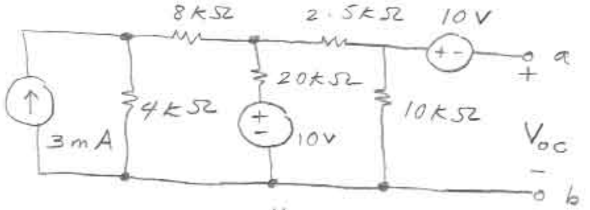
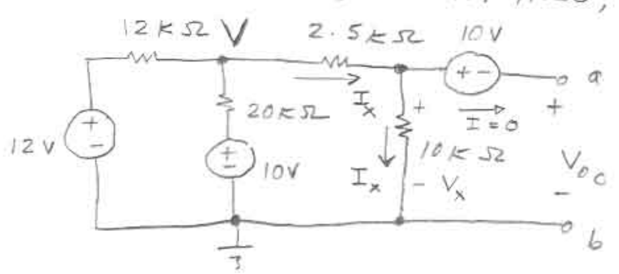
4.77

a) First find the Thevenin's Equivalent circuit. Remove the load:



⇓ source transformation for 3mA & 4kΩ, then combine 4kΩ & 8kΩ.



Use nodal analysis:

$$\frac{V-12}{12K} + \frac{V-10}{20K} + \frac{V}{12.5K} = 0$$

(notice that 2.5kΩ & 10kΩ are in series. Why?)

Solving $V = 7.031\ V$

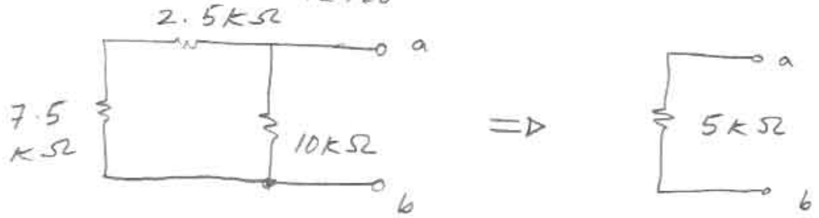
$$VDR \Rightarrow V_x = \left(\frac{10K}{10K + 2.5K}\right)(7.031) = 5.625V$$

$$\therefore V_{oc} = -10 + V_x = -10 + 5.625 = -4.375V$$

Next find R_{th} by setting all <u>independent</u> sources to zero:

$R_{eq} = R_{th}$

$12K \parallel 20K = \frac{12 \times 20}{12+20} K = 7.5 \, k\Omega$



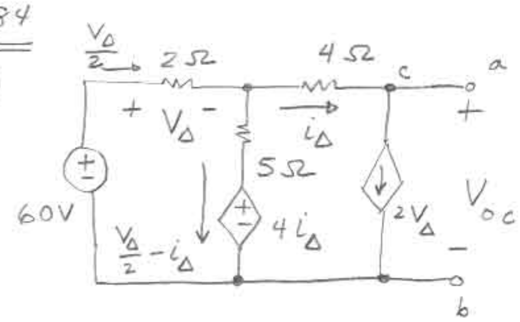
$\therefore \; R_{th} = 5 \, k\Omega.$

$\therefore \; R_o = R_{th} = 5 \, k\Omega \Leftarrow$ Answer to part a.

b) $P_{max} = \frac{V_{th}^2}{4R_{th}} = \frac{V_{oc}^2}{4R_{th}} = \frac{(-4.375)^2}{4 \times 5000} = 957 \, \mu W$

4.84

a)



⇐ Remove load & find the open-circuit voltage

$i_\Delta = 2 V_\Delta$ ① (KCL at node c)

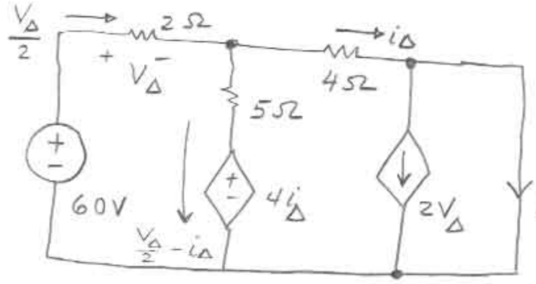
KVL $\Rightarrow -60 + V_\Delta + 5\left(\frac{V_\Delta}{2} - i_\Delta\right) + 4 i_\Delta = 0$

$3.5 V_\Delta - i_\Delta = 60$ ②

solving. $V_\Delta = 40 V$ & $i_\Delta = 80 A$

$V_{oc} = -4 i_\Delta - V_\Delta + 60 = -4 \times 80 - 40 + 60 = -300 V$

$\therefore \; V_{th} = -300 V$



⟸ Replace the load by a short circuit & find the current through it.

$$KVL \Rightarrow -60 + V_\Delta + 5\left(\frac{V_\Delta}{2} - i_\Delta\right) + 4i_\Delta = 0$$

$$3.5V_\Delta - i_\Delta = 60 \quad (1)$$

$$KVL \Rightarrow -60 + V_\Delta + 4i_\Delta = 0$$

$$V_\Delta + 4i_\Delta = 60 \quad (2)$$

$$V_\Delta = 20\,V \quad \& \quad i_\Delta = 10\,A$$

$$KCL \Rightarrow i_\Delta = 2V_\Delta + i_{sc} \Rightarrow i_{sc} = i_\Delta - 2V_\Delta$$

$$i_{sc} = 10 - 40 = -30\,A$$

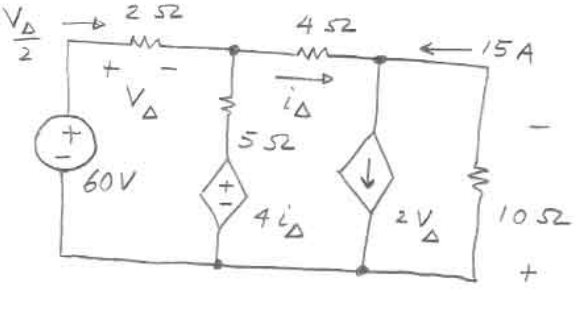
$$\therefore R_o = R_{th} = \frac{V_{oc}}{i_{sc}} = \frac{-300}{-30} = 10\,\Omega$$ ⟸ Answer to part a.

b) $$P_{max} = \frac{V_{th}^2}{4 \times R_{th}} = \frac{(-300)^2}{4 \times 10} = 2.25\,kW$$

c) Place the $10\,\Omega$ load which results in maximum power absorption, then calculate the resulting voltages and currents in the circuit to find the power associated with each element.

Notice that the voltage accross the $10\,\Omega$ resistor is $\frac{V_{th}}{2} = -\frac{300}{2} = -150$ V

(Why ?)



$$KVL \Rightarrow -60 + V_\Delta + 5\left(\frac{V_\Delta}{2} - i_\Delta\right) + 4i_\Delta = 0$$

$$3.5\,V_\Delta - i_\Delta = 60 \quad (1)$$

$$KVL \Rightarrow -60 + V_\Delta + 4i_\Delta - 150 = 0$$

$$V_\Delta + 4i_\Delta = 210 \quad (2)$$

$$\therefore \quad V_\Delta = 30\text{ V}, \quad i_\Delta = 45\text{ A}$$

Since the power can only be generated by sources, we find.

$$P_{60V} = -60\left(\frac{V_\Delta}{2}\right) = -60 \times \frac{30}{2} = -900\,W$$

$$P_{4i_\Delta} = +4i_\Delta\left(\frac{V_\Delta}{2} - i_\Delta\right) = 4 \times 45\left(\frac{30}{2} - 45\right)$$
$$= -5400\,W$$

$$P_{2V_\Delta} = -150\,(2V_\Delta) = -300(30) = -9000\,W$$

$\therefore$ Total power generated =

$900 + 5400 + 9000 = 15300\,W = 15.3\,KW$

$\therefore$ % of power absorbed by the $10\,\Omega$ load is:

$$\frac{2.25}{15.3} \times \frac{100}{100} = 14.71\%$$

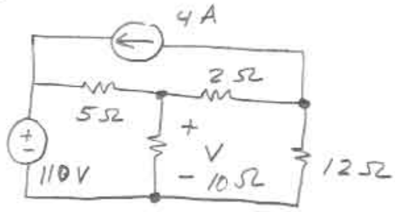
4.86 This problem is easy to solve, but it is tricky! Notice here that we are not trying to find the maximum power absorbed by R_o.

The fixed $8\,\Omega$ resistor will absorb more and more power as the current through it increases. It has a maximum current when $R_o = 0\,\Omega$. $\left(I_{max} = \frac{24}{8} = 3\,A\right)$.

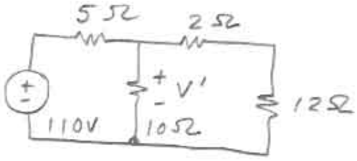
$$\therefore P_{max} = \left(\frac{24}{8}\right)^2 \times 8 = 72\,W.$$

4.87

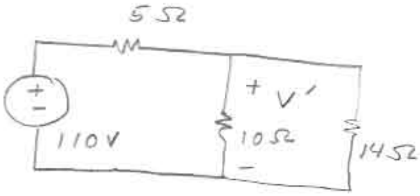
a)



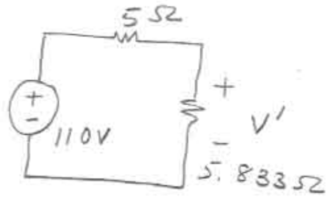
$V' = V|_{110V}$ ⇒



⇒

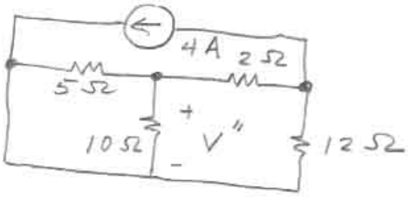


⇒

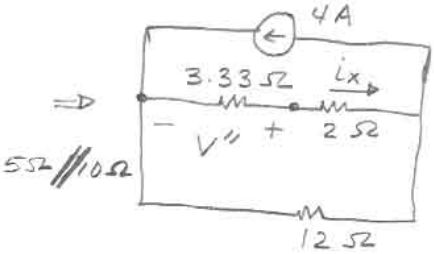


VDR ⇒ $V' = \frac{5.833}{10.833} \times 110 = 59.23\ V$

To find $V'' = V|_{4A}$ ⇒



⇒



CDR ⇒ $i_x = \frac{12}{3.33+2+12} \times 4 = 2.77\ A$

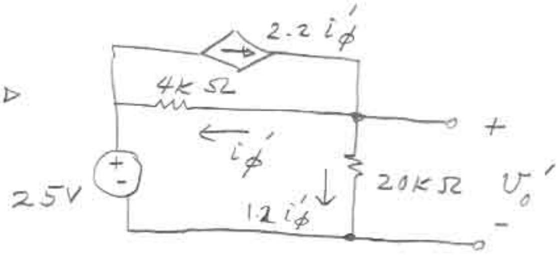
∴ $V'' = -3.33\, i_x = -3.33(2.77) = -9.22V$

∴ $V = V' + V'' = 59.23 - 9.22 = 50\ V$

b) $P_{10\Omega} = \frac{V^2}{R} = \frac{(50)^2}{10} = 250\ W$

4.90

$v_o' = v_o \big|_{25V} \Rightarrow$



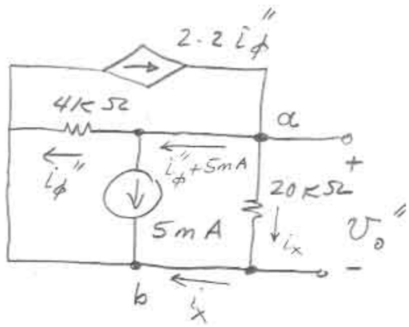
$KVL \Rightarrow -25 - 4000 i_\phi' + 20000(1.2 i_\phi') = 0$

$i_\phi' = \frac{25}{20000} = 1.25 \ mA$

$\therefore v_o' = 20k(1.2 i_\phi') = 20000 \times 1.2 \times 1.25 \times 10^{-3}$

$= 30V$

$v_o'' = v_o \big|_{5mA} \Rightarrow$



KCL at node a $\Rightarrow$

$i_x = 2.2 i_\phi - (i_\phi'' + 5mA)$

$= 1.2 i_\phi - 5mA$

$KVL \Rightarrow -4000 i_\phi'' + 20000 i_x = 0$

$-4000 i_\phi'' + 20000(1.2 i_\phi'' - 5mA) = 0$

$20000 i_\phi'' = 100$

$i_\phi'' = \frac{1}{200} = 5mA \Rightarrow v_o'' = 20000 i_x$

$\therefore v_o'' = 20000(1.2 \times 5mA - 5mA) = 20V$

$\therefore v_o = v_o' + v_o'' = 30 + 20 = 50V$