

$$1) a) -V_1 - 4i_d - 240 = 0 \quad V_1 = -4i_d - 240 \rightarrow 4i_d = -V_1 - 240$$

$$i_d = -0.25V_1 - 60$$

$$-19 + \frac{V_1}{40} + \frac{V_1 - V_2}{5} + i_d + \frac{-240 - V_2}{10} = 0$$

$$\left[\frac{1}{40} + \frac{1}{5}\right] \cdot V_1 - \left[\frac{1}{5} + \frac{1}{10}\right] V_2 + i_d = 19 + \frac{240}{10}$$

$$0.225V_1 - 0.3V_2 + i_d = 43$$

$$\downarrow$$

$$(-0.25V_1 - 60)$$

$$-0.025V_1 - 0.3V_2 = 103$$

$$\frac{V_2 - V_1}{5} + \frac{V_2 + 240}{10} - 2i_b = 0 \quad i_b = \frac{V_2 - V_1}{5}$$

$$\frac{V_2 - V_1}{5} + \frac{V_2 + 240}{10} - 2\left[\frac{V_2 - V_1}{5}\right] = 0$$

$$\left[-\frac{1}{5} + \frac{2}{5}\right] V_1 + \left[\frac{1}{5} - \frac{2}{5}\right] V_2 + \frac{V_2}{10} = -\frac{240}{10}$$

$$0.2V_1 - 0.1V_2 = -24$$

$$V_1 = -280 \quad V_2 = -320$$

$$i_a = \frac{V_1}{40} = \frac{-280}{40} = -7A$$

$$i_b = \frac{V_2 - V_1}{5} = \frac{-320 + 280}{5} = -8A$$

$$-19 + i_a - i_b + i_c = 0$$

$$i_c = 18A$$

$$i_c = \frac{-240 - V_2}{10} = 8A$$

$$-i_c + i_c + i_d = 0$$

$$i_d = i_c - i_c = 18 - 8 = 10A$$

$$[i_a = -7A]$$

$$[i_b = -8A]$$

$$[i_c = 8A]$$

$$[i_d = 10A]$$

$$[i_e = 18A]$$

$$b) i_3 - i_2 = 2i_b \quad ; \quad i_b = i_4 - i_2$$

$$i_3 - i_2 = 2(i_4 - i_2) \quad ; \quad i_1 = 19A$$

$$i_3 - i_2 = 2i_4 - 2i_2 \quad ; \quad i_d = i_3$$

$$\underline{i_3 = 2i_4 - i_2}$$

$$40(i_2 - i_1) + 5(i_2 - i_4) + 10(i_3 - i_4) - 240 = 0$$

$$-40i_1 + 45i_2 + 10i_3 - 15i_4 = 240$$

$$-760 + 45i_2 + 20i_4 - 10i_2 - 15i_4 = 240$$

$$\underline{35i_2 + 5i_4 = 1000}$$

$$-4i_d + 10(i_4 - i_3) + 5(i_4 - i_2) = 0$$

$$-4i_3 + 10i_4 - 10i_3 + 5i_4 - 5i_2 = 0$$

$$-5i_2 - 14i_3 + 15i_4 = 0$$

$$\underline{9i_2 - 13i_4 = 0}$$

$$\underline{i_2 = 26A \quad , \quad i_4 = 18A}$$

$$i_a = i_1 - i_2 = 19 - 26 = \underline{-7A}$$

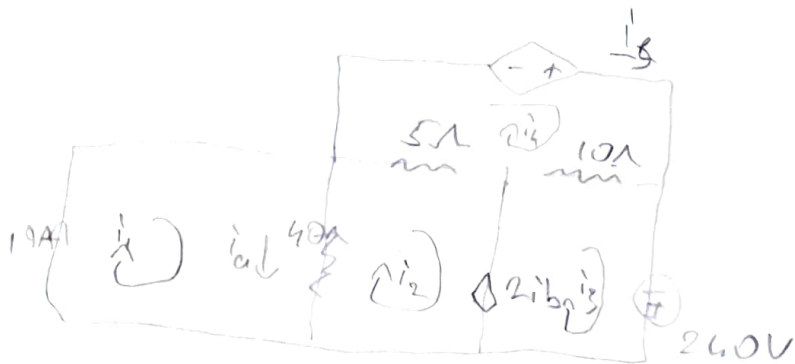
$$i_3 = 2(18) - 26 = \underline{10A}$$

$$i_b = i_4 - i_2 = 18 - 26 = \underline{-8A}$$

$$i_d = i_3 = \underline{10A}$$

$$i_c = i_4 - i_3 = 18 - 10 = \underline{8A}$$

$$i_e = i_4 = \underline{18A}$$



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$$c) P_{19A} = +V_1 \cdot i_{19A} = +280 \cdot 19 = +5320 \text{ W}$$

$$P_{40\Omega} = +i_a^2 \times 40 = (-7)^2 \times 40 = +1960 \text{ W}$$

$$P_{5\Omega} = +i_b^2 \times 5 = (-8)^2 \times 5 = +320 \text{ W}$$

$$P_{10\Omega} = i_c^2 \times 10 = (8)^2 \times 10 = +640 \text{ W}$$

$$P_{-240V} = -240 \times i_d = -240 \times 10 = -2400 \text{ W}$$

$$P_{2\Omega} = -V_2 \times 2i_b = -320 \times 2 \times -8 = -5120 \text{ W}$$

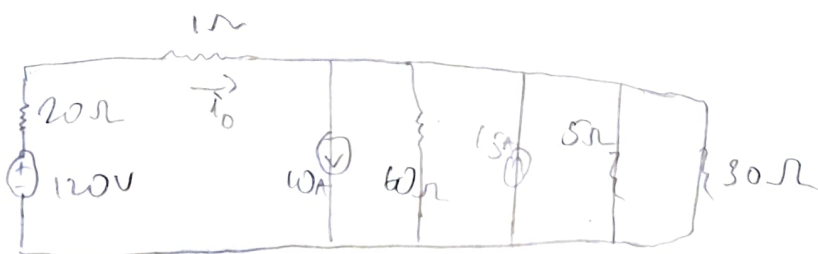
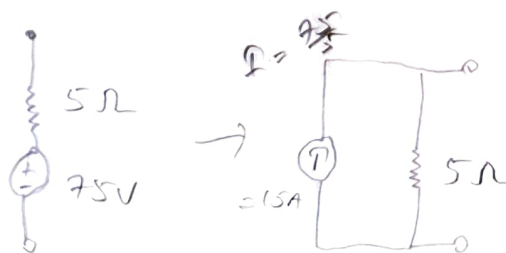
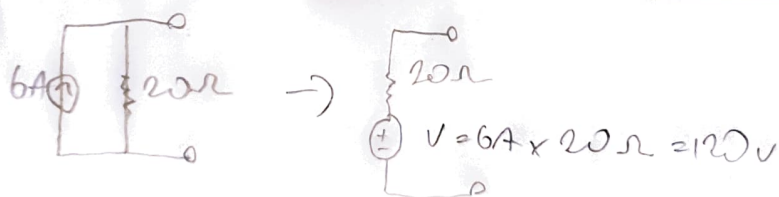
$$P_{4\Omega} = -4i_d \times i_e = 4 \times 10 \times 18 = -720 \text{ W}$$

$$P_{abs} = 5320 + 1960 + 320 + 640 = 8240 \text{ W}$$

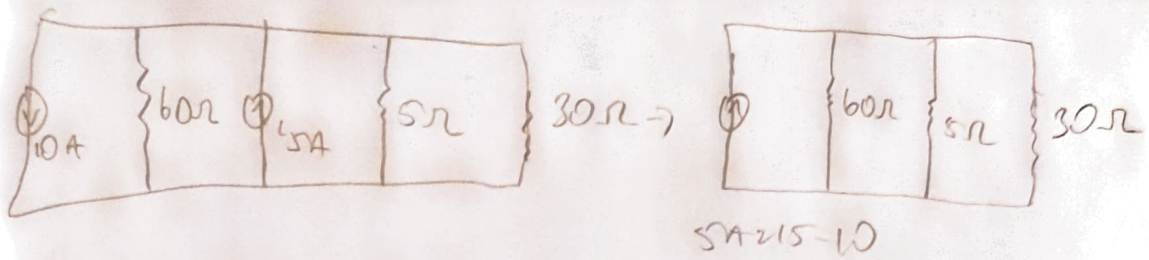
$$P_{del} = -2400 + 5120 + 720 = 8240 \text{ W}$$

$$P_{abs} = P_{del} \quad \text{verifed}$$

2) a)

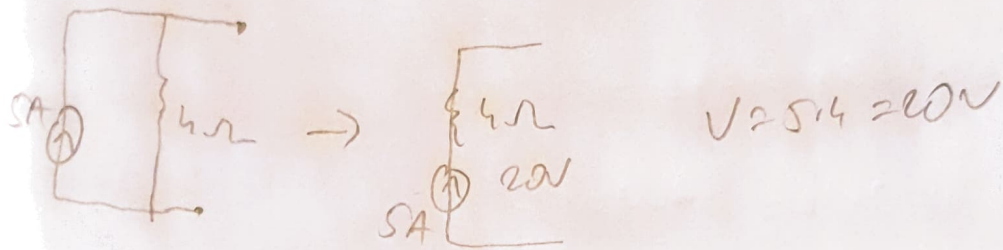


circuit will
1606 W

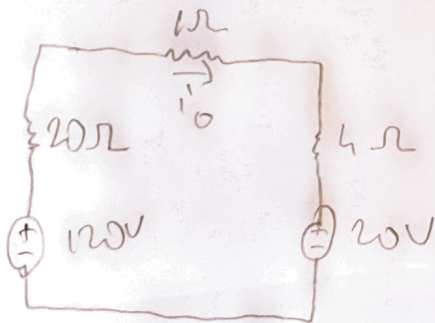


$$60 \parallel 5 \parallel 30 = 60 \parallel 30 = \frac{60 \cdot 30}{60 + 30} = 20 \Omega$$

$$20 \parallel 5 \parallel 30 = \frac{20 \cdot 5}{20 + 5} = \frac{100}{25} = 4 \Omega$$



It will look like



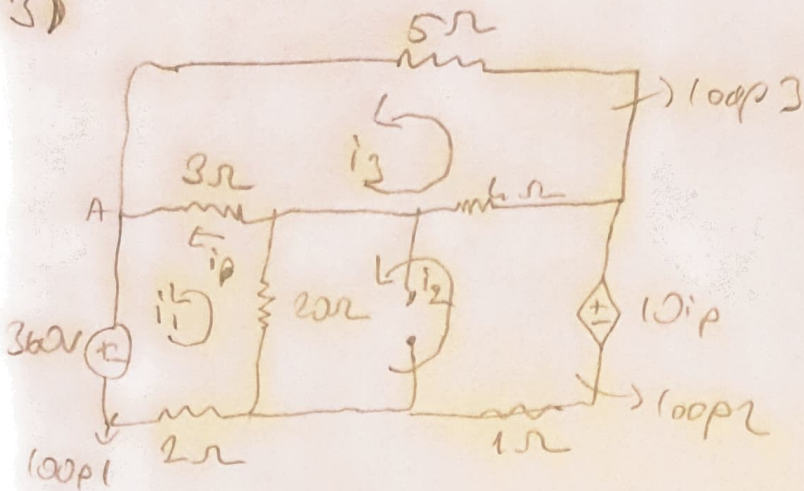
Apply KVL to find i_o

$$120 = 20i_o + i_o + 4i_o + 20$$

$$100 = 25i_o$$

$$i_o = \frac{100}{25} = 4A$$

3)



Apply KVL (loop 1)

$$360 + 2i_1 + 20(i_1 - i_2) + 3(i_1 - i_3) = 0$$

$$25i_1 - 20i_2 - 3i_3 = -360$$

$$i_3 + i_p = i_1 \quad i_p = i_1 - i_2$$

KVL (loop 2)

$$-10i_p + 4(i_2 - i_3) + 20(i_2 - i_1) + i_2 = 0$$

$$-20i_1 + 25i_2 - 4i_3 - 10(i_1 - i_2) = 0$$

$$-30i_1 + 25i_2 - 4i_3 = 0$$

KVL (loop 3)

$$5i_3 + 3(i_3 - i_1) + 4(i_3 - i_2) = 0$$

$$-3i_1 - 4i_2 + 12i_3 = 0$$

$$i_1 = 34.788 \text{ A}$$

$$i_2 = 57.314 \text{ A}$$

$$i_3 = 27.804 \text{ A}$$

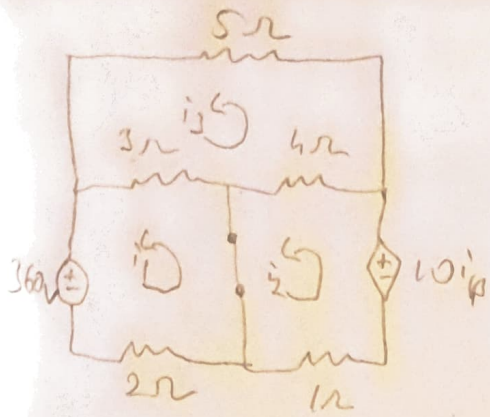
$$i_p = 6.987 \text{ A}$$

$$V_{th} + 1(i_2) - 10i_p + 4(i_2 - i_3) = 0$$

$$V_{th} + 5i_2 - 4i_3 - 10i_p = 0$$

$$V_{th} = -1057.496$$

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KVL (loop 1)

$$360 + 2i_1 + 3(i_1 - i_2) = 0$$

$$5i_1 - i_2 = -360$$

$$i_p = i_1 - i_2$$

Apply KVL (loop 2)

$$-10i_p + i_2 + 4(i_2 - i_3) = 0$$

$$-10i_1 + 5i_2 + 14i_3 = 0$$

KVL (loop 3)

$$5i_3 + 3(i_3 - i_1) + 4(i_3 - i_2) = 0$$

$$-3i_1 - 4i_2 + 12i_3 = 0$$

$$i_1 = -82.849 \text{ A}$$

$$I_{sc} = I_2 - I_1 = -100.602 + 82.849$$

$$i_2 = -100.602 \text{ A}$$

$$= -17.753 \text{ A}$$

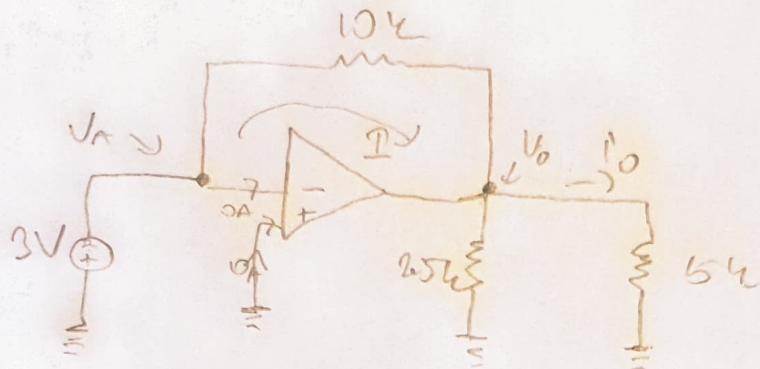
$$i_3 = -54.246 \text{ A}$$

$$R_{th} = \frac{V_{th}}{I_{sc}} = \frac{-105.496}{-17.753} = 5.942 \Omega$$

$$R_L = R_{th} = 5.942 \Omega$$

b) $(P_L)_{\max} = \frac{(V_{th})^2}{4 \cdot R_L} = \frac{(-105.496)^2}{4(5.942)} = \underline{\underline{468.251 \text{ W}}}$

4)



KT $\rightarrow V_A \Rightarrow -3$

KVL from V_A to $V_O \rightarrow -3 - 10 \cdot 10^3 I - V_O = 0$

$[V_O \Rightarrow -3 - 10 \cdot 10^3 I < -6]$

Node analysis at Node

$$\frac{V_O}{2.5 \cdot 10^3} + \frac{V_O}{5 \cdot 10^3} + \frac{V_O + 3}{10 \cdot 10^3} = 0$$

$$V_O \left(\frac{1}{2.5 \cdot 10^3} + \frac{1}{5 \cdot 10^3} + \frac{1}{10 \cdot 10^3} \right) = \frac{3}{10 \cdot 10^3}$$

$$V_O \left(\frac{1}{2.5} + \frac{1}{5} + \frac{1}{10} \right) = \frac{-3}{10} \quad \boxed{V_O = -0.428 \text{ V}}$$

$$\boxed{-6 < V_O < +6}$$

$$i_O = \frac{V_O}{5 \cdot 10^3} = \frac{-0.428}{5 \cdot 10^3} = 0.00056$$