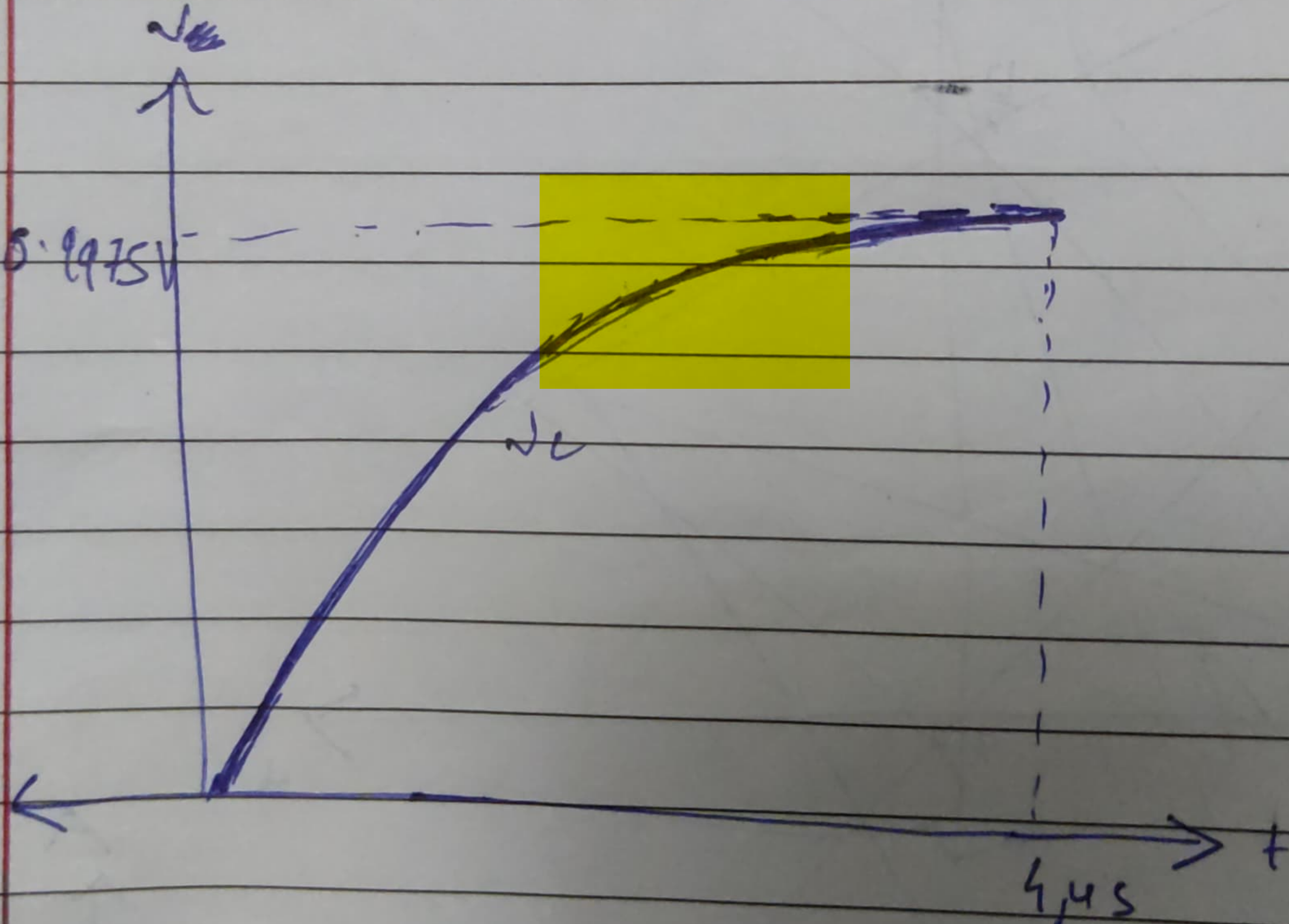
$$\boxed{v_C = \left(\frac{e^{-t/a}}{a}\right) \times \int_0^t e^{t/a}\,u(t)\,dt}$$

$\therefore V_C =$

$$v_C = \frac{q}{C}$$

$$\boxed{V_C = \left(1 - e^{-\frac{3t}{2\times10^{-6}}}\right)}$$ for $t \geq 0$, else $v_C = 0$

(b)



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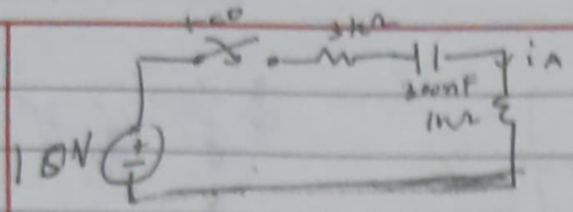
A8)



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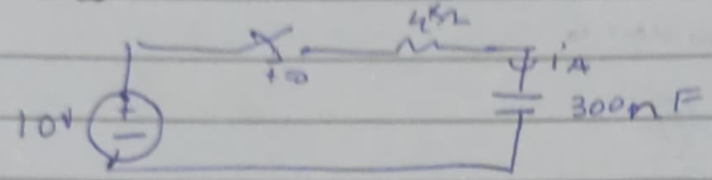

Since at $t=0$, switch is closed

$\therefore q(0) = 0$

$(i_A(0) = 0)$

$\therefore$ we have $4\times10^{3}\frac{dq}{dt} + \frac{q}{300\times10^{-4}} = 10$

$$\therefore \left[q\, e^{\frac{t}{1200\times10^{-6}}}\right]_{t=0}^{t=t} = \int_0^t \frac{10^{-2}}{4} e^{\frac{t}{1200\times10^{-6}}}\, dt$$

$\because q(0) = 0$

$$\therefore q = \left(\frac{10^{-2}\times1200\times10^{-6}}{4}\right) e^{-\frac{t}{1200\times10^{-6}}} \times \left(e^{\frac{t}{1200\times10^{-6}}} - 1\right)$$

$$\therefore q(t) = \cancel{3000}\cdot 3\mu C \times \left(1 - e^{-\frac{t}{1200\mu s}}\right)$$

$$i_A = \frac{dq}{dt} = \frac{3\times10^{-6}}{1200\times10^{-6}} e^{-t/1200\mu s}$$

$$\therefore \boxed{i_A = \left(2.5\, e^{-\frac{t}{\tau}}\right) mA \quad \text{when } \tau = 1200\mu s}$$

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