Problem 1

a)

Wye-Delta transformation

\[ R_x = \frac{R^2}{3R} = \frac{R}{3} \]

b)

KVL: \( -U_{s1} + i(R_{s1} + R_{s2}) + U_{s2} = 0 \)

\[ i = \frac{U_{s1} - U_{s2}}{R_{s1} + R_{s2}} = \frac{1V - 4V}{2k\Omega + 1k\Omega} = \frac{-3V}{3k\Omega} = -1mA \]

KVL w/ \( U_{ab} \): \( -U_{s1} + iR_{s1} + U_{ab} = 0 \)

\[ U_{ab} = U_{s1} - iR_{s1} = 1V - (-1mA)(2k\Omega) = 1V + 2V = 3V \]

c)

Norton equivalent source

\[ \frac{U_{1}}{R_{1}} \]

Resistors are in parallel → can be combined

Current sources are in parallel → can be combined

\( (\frac{U_{1}}{R_{1}} + I_{1}) (R_{1} || R_{2}) \) →

Source transformation

\[ U_{th} = (\frac{U_{1}}{R_{1}} + I_{1})(R_{1} || R_{2}) \]

\[ R_{th} = \frac{R_{1}R_{2}}{R_{1} + R_{2}} \]

d)

The current source is supplying power.

\[ U_{ab} = (\frac{U_{1}}{R_{1}} + I_{1}) \cdot R \]

\[ = (\frac{1V}{1k\Omega} + 1A) \cdot 1k\Omega = 2V \]

\[ P = (U_{ab})(-I_{1}) = -2W, P < 0 \]
Problem 2

(a) Node 1:
- KVL shows no current flows in the triangle
  \[ I R_7 + I R_8 + I R_9 = 0 \]
  \[ I (R_7 + R_8 + R_9) = 0 \Rightarrow I = 0 \]
- KCL:
  \[ \frac{U_1 - U_A}{R_3} + \frac{U_1 - U_2}{R_1} = 0 \Rightarrow \text{EQ1} \]

(b) Node 2 & 3:
- Nodes 2 & 3 form a supernode b/c only a voltage source in between
- KCL:
  \[ \frac{U_2 - U_1}{R_1} + \frac{U_2}{R_2} + I_B - I_A = 0 \Rightarrow \text{EQ3} \]

System of equations:

EQ1: \[ \frac{U_1 - U_A}{R_3} + \frac{U_1 - U_2}{R_1} = 0 \Rightarrow \left( \frac{1}{R_1} + \frac{1}{R_3} \right) U_1 + \left( -\frac{1}{R_1} \right) U_2 = \frac{U_A}{R_3} \]

EQ2: \[ \frac{U_2 - U_1}{R_1} + \frac{U_2}{R_2} - I_A = 0 \Rightarrow \left( -\frac{1}{R_1} \right) U_1 + \left( \frac{1}{R_1} + \frac{1}{R_2} \right) U_2 = I_A \]

Current through R_7 is 0, so U_x = 0, so αUX = 0, so \[ U_3 = U_2 \]
\[ i_1 = \alpha V_x \]

\[ I_A = i_2 - i_1 \]

\[ (i_4 - i_1)R_4 + (i_4 - i_2)R_9 + i_4R_8 = 0 \]

\[ -V_A + i_3R_T + (i_3 - i_2)R_6 = 0 \]

\[ V_x = i_3R_T \]

**total 5 unknowns: \( i_1, V_x, i_2, i_3, i_4 \)**

**total 5 equations**

\[ \therefore \text{ fulfills requirement} \]

\[ \begin{align*}
  i_1 & = \alpha V_x \\
  -i_1 + i_2 & = I_A \\
  -R_4 i_1 - R_9 i_2 + (R_4 + R_8 + R_9) i_4 & = 0 \\
  -R_6 i_2 + (R_6 + R_T) i_3 & = V_A \\
  R_T i_3 & = V_x
\end{align*} \]
### Question 4

![Circuit Diagram](image)

**Step 1:** Put a ground = 0V

**Step 2:** Use KCL (Kirchhoff's Current Law)

**Step 3:** Use KCL

**Step 4:** Use KCL

**Step 5:** Use KCL

**Step 6:** Voltage drop

### Table: Power and Consuming/Providing

<table>
<thead>
<tr>
<th>Unknown Element</th>
<th>Symbol</th>
<th>Power Mag. (W)</th>
<th>Consuming or Providing</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>+ 3/2 V by @1A</td>
<td>1 \cdot (0 - 3/2) = 3/2</td>
<td>Providing</td>
</tr>
<tr>
<td>2</td>
<td>- 5/4 V</td>
<td>1/2 = 1/4</td>
<td>Consuming</td>
</tr>
<tr>
<td>3</td>
<td>- 5/4 V</td>
<td>3 \cdot 3/4 = 9/16</td>
<td>Consuming</td>
</tr>
<tr>
<td>4</td>
<td>- 5/4 V</td>
<td>5 \cdot 5/4 = 25/16</td>
<td>Consuming</td>
</tr>
<tr>
<td>5</td>
<td>- 5/4 V</td>
<td>1/4 \cdot 5/4 = 5/16</td>
<td>Consuming</td>
</tr>
</tbody>
</table>

### Additional Diagrams

- **OR Circuit:** ![OR Circuit Diagram](image)

- **Series Circuit:** ![Series Circuit Diagram](image)

- **Parallel Circuit:** ![Parallel Circuit Diagram](image)
Q4 rubric

Each correct symbol, e.g. \( \text{\includegraphics[width=0.05\textwidth]{resistor}} \), \( \text{\includegraphics[width=0.05\textwidth]{batterysymbol}} \) worth 2 points. In total there should be 5 symbols.

Each correct symbol value with correct unit, e.g., 1.5V, 1 ohm, worth 1 point. In total there should be 5 values with correct unit.

Each correct power magnitude worth 1 point. In total there should be 5 power magnitudes.

Each correct consuming or providing power, worth 1 point. In total there should be 4 consuming and 1 providing.