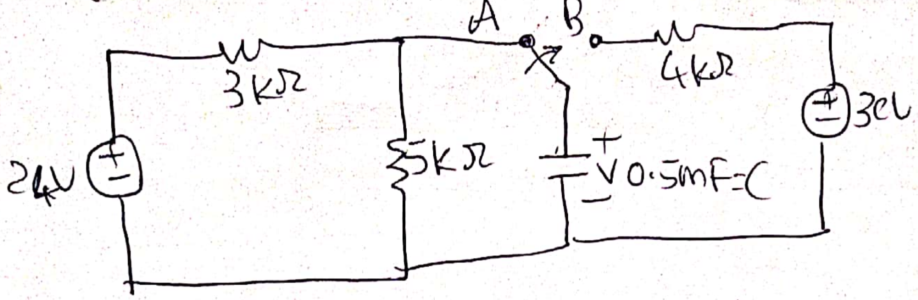
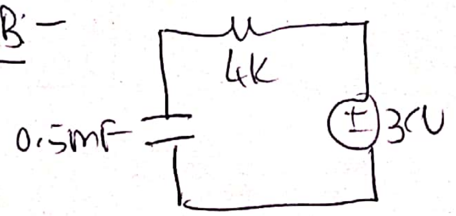
① Switch is at position 'A' for a long time. At $t=0$, switch moves to B. Determine $v(t)$ for $t \geq 0$; and calculate $v(t)$ at $t=1s$ and $4sec$.



a] At A:- After a long time 'C' acts like o.c. [at $t=0^-$]

$$\therefore \boxed{V(0^-) = \frac{24}{8k}\times 5k = 15V} = \underline{V(0^+)}$$

b] At $t=0^+$ switch at B:-



'C' acts like o.c. at $t=\infty$.

$$\therefore \boxed{V(\infty) = 30V}$$

$$\therefore v(t) = v(\infty) + [v(0^+) - v(\infty)]e^{-t/RC}$$

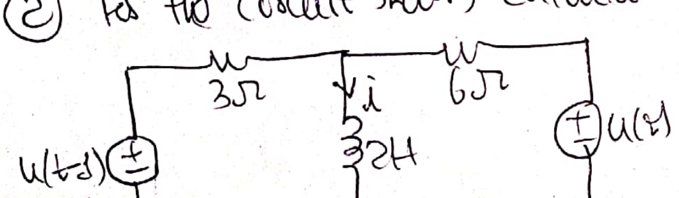
$RC = 4\times10^3 \times 0.5\times10^{-3}$

$\boxed{RC = 2sec.}$

$$\therefore \boxed{v(t) = (30 - 15e^{-0.5t})\,V}$$

$$\boxed{V(1) = 30 - 15e^{-0.5} = 20.9V} \quad \boxed{V(4) = 30 - 15e^{-2} = 27.97V}$$

② For the circuit shown, calculate $i(t)$ if $i(0)=0A$.



a] For $t<0$:- $u(t-1)=0$ and $u(t)=0$

$$\therefore \boxed{i(0^-) = 0A = i(0^+)}$$

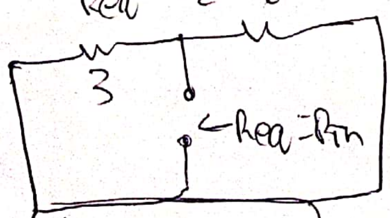
b] For $0<t<1$:- $u(t-1)=0$; $u(t)=1V$

$$\therefore \boxed{i(\infty) = \frac{1}{6}A} \text{ ['L' acts like s.c]}$$

$$\therefore \boxed{i(t) = i(\infty) + [i(0^+) - i(\infty)]e^{-t/\tau}\,A} \quad \boxed{\tau = 1sec}$$

$$\therefore \boxed{i(t) = \frac{1}{6}[1 - e^{-t}]\,A}$$

$$\tau = \frac{L}{R_{eq}} = \frac{2}{2} = \boxed{1sec.}$$

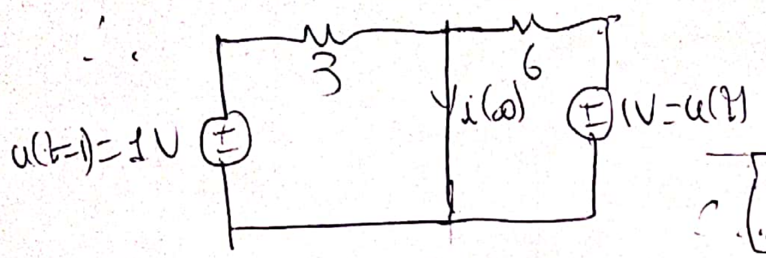


$\boxed{R_{Th} = 3 \| 6 = 2\Omega}$

c] For $t>1$:- $u(t-1)=1V$; $u(t)=1V$

∴ $\boxed{i(1)=\frac{1}{6}[1-e^{-1}]=0.1053A}$ $\boxed{i(\infty)=\frac{1}{3}+\frac{1}{6}=\frac{3}{6}=\frac{1}{2}A}$

'L' acts like s.c.



∴ $i(t)=i(\infty)+[i(1)-i(\infty)]e^{-t/1}$

∴ $\boxed{i(t)=0.5-0.3947e^{-t}\ A}$

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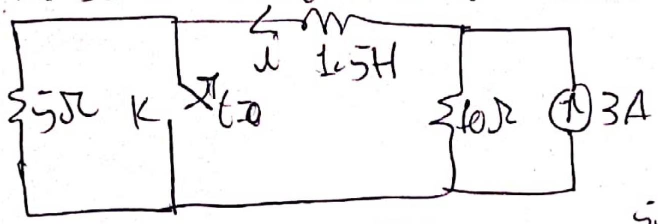
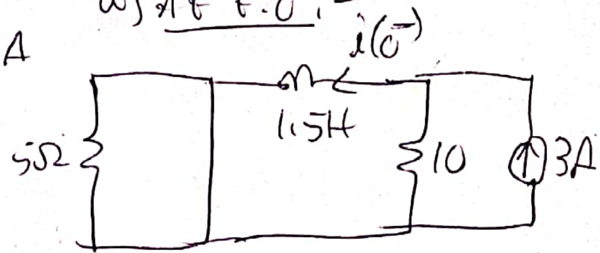
(3) The switch is closed for a long time, and opened at $t=0$. Find $i(t)$; $t\geq 0$.



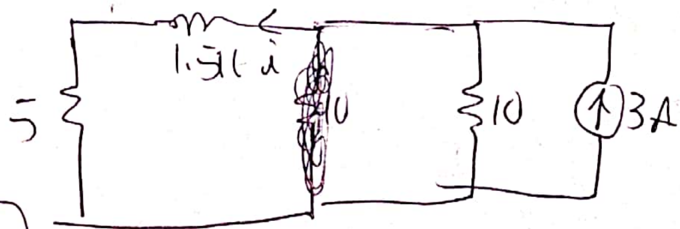
a] At $t=0^-$:-



5Ω shorted and 10Ω also.

∴ $\boxed{i(0^-)=i(0^+)=3A}$

b] At $t=0^+$:- 'K' is open.



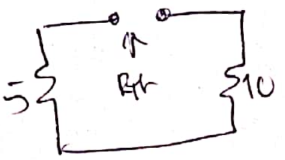
As $t\to\infty$ 'L' acts like s.c.

$\boxed{i(\infty)=\frac{3\times 10}{5+10}=\frac{30}{15}=2A}$

∴ $i(t)=i(\infty)+[i(0^+)-i(\infty)]e^{-tR/L}$

c] τ → time const:- De-activate independent sources and open inductor

Calculate R_{Th}, at $t=0^+$:-



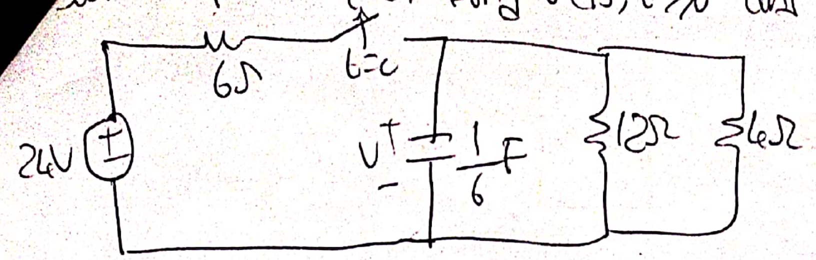
$\boxed{R_{Th}=15\Omega}$

$\boxed{\tau=\frac{L}{R}=\frac{1.5}{15}=0.1sec}$

∴ $i(t)=i(\infty)+[i(0)-i(\infty)]e^{-t/0.1}$

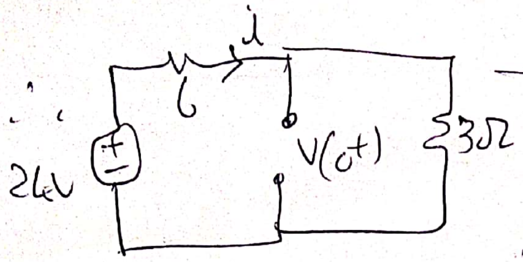
∴ $\boxed{i(t)=2+[3-2]e^{-t10}=2+e^{-10t}\ A}$

switch opens at $t=0$. Find $v(t)$, $t>0$ and $w_c(0)$.



a] When switch 'K' is closed:− $v(0^-) = v(0^+)$ = voltage across C

when s.s. is reached it acts like o.c.



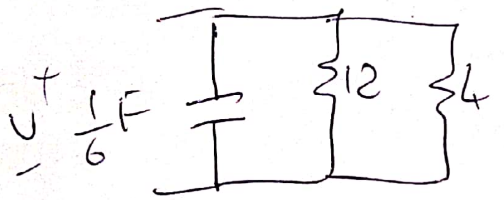
$$\boxed{i = \frac{24}{9} = \frac{8}{3} A}$$

$\therefore v(0^+) + 6i - 24 = 0$

$\therefore \cancel{v(0^+) = 24 - 6\times\frac{8}{3} = 24 - 16 = 8V}$ $\quad v(0^+) = 24 - 6\times(8/3)$

$$\therefore \boxed{v(0^+) = 24 - 16 = 8V}$$

b] When 'K' is open:− It is a source-free RC-ckt.



$$\boxed{R_{eq} = 12 \| 4 = 3\Omega}$$

$$\boxed{\tau = \frac{1}{6}\times 3 = \frac{1}{2}\text{ sec.}}$$

$\therefore v(t) = v(0^+)e^{-t/RC} = 8e^{-t/1/2} = \boxed{8e^{-2t}}$ Volts

c] $w_c(0) = \frac{1}{2}Cv^2(0^+) = \frac{1}{2}\times\frac{1}{6}\times 8^2 = \frac{64}{12} = \boxed{5.33J}$

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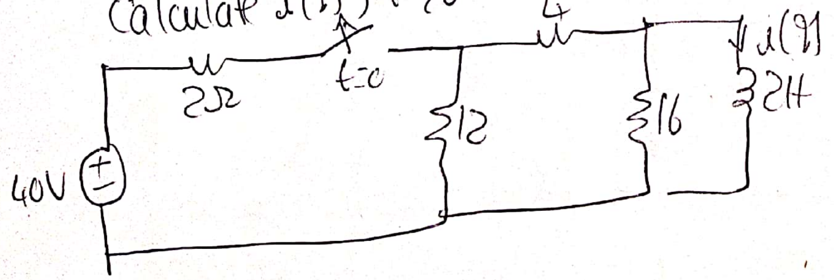
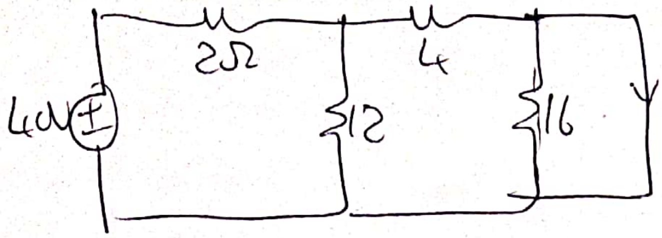
⑤ The switch is closed for a long time. At $t=0$, the switch is opened. Calculate $i(t)$; $t>0$



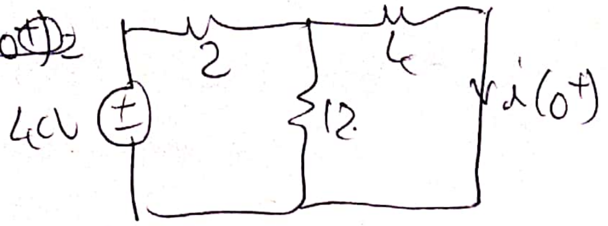
a] When 'K' is closed:- For along time 'L' acts like s.c.



$i(0^-)=i(0^+)$

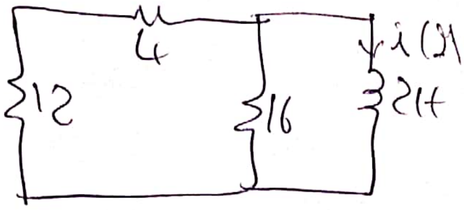
16Ω is shorted.

$\therefore i(0^+)=$



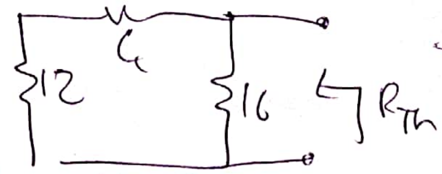
$$\boxed{i(0^+)=\frac{40}{5}\times\frac{12}{16}=6A}$$

b] When 'K' is open:-



→ Source-free R-L Ckt.

$$\therefore \boxed{\tau=\frac{L}{R_{Th}}}$$

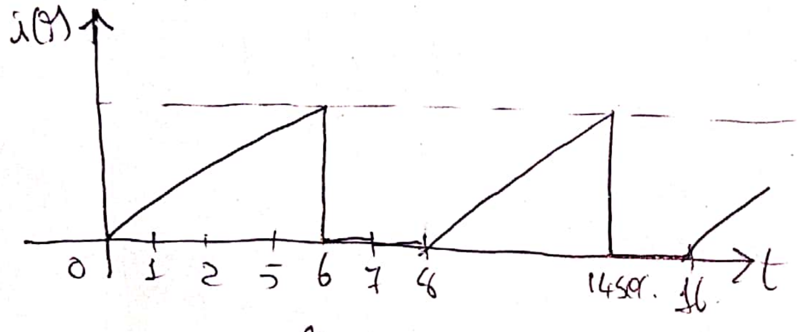


$$\boxed{R_{Th}=16\|16=8\Omega}$$

$$\therefore \boxed{\tau=\frac{2}{8}=\frac{1}{4}\,sec.}$$

$$\therefore \boxed{i(t)=i(0^+)e^{-t/\tau}=6e^{-4t}A}$$

(6) The current w/f is as shown in the figure, with a period of 8sec.
(a) What is the avg. value of current over a single period; (b) If $q(0)=0$; sketch $q(t)$ $0<t<20s$.



$\boxed{T=8sec}$

(a) $i_{avg}=\frac{1}{T}\int_0^T i(t)\,dt$

$\boxed{i(t)=t;\ 0\le t\le 6sec.}$

$\boxed{i(t)=0;\ 6\le t\le 8sec.}$

$$\therefore i_{avg}=\frac{1}{8}\int_0^8 \tau\,d\tau=\frac{1}{8}\int_0^6 \tau\,d\tau+\frac{1}{8}\int_6^8 0\,d\tau=\frac{1}{8}\times\frac{\tau^2}{2}\Big|_0^6$$

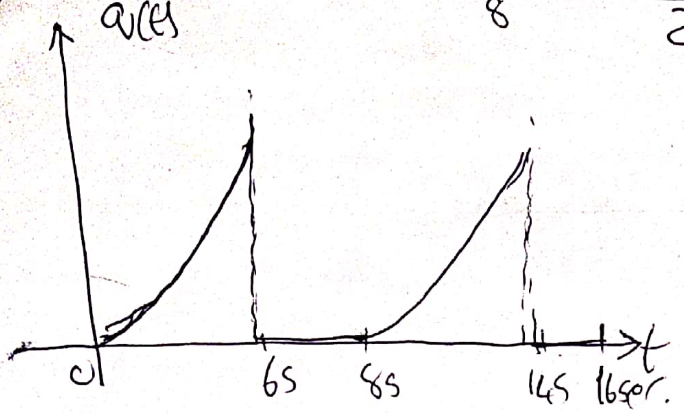
$$\therefore \boxed{i_{avg}=\frac{1}{16}[36-0]=\frac{36}{16}=2.25A}$$

$$\boxed{i(t)=\frac{dq(t)}{dt}}$$

(b) $\boxed{q(t)=\int_{-\infty}^{t} i(\tau)\,d\tau}=\int_0^t \tau\,d\tau=\frac{\tau^2}{2}\Big|_0^t=0.5t^2=\boxed{500t^2\,mC};\ 0\le t\le 6$

$=0;\ 6\le t\le 8sec.$

$8 \le t \le 14$ sec. $q(t) = \int_8^t \tau \, d\tau = \frac{\tau^2}{2}\Big|_8^t = 0.5[t-8]^2 = \boxed{500(t-8)^2 \text{ mC}}$



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(7) An new type of device accumulates charge according to expression $q(t) = (10t^2 - 22)$ mC (t in sec) [a] In interval $0 \le t \le 5$ sec. at what time does current flow into device is zero.

[b] Sketch $q(t)$ over the interval $0 \le t \le 5$ msec. and $i(t)$.

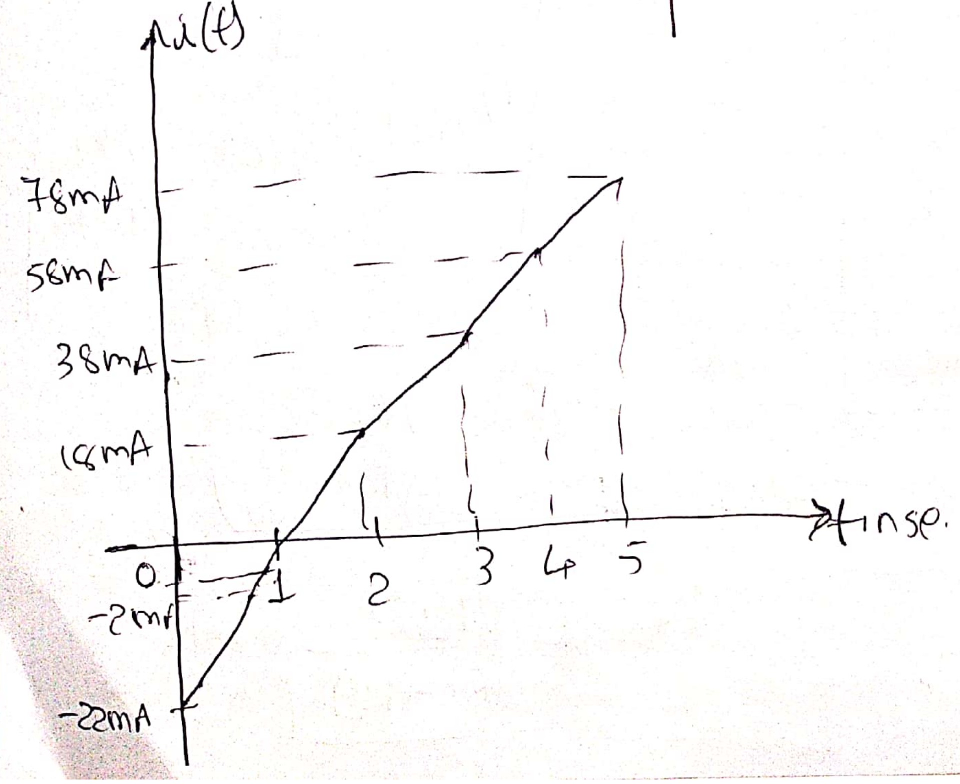
[a] $i(t) = \frac{dq(t)}{dt} = \frac{d}{dt}[10t^2 - 22] \Rightarrow (20t - 22) = 0$ mA $\boxed{t = 1.1 \text{ sec}}$

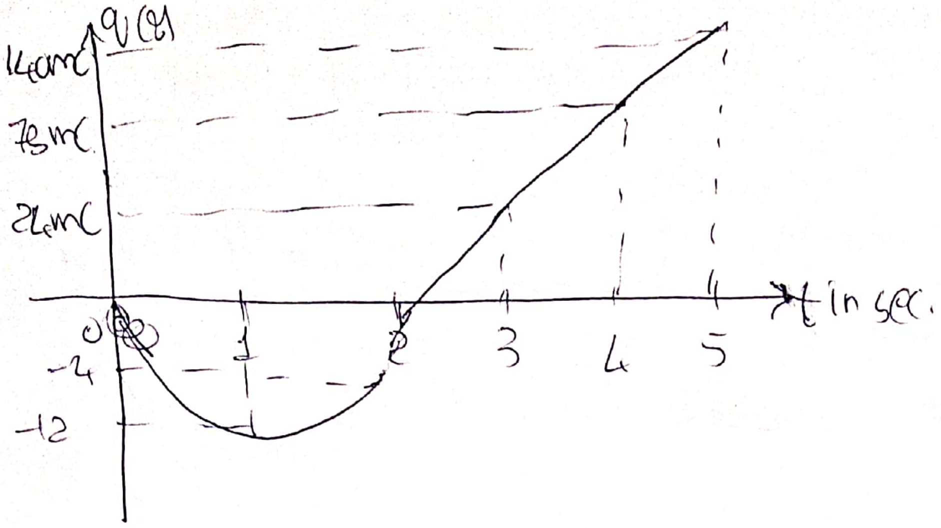
[b] $\boxed{i(t) = (20t - 22) \text{ mA}}$

$i(0) = -22$ mA	$i(3) = 38$ mA
$i(1) = -2$ mA	$i(4) = 58$ mA
$i(2) = 18$ mA	$i(5) = 78$ mA

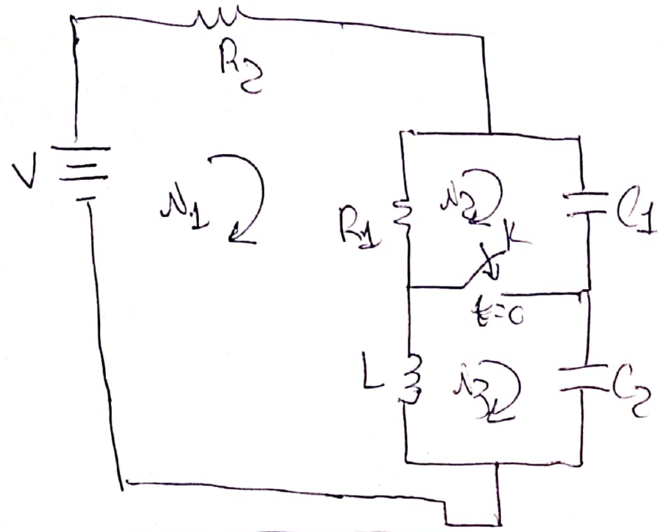
$\boxed{q(t) = (10t^2 - 22) \text{ mC}}$

$q(0) = 0$	$q(3) = 24$ mC
$q(1) = -12$ mC	$q(4) = 72$ mC
$q(2) = -4$ mC	$q(5) =$ [illegible] mC

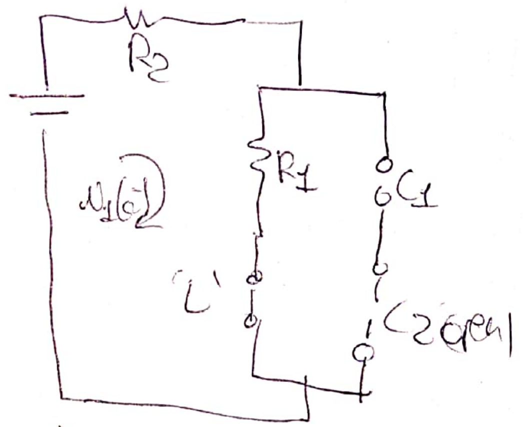




8. Find the values of all loop currents at $t=0^+$, K closed at $t=0$.



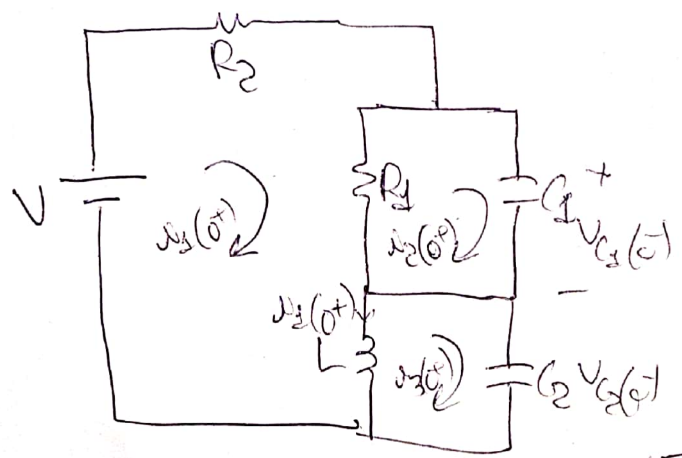
a] At $t=0^-$, with steady state reached when 'K' is open C_1, C_2 acts like o.c. and 'L' acts like s.c.



$$\boxed{i_1(0^-) = \frac{V}{R_1 + R_2} \text{ A}} \quad \text{—[1]}$$

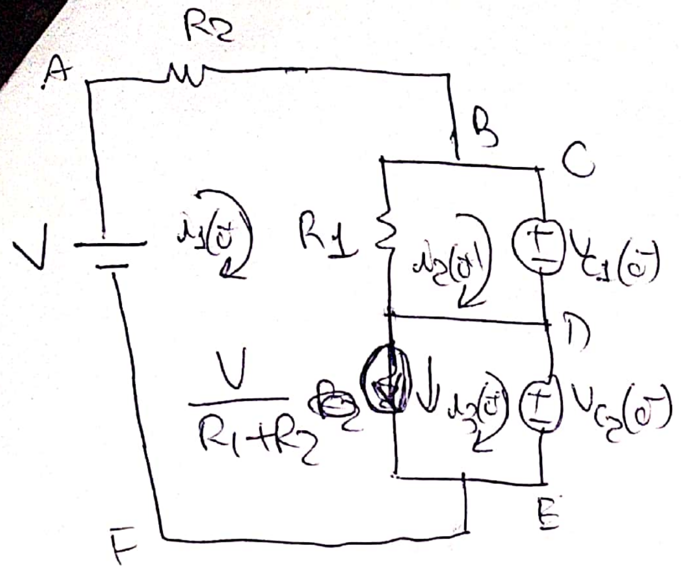
$$\boxed{V_{C_1}(0^-) + V_{C_2}(0^-) = \frac{V R_1}{R_1 + R_2}} \quad \text{—[2]}$$

b] At $t=0^+$:-



$$\boxed{V_{C_1}(0^-) = \frac{V R_1 C_2}{(C_1 + C_2)(R_1 + R_2)}} \quad \text{—[3]-a} \quad = V_{C_1}(0^+)$$

$$\boxed{V_{C_2}(0^-) = \frac{V R_1 C_1}{(C_1 + C_2)(R_1 + R_2)}} \quad \text{—[3]-b} \quad = V_{C_2}(0^+)$$



Applying KVL for mesh A-B-C-D-F-F-A :-

$$+V - R_2 i_1(0^+) - V_{C1}(0^+) - V_{C2}(0^+) = 0$$

$$\boxed{R_2 i_1(0^+) = V - V_{C1}(0^+) - V_{C2}(0^+)}$$

$$\cancel{R_2 i_1(0^+) = V - \frac{VR_1C_2}{(R_1+R_2)} - \frac{VR_1C_1}{R_1+R_2}}$$

$$R_2 i_1(0^+) = V - \frac{VR_1C_2}{(R_1+R_2)(C_1+C_2)} - \frac{VR_1C_1}{(R_1+R_2)(C_1+C_2)}$$

$$\therefore R_2 i_1(0^+) = \frac{VR_1C_1 + VR_1C_2 + VR_2C_1 + VR_2C_2 - VR_1C_2 - VR_1C_1}{(R_1+R_2)(C_1+C_2)}$$

$$\therefore i_1(0^+) = \frac{V\cancel{R_2}(C_1+C_2)}{\cancel{R_2}(R_1+R_2)(C_1+C_2)} = \boxed{\frac{V\cancel{(C_1+C_2)}}{(R_1+R_2)\cancel{(C_1+C_2)}}}$$

$$\therefore i_1(0^+) - i_3(0^+) = \frac{V}{R_1+R_2}$$

$$\therefore \boxed{i_3(0^+) = \frac{V}{R_1+R_2} - \frac{V}{R_1+R_2} = 0A}$$

KVL for mesh-2:-

$$+V_{C1}(0^+) + R_1[i_2(0^+) - i_1(0^+)] = 0$$

$$R_1 i_2(0^+) = R_1 i_1(0^+) - V_{C_1}(0^+)$$

$$\therefore R_1 i_2(0^+) = \frac{R_1 V}{(R_1+R_2)} - \frac{V R_1 C_2}{(C_1+C_2)(R_1+R_2)}$$

$$\therefore R_1 i_2(0^+) = \frac{V R_1 C_1 + V R_1 C_2 - V R_1 C_2}{(R_1+R_2)(C_1+C_2)}$$

$$\therefore i_2(0^+) = \frac{V R_1 C_1}{(R_1+R_2)(C_1+C_2) R_1} = \boxed{\frac{V C_1}{(R_1+R_2)(C_1+C_2)} A}$$