Set (N-2)

1

(a)

(i) phase difference = 0

(ii) Eqv impedence = 3Ω

(iii) $j\omega L + \frac{1}{j\omega C} = 0$

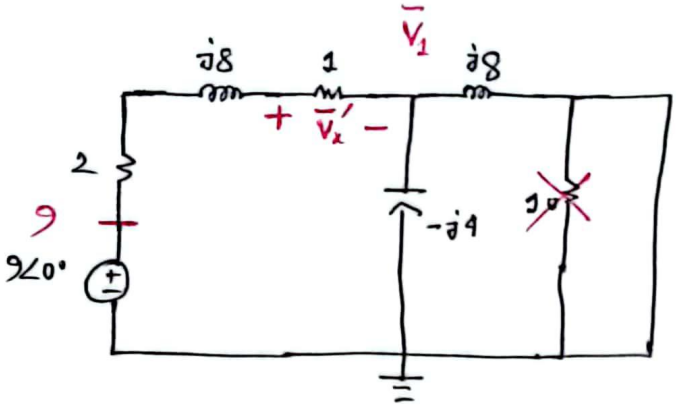
$\Rightarrow 0.04\,\omega = \frac{1}{0.25\,\omega}$

$\Rightarrow 0.01\,\omega^2 = 1$

$\Rightarrow \omega = \sqrt{\frac{1}{0.01}} = 10$ rad/s

(b)

9 sin(8t) active only:




$\omega = 8$

$1H \Leftrightarrow j\omega L = j \times 8 \times 1 = j8\,\Omega$

$\frac{1}{32}F \Leftrightarrow \frac{1}{j \times 8 \times 1/32} = -j4\,\Omega$

$\frac{\bar{V}_1}{-j4} + \frac{\bar{V}_1}{j8} + \frac{\bar{V}_1 - 9}{2+1+j8} = 0$

$\Rightarrow \bar{V}_1 \left(\frac{1}{-j4} + \frac{1}{j8} + \frac{1}{3+j8}\right) = \frac{9}{3+j8}$

$\Rightarrow \bar{V}_1 \left(\frac{3}{73} + j\frac{9}{584}\right) = \frac{9}{3+j8}$

$\Rightarrow \bar{V}_1 = -j24 = 24\angle -90°$

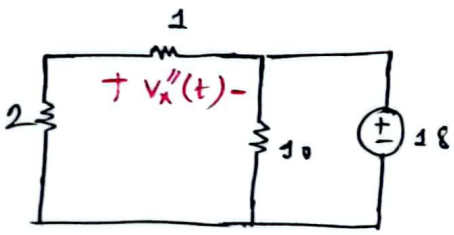
$\bar{V}_x' = 1 \times \frac{9 - \bar{V}_1}{3+j8}$

$= 1 \times \frac{9+j24}{3+j8}$

$= 3\angle 0°$

$v_x'(t) = 3\sin(8t)$

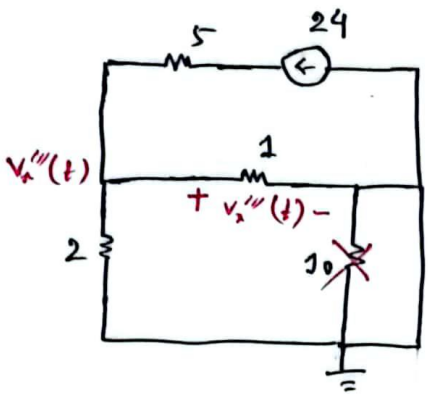
18V active only:




$v_x''(t) = -18 \times \frac{1}{1+2}$

$= -6\,V$

29 A active alone




$$\frac{V_x'''(t)}{3} + \frac{V_x'''(t)}{2} = 24$$

$$\Rightarrow V_x'''(t) \times \frac{3}{2} = 24$$

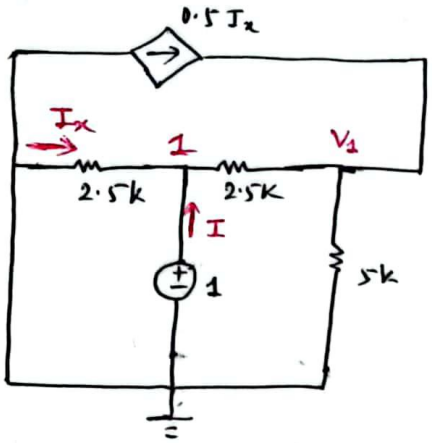
$$\Rightarrow V_x'''(t) = 24 \times \frac{2}{3} = 16\ V$$

$$V_x(t) = V_x'(t) + V_x''(t) + V_x'''(t)$$

$$= 3\sin(8t) - 6 + 16 = 3\sin(8t) + 10\ V$$

2

(a)




$$I_x = \frac{0 - 1}{2.5} = -0.4\ mA$$

$$\frac{V_1}{5} + \frac{V_1 - 1}{2.5} = 0.5\, I_x = 0.5(-0.4)$$

$$\Rightarrow \frac{3V_1}{5} = \frac{1}{5}$$

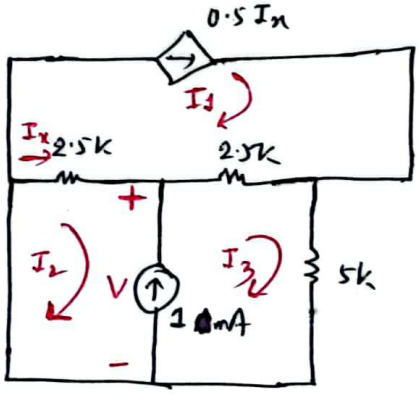
$$\Rightarrow V_1 = \frac{1}{3}\ V$$

$$I + I_x = \frac{1 - V_1}{2.5}$$

$$\Rightarrow I = \frac{1 - \frac{1}{3}}{2.5} + 0.4 = \frac{2}{3}\ mA$$

$$R_{TH} = R_L = \frac{1}{\frac{2}{3}} = \frac{3}{2}\ k\Omega = 1.5\ k\Omega$$

Mesh:




$$I_3 - I_2 = 1 \Rightarrow -I_2 + I_3 = 1 \quad \cdots (1)$$

$$I_1 = 0.5\, I_x = 0.5(I_2 - I_1)$$

$$\Rightarrow 1.5\, I_1 - 0.5\, I_2 = 0 \quad \cdots (2)$$

~~$2.5 I_2 + 2.5 I_3 + 5 I_3 =$~~

$$2.5(I_2 - I_1) + 2.5(I_3 - I_3) + 5 I_3 = 0$$

$$\Rightarrow -5 I_1 + 2.5 I_2 + 7.5 I_3 = 0 \quad \cdots (3)$$

$I_1 = -0.3A, \quad I_2 = -0.9A, \quad I_3 = 0.1A$

$I_x = I_2 - I_1 = -0.6\ A$

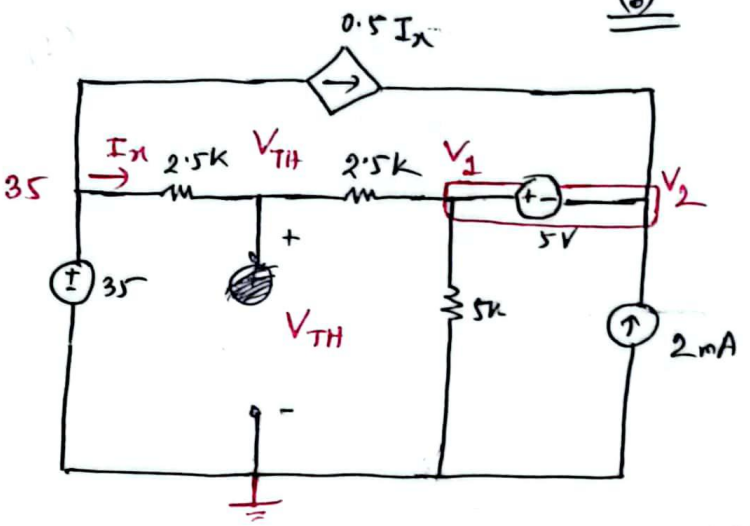
Now, $\quad 2.5 I_x + V = 0$

$\Rightarrow \quad V = 1.5\ V$

$$R_{TH} = R_L = \frac{1.5}{1\ mA} = 1.5\ k\Omega$$

(Ans)

(b)




$$I_x = \frac{35 - V_{TH}}{2.5}$$

$V_{TH} = 30V, \quad V_1 = 25V, \quad V_2 = 20V$

$V_{TH}$ Node-KCL

$$\frac{V_{TH} - 35}{2.5} + \frac{V_{TH} - V_1}{2.5} = 0$$

$$\Rightarrow \frac{4V_{TH}}{5} - \frac{V_1}{2.5} = 14 \quad \ldots(1)$$

Supernode

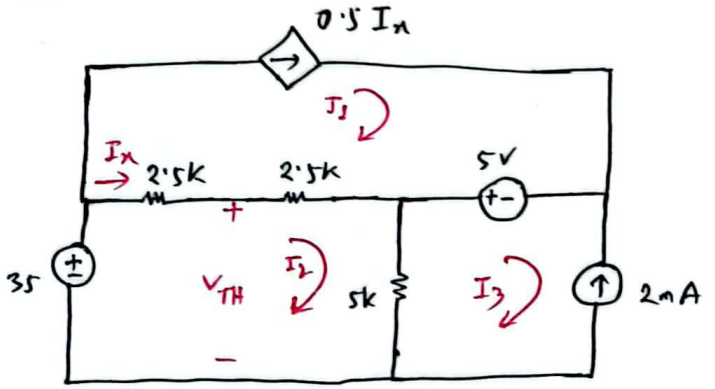
$$V_1 - V_2 = 5 \quad \ldots(2)$$

$$\frac{V_1 - V_{TH}}{2.5} + \frac{V_1}{5} = 2 + 0.5 I_x$$

$$\Rightarrow \frac{V_1 - V_{TH}}{2.5} + \frac{V_1}{5} = 2 + \frac{35 - V_{TH}}{5}$$

$$\Rightarrow \frac{3V_1}{5} - \frac{V_{TH}}{5} = 9 \quad \ldots(3)$$

Mesh:




$I_x = I_2 - I_1$

$I_1 = 0.5 I_x = 0.5 (I_2 - I_1)$

$\Rightarrow \quad 1.5 I_1 - 0.5 I_2 = 0 \quad \ldots(1)$

$I_3 = -2 \quad \ldots(2)$

$$2.5 (I_2 - I_1) + 2.5 (I_2 - I_1) + 5 (I_2 - I_3) = 35$$

$$\Rightarrow -5 I_1 + 10 I_2 - 5 I_3 = 35 \quad \ldots(3)$$

$I_1 = 1\ mA, \quad I_2 = 3\ mA, \quad I_3 = -2mA$

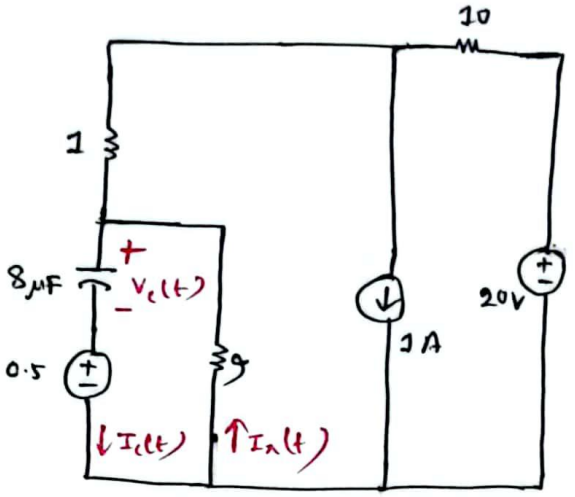
$I_x = I_2 - I_1 = 2\ mA$

$2.5 I_x + V_{TH} = 35 \quad \Rightarrow \boxed{V_{TH} = 30\ V}$

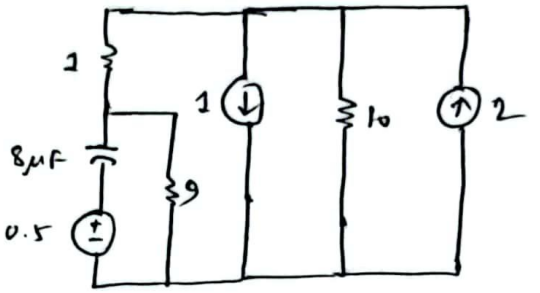
$$P_{max} = \frac{V_{TH}^2}{4R_{TH}} = \frac{30^2}{4 \times 1.5 \times 10^3} = 0.15\,W = 150\,mW$$

## 3

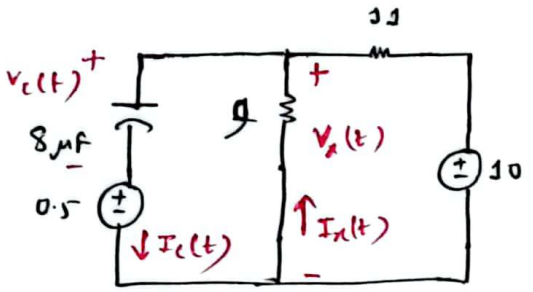
**t<0:**



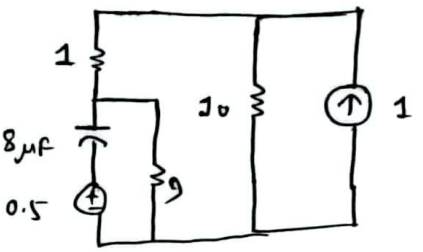

⇒




⇓



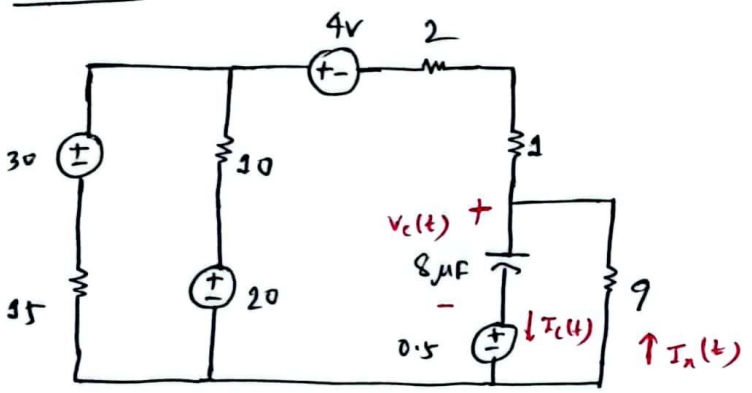

⇐



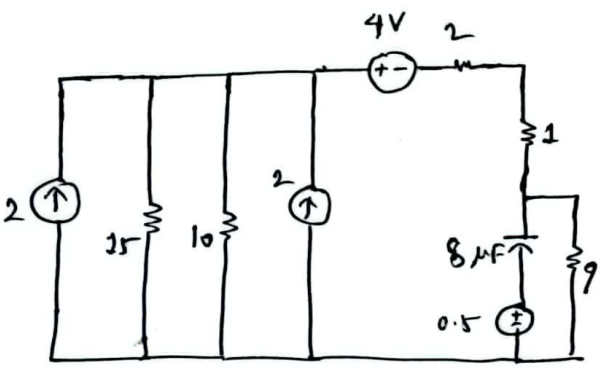

$$V_x(0^-) = \frac{9}{9+11} \times 10 = 4.5\,V \qquad I_c(0) = 0A$$

$$V_c(0^-) = V_x(0^-) - 0.5 = 4\,V$$

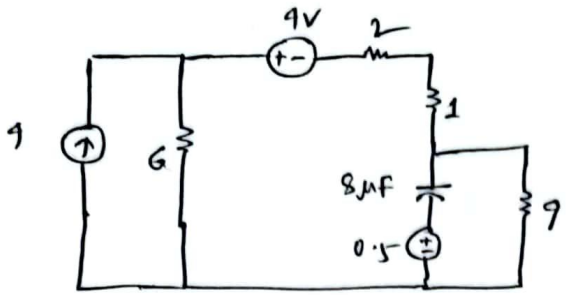
**t>0:**



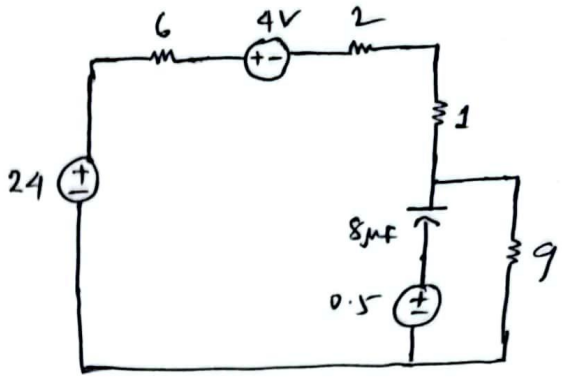

⇒




⇓



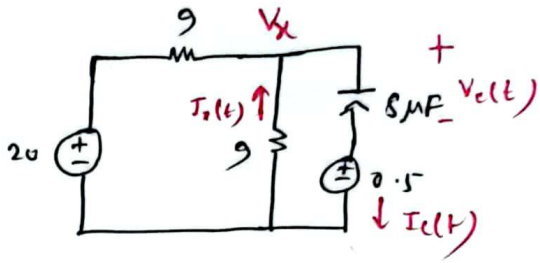

$\Rightarrow$




$\Downarrow$

$$V_x(\infty) = \frac{9}{9+9} \times 20 = 10V$$

$$V_c(\infty) = 10 - 0.5 = 9.5V$$




$$V_c(t) = V_c(\infty) + \left[ V_c(0) - V_c(\infty) \right] e^{-t/\tau}$$

$$= 9.5 + (4 - 9.5)\, e^{-\frac{t}{3.6\times10^{-5}}}$$

$$= 9.5 - 5.5\, e^{-27777.78t}$$

$$R_{TH} = 9 \| 9 = 4.5\Omega$$

$$\tau = R_{TH} C = 4.5 \times 8\times10^{-6}$$

$$= 3.6\times10^{-5} \text{ sec}$$

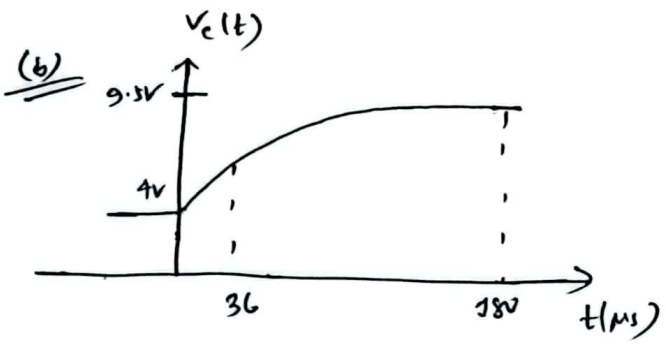
$$= 36\ \mu s$$

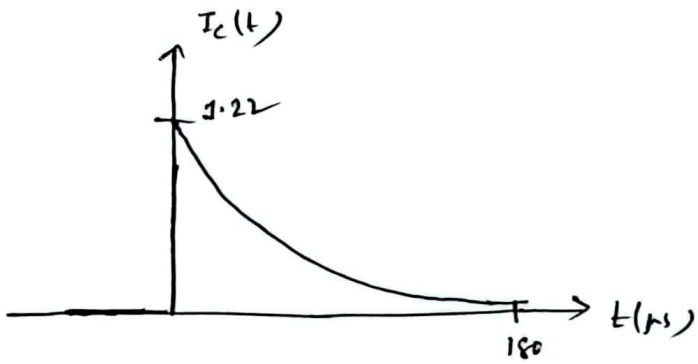
$$I_c(t) = C \frac{dV_c(t)}{dt}$$

$$= 8\times10^{-6} \times 5.5 \times 27777.78\, e^{-27777.78t}$$

$$= 1.22\, e^{-27777.78t}$$

(b)




(c) $V_x(t) = V_c(t) + 0.5 = 10 - 5.5\, e^{-27777.78t}$ V

$$I_x(t) = -\frac{V_x(t)}{9}$$

$$I_x(0.02) = -\frac{10}{9} = -1.11\ A$$