Name: Solution

Student Id: 

Presented here are one of many different ways to solve these problems.

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1. (12+4+4 points) Using nodal analysis, (a) calculate the value of $i_0$ in the following circuit. Calculate the power generated/consumed by (b) the current dependent current source ($2i_0$) and (c) 20Ω resistance.

\[
\begin{align*}
\text{KCL at } & \quad 1: \quad \frac{v_1-10}{20} + \frac{v_1}{10} + \frac{v_1-v_2}{10} = 0 \\
& \quad 2: \quad \frac{v_1-v_2}{10} + 2i_0 + \frac{10-v_2}{10} = 0 \quad , \quad i_0 = \frac{v_1}{10} \\
\end{align*}
\]

\[
\begin{align*}
v_1-10 + 2v_1 + 2v_1-2v_2 = 0 & \quad 5v_1 - 2v_2 = 10 \\
v_1 - v_2 + 2v_1 + 10 - v_2 = 0 & \quad 3v_1 - 2v_2 = -10 \\
2v_1 = 20 & \quad v_1 = 10 \\
v_2 = 20 &
\]

(a) $i_0 = \frac{v_1}{10} = \frac{10}{10} = 1 \text{ A}$

(b) $P_{2i0} = v_2 \cdot i_0 = 20x-(2x1) = -40 \text{ W} \quad \text{(provide power)}$

(c) $P_{20i} = (v_1-10) \cdot i_{20i} = 0 \text{ W} \quad \text{(no power consumed)}$
2. (15+5 points) Using superposition theorem, calculate the voltage and the power of 6kΩ resistor in the following circuit.

With 2mA Source Only:

\[ i_{6k} = 2mA, \quad \frac{(2k+1k)}{6k+(2k+1k)} = \frac{2}{3} \text{ mA} \]

\[ V_{6k} = \frac{2}{3} \text{ mA} \cdot 6k = \frac{12}{3} = 4 \text{ V} \]

With 3V Source Only:

\[ i_{6k} = \frac{3}{(6+1+2)}k = \frac{1}{6} \text{ mA} \]

\[ V_{6k} = 3 \cdot \frac{6k}{(6+2+1)k} = 2 \text{ V} \]

\[ i_{6k} = \frac{2}{3} \text{ mA} + \frac{1}{3} \text{ mA} = 1 \text{ mA} \]

\[ V_{6k} = 4 + 2 = 6 \text{ V} \]

\[ P_{6k} = V_{6k} \cdot i_{6k} = 6 \cdot 1 \text{ m} = 6 \text{ mW} \]
3. (20 points) For the following circuit determine the value of $R_{\text{load}}$ that would result in maximum power being transferred to $R_{\text{load}}$. (Hint: Δ-Y conversion would help you simplify the network.)

**Using Δ-Y conversion with Y network in the circuit drawn**

($R_d = 3 R_f$)

For maximum power transfer

$R_{\text{load}} = 15 \Omega$
4. (10+10 points) Determine the Thevenin equivalent for the following circuit:

\[ V_{th} = V_{oc} = V_x \]

KCL at X, \[ \frac{5-V_x}{20K} + \frac{0.5V_x-V_x}{10K} = 0 \]

\[ 5-V_x + V_x - 2V_x = 0 \]

\[ V_x = \frac{5}{2} \text{V} \]

To find \( R_{th} \), turn off the independent source and apply test source to the port, then \( R_{th} = \frac{V_{test}}{I_{test}} \).

\[ I_{test} = \frac{V_x}{20K} + \frac{V_x-0.5V_x}{10K} \]

\[ = \frac{1}{20K} + \frac{1}{20K} \]

\[ \Rightarrow V_x = V_{test} = 1 \text{V} \]

\[ R_{th} = \frac{1}{(10K)} = 10K \\text{Ω} \]
5. (10+10 points) Consider the following transistor circuit with $V_{BE}=0.7\,V$ and $\beta=99$. Determine the $V_0$ and $V_{CE}$.

$$I_B = 0.1\,mA$$
$$I_C = \beta I_B = 99 \times 0.1 = 9.9\,mA$$
$$I_E = (\beta+1) I_B = 100 \times 0.1 = 10\,mA$$

$$V_0 = I_E \times 500 = 10\,mA \times 500 = 5\,V$$

KVL along the loop in the figure

$$-20 + I_E \times 1000 + V_{CE} + V_0 = 0$$

$$V_{CE} = 20 - 9.9\,mA \times 1000 - 5$$
$$= 20 - 9.9 - 5$$
$$= 5.1\,V$$