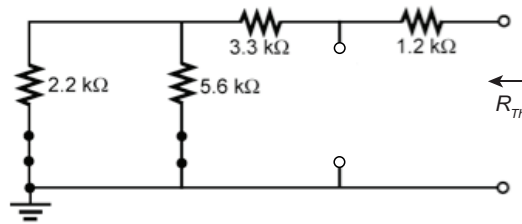


$$V = \frac{1.2 \text{ k}\Omega(12 \text{ V})}{1.2 \text{ k}\Omega + 4.03 \text{ k}\Omega} = 2.75 \text{ V}$$

18. R_{Th} :



$$\begin{aligned} R_{Th} &= 1.2 \text{ k}\Omega + 3.3 \text{ k}\Omega + 2.2 \text{ k}\Omega \parallel 5.6 \text{ k}\Omega \\ &= 4.5 \text{ k}\Omega + 1.58 \text{ k}\Omega \\ &= \mathbf{6.08 \text{ k}\Omega} \end{aligned}$$

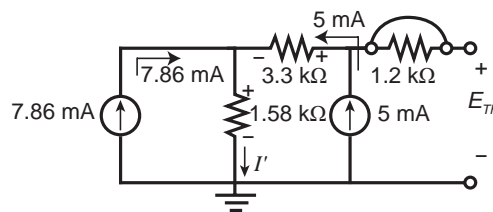
E_{Th} : Source conversions:

$$\uparrow I_1 = \frac{22 \text{ V}}{2.2 \text{ k}\Omega} = 10 \text{ mA}, R_s = 2.2 \text{ k}\Omega$$

$$\downarrow I_2 = \frac{12 \text{ V}}{5.6 \text{ k}\Omega} = 2.14 \text{ mA}, R_s = 5.6 \text{ k}\Omega$$

Combining parallel current sources: $I'_T = I_1 - I_2 = 10 \text{ mA} - 2.14 \text{ mA} = 7.86 \text{ mA} \uparrow$

and $2.2 \text{ k}\Omega \parallel 5.6 \text{ k}\Omega = 1.58 \text{ k}\Omega$



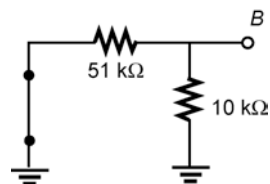
$$I' = 7.86 \text{ mA} + 5 \text{ mA} = 12.86 \text{ mA}$$

$$V_{3.3\text{k}\Omega} = IR = (5 \text{ mA})(3.3 \text{ k}\Omega) = 16.5 \text{ V}$$

$$V_{1.58\text{k}\Omega} = IR = (12.86 \text{ mA})(1.58 \text{ k}\Omega) = 20.3 \text{ V}$$

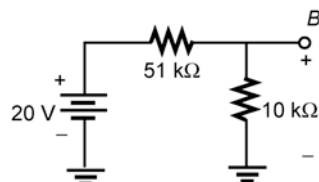
$$E_{Th} = 16.5 \text{ V} + 20.3 \text{ V} = \mathbf{36.8 \text{ V}}$$

19. a. R_{Th} :



$$\leftarrow R_{Th} = 51 \text{ k}\Omega \parallel 10 \text{ k}\Omega = \mathbf{8.36 \text{ k}\Omega}$$

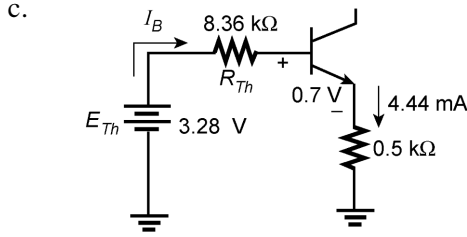
E_{Th} :



$$E_{Th} = \frac{10 \text{ k}\Omega(20 \text{ V})}{10 \text{ k}\Omega + 51 \text{ k}\Omega} = 3.28 \text{ V}$$

b. $I_E R_E + V_{CE} + I_C R_C = 20 \text{ V}$
 but $I_C = I_E$
 and $I_E(R_C + R_E) + V_{CE} = 20 \text{ V}$

$$\text{or } I_E = \frac{20 \text{ V} - V_{CE}}{R_C + R_E} = \frac{20 \text{ V} - 8 \text{ V}}{2.2 \text{ k}\Omega + 0.5 \text{ k}\Omega} = \frac{12 \text{ V}}{2.7 \text{ k}\Omega} = \mathbf{4.44 \text{ mA}}$$



$$E_{Th} - I_B R_{Th} - V_{BE} - V_E = 0$$

$$\text{and } I_B = \frac{E_{Th} - V_{BE} - V_E}{R_{Th}} = \frac{3.28 \text{ V} - 0.7 \text{ V} - (4.44 \text{ mA})(0.5 \text{ k}\Omega)}{8.36 \text{ k}\Omega}$$

$$= \frac{2.58 \text{ V} - 2.22 \text{ V}}{8.36 \text{ k}\Omega} = \frac{0.36 \text{ V}}{8.36 \text{ k}\Omega} = \mathbf{43.06 \mu\text{A}}$$

d. $V_C = 20 \text{ V} - I_C R_C = 20 \text{ V} - (4.44 \text{ mA})(2.2 \text{ k}\Omega)$
 $= 20 \text{ V} - 9.77 \text{ V}$
 $= \mathbf{10.23 \text{ V}}$

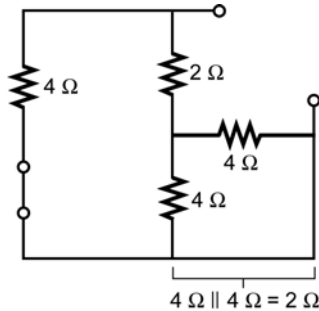
20. a. $E_{Th} = \mathbf{20 \text{ V}}$

$$I = 1.6 \text{ mA} = \frac{E_{Th}}{R_{Th}} = \frac{20 \text{ V}}{R_{Th}}, R_{Th} = \frac{20 \text{ V}}{1.6 \text{ mA}} = \mathbf{12.5 \text{ k}\Omega}$$

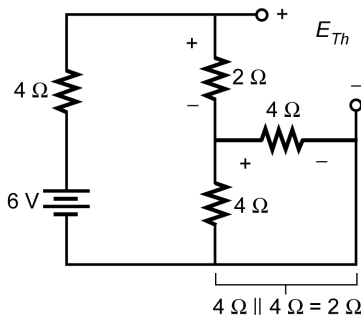
b. $E_{Th} = \mathbf{60 \text{ mV}}, R_{Th} = \mathbf{2.72 \text{ k}\Omega}$

c. $E_{Th} = \mathbf{16 \text{ V}}, R_{Th} = \mathbf{2.2 \text{ k}\Omega}$

21.



$$R_{Th} = 4 \Omega \parallel (2 \Omega + 2 \Omega) = \frac{4 \Omega}{2} = \mathbf{2 \Omega}$$

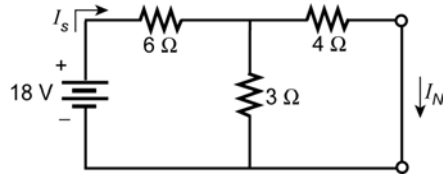


$$V_{4\Omega} = \frac{2 \Omega(6 \text{ V})}{2 \Omega + 4 \Omega + 2 \Omega} = \frac{12 \text{ V}}{8 \Omega} = 1.5 \text{ V}$$

$$V_{2\Omega} = V_{4\Omega} = 1.5 \text{ V}$$

$$E_{Th} = V_{4\Omega} + V_{2\Omega} = 1.5 \text{ V} + 1.5 \text{ V} = \mathbf{3 \text{ V}}$$

22. a. From Problem 9, $R_N = R_{Th} = 6 \Omega$



$$R_T = 6 \Omega + 3 \Omega \parallel 4 \Omega$$

$$= 6 \Omega + 1.714 \Omega = 7.714 \Omega$$

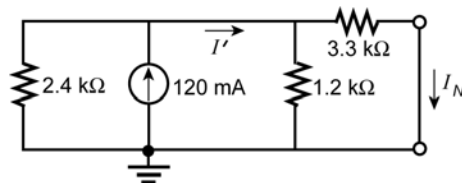
$$I_s = \frac{E}{R_T} = \frac{18 \text{ V}}{7.714 \Omega} = 2.333 \text{ A}$$

$$I_N = \frac{3 \Omega(2.333 \text{ A})}{3 \Omega + 4 \Omega} = 1 \text{ A}$$

- b. $R_{Th} = 6 \Omega$, $E_{Th} = I_N R_N = (1 \text{ A})(6 \Omega) = 6 \text{ V}$

c. same results

23. a. From Problem 10, $R_N = R_{Th} = 4.1 \text{ k}\Omega$



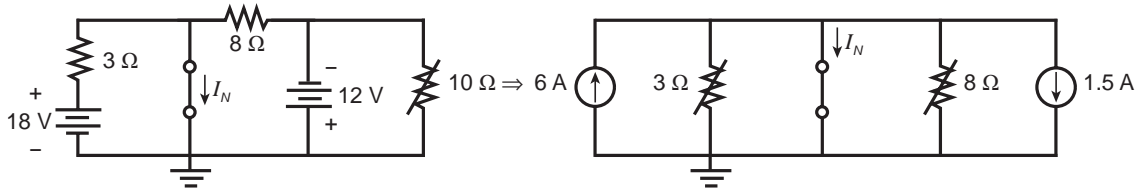
$$I' = \frac{2.4 \text{ k}\Omega(120 \text{ mA})}{2.4 \text{ k}\Omega + (1.2 \text{ k}\Omega \parallel 3.3 \text{ k}\Omega)} = 87.80 \text{ mA}$$

$$I_N = \frac{1.2 \text{ k}\Omega(87.80 \text{ mA})}{1.2 \text{ k}\Omega + 3.3 \text{ k}\Omega} = 23.41 \text{ mA}$$

- b. $R_{Th} = 4.1 \text{ k}\Omega$, $E_{Th} = I_N R_N = (23.41 \text{ mA})(4.1 \text{ k}\Omega) = 96 \text{ V}$

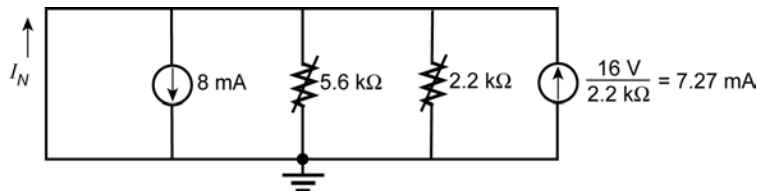
c. same results.

24. From Problem 12, $R_N = R_{Th} = 2.18 \Omega$



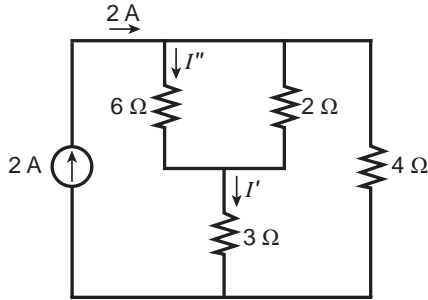
$$I_N = 6 \text{ A} - 1.5 \text{ A} = 4.5 \text{ A}$$

25. From Problem 13, $R_N = R_{Th} = 1.58 \text{ k}\Omega$



$$I_N = 8 \text{ mA} - 7.27 \text{ mA} = 0.73 \text{ mA}$$

26. From Problem 14, $R_N = R_{Th} = 7.56 \Omega$



$$I' = \frac{4 \Omega (2 \text{ A})}{4 \Omega + 3 \Omega + 6 \Omega \parallel 2 \Omega}$$

$$= \frac{4 \Omega (2 \text{ A})}{7 \Omega + 1.5 \Omega} = 0.941 \text{ A}$$

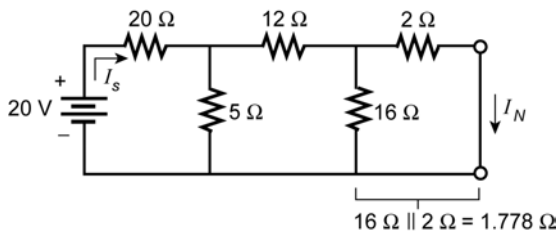
$$I'' = \frac{2 \Omega I'}{2 \Omega + 6 \Omega} = \frac{12 \Omega (0.941 \text{ A})}{8 \Omega} = 0.235 \text{ A}$$

$$I_N = 2 \text{ A} - I''$$

$$= 2 \text{ A} - 0.235 \text{ A}$$

$$= \mathbf{1.765 \text{ A}}$$

27. From Problem 16, $R_N = R_{Th} = 10 \Omega$



$$R_T = 20 \Omega + 5 \Omega \parallel (12 \Omega + 1.778 \Omega) = 23.67 \Omega$$

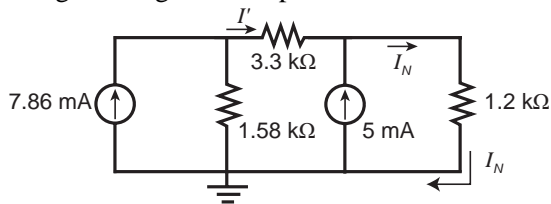
$$I_s = \frac{E_T}{R_T} = \frac{20 \text{ V}}{23.67 \Omega} = 844.95 \text{ mA}$$

$$I_{12\Omega} = \frac{5 \Omega (844.95 \text{ mA})}{5 \Omega + (12 \Omega + 1.778 \Omega)} = 224.98 \text{ mA}$$

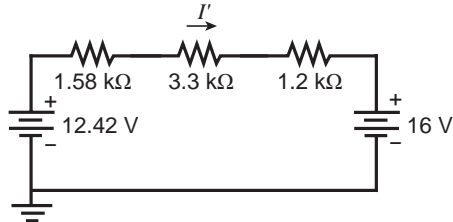
$$I_N = \frac{16 \Omega (224.98 \text{ mA})}{16 \Omega + 2 \Omega} = \mathbf{200 \text{ mA}}$$

28. From Problem 18, $R_N = R_{Th} = 6.08 \text{ k}\Omega$

I_N : Starting with figure from problem 18:



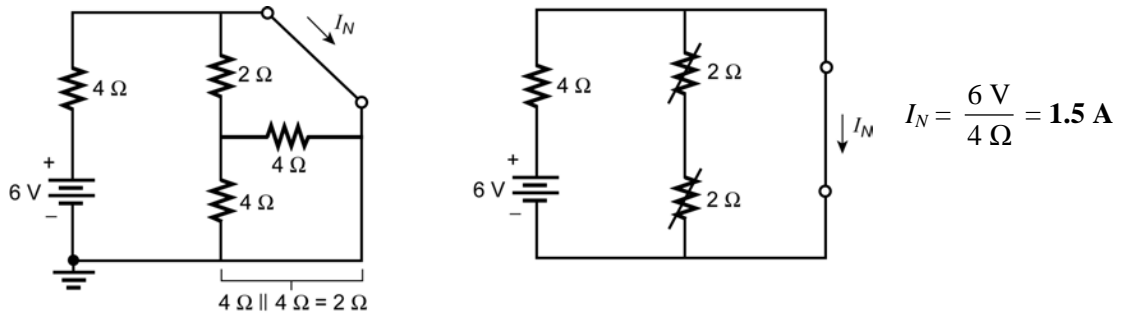
and converting sources:



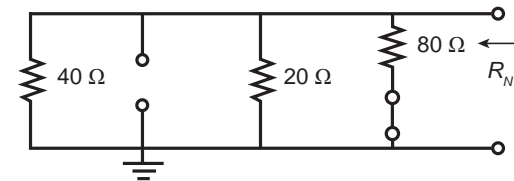
$$I' = \frac{12.42 \text{ V} - 6 \text{ V}}{1.58 \text{ k}\Omega + 3.3 \text{ k}\Omega + 1.2 \text{ k}\Omega} = 1.06 \text{ mA}$$

$$I_N = I' + 5 \text{ mA} = 1.06 \text{ mA} + 5 \text{ mA} = \mathbf{6.06 \text{ mA}}$$

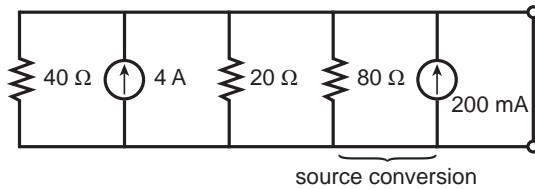
29. From Problem 21, $R_N = R_{Th} = \mathbf{2 \Omega}$



30. R_N :



$$R_N = \frac{1}{\frac{1}{40 \Omega} + \frac{1}{20 \Omega} + \frac{1}{80 \Omega}} = \mathbf{11.43 \Omega}$$



$$\downarrow I_N = 4 \text{ A} + 200 \text{ mA} = \mathbf{4.2 \text{ A}}$$

31. a. $R = R_{Th} = \mathbf{6 \Omega}$ from Problem 9

- b. $E_{Th} = \mathbf{6 \text{ V}}$ from Problem 9

$$P_{\max} = \frac{E_{Th}^2}{4R_{Th}} = \frac{(6 \text{ V})^2}{4(6 \Omega)} = \mathbf{1.5 \text{ W}}$$

32. a. $R = R_{Th} = \mathbf{2.18 \Omega}$ from Problem 12

- b. $E_{Th} = \mathbf{9.81 \text{ V}}$ from Problem 12

$$P_{\max} = \frac{E_{Th}^2}{4R_{Th}} = \frac{(9.81 \text{ V})^2}{4(2.18 \Omega)} = \mathbf{11.06 \text{ W}}$$

33. a. $R = R_{Th} = \mathbf{7.56 \Omega}$ from Problem 14

- b. $E_{Th} = \mathbf{13.33 \text{ V}}$ from Problem 14

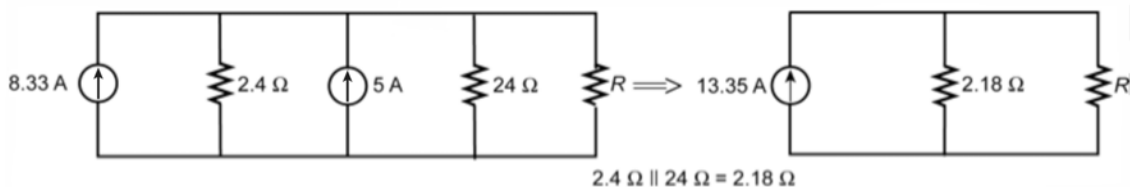
$$P_{\max} = \frac{E_{Th}^2}{4R_{Th}} = \frac{(13.33 \text{ V})^2}{4(7.56 \Omega)} = \mathbf{5.88 \text{ W}}$$

34. a. $R = R_{Th} = 6.08 \text{ k}\Omega$ from Problem 18

b. $E_{Th} = 36.8 \text{ V}$ from Problem 18

$$P_{\max} = \frac{E_{Th}^2}{4R_{Th}} = \frac{(36.8 \text{ V})^2}{4(6.08 \text{ k}\Omega)} = 55.51 \text{ mW}$$

35. a.



$$R = R_N = R_{Th} = 2.18 \Omega$$

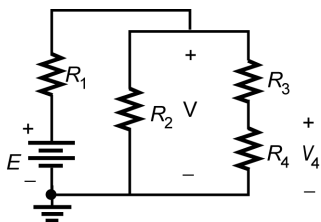
b.
$$P_{\max} = \frac{I_N^2 R_N}{4} = \frac{(13.33 \text{ A})^2 2.18 \Omega}{4} = 96.84 \text{ W}$$

36.
$$P_{\max} = \left[\frac{E_{Th}}{R_{Th} + R_4} \right]^2 R_4$$

with $R_1 = 0 \Omega$, E_{Th} is a maximum and R_{Th} is a minimum.

$$\therefore R_1 = 0 \Omega$$

37. a.



V , and therefore V_4 will be its largest value when R_2 is as large as possible. Therefore, choose $R_2 = \text{open-circuit } (\infty \Omega)$ and

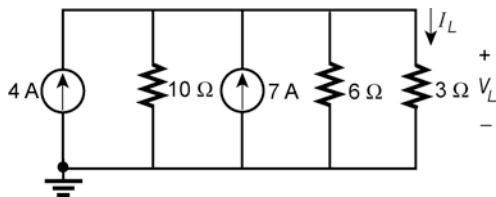
$$P_4 = \frac{V_4^2}{R_4} \text{ will be a maximum.}$$

b. No, examine each individually.

38. The voltage V_L across R_L will be a maximum when R of the potentiometer = 500Ω because the full voltage, E , will appear across R_L .

$$P_{\max} = \frac{V_L^2}{R_L} = \frac{E^2}{R_L} = \frac{(12 \text{ V})^2}{500 \Omega} = 1.44 \text{ W}$$

39.



$$I_T \uparrow = 4 \text{ A} + 7 \text{ A} = 11 \text{ A}$$

$$R_T = 10 \Omega \parallel 6 \Omega \parallel 3 \Omega = 1.67 \Omega$$

$$V_L = I_T R_T = (11 \text{ A})(1.67 \Omega) = 18.37 \text{ V}$$

$$I_L = \frac{V_L}{R_L} = \frac{18.37 \text{ V}}{3 \Omega} = 6.12 \text{ A}$$

$$40. \quad E_{\text{eq}} = \frac{-5 \text{ V} / 2.2 \text{ k}\Omega + 20 \text{ V} / 8.2 \text{ k}\Omega}{1 / 2.2 \text{ k}\Omega + 1 / 8.2 \text{ k}\Omega} = 0.2879 \text{ V}$$

$$R_{\text{eq}} = \frac{1}{1 / 2.2 \text{ k}\Omega + 1 / 8.2 \text{ k}\Omega} = 1.7346 \text{ k}\Omega$$

$$I_L = \frac{E_{\text{eq}}}{R_{\text{eq}} + R_L} = \frac{0.2879 \text{ V}}{1.7346 \text{ k}\Omega + 5.6 \text{ k}\Omega} = \mathbf{39.3 \mu\text{A}}$$

$$V_L = I_L R_L = (39.3 \mu\text{A})(5.6 \text{ k}\Omega) = \mathbf{220 \text{ mV}}$$

$$41. \quad I_T \downarrow = 5 \text{ A} - 0.4 \text{ A} - 0.2 \text{ A} = 4.40 \text{ A}$$

$$R_T = 200 \Omega \parallel 80 \Omega \parallel 50 \Omega \parallel 50 \Omega = 17.39 \Omega$$

$$V_L = I_T R_T = (4.40 \text{ A})(17.39 \Omega) = \mathbf{75.52 \text{ V}}$$

$$I_L = \frac{V_L}{R_L} = \frac{76.52 \text{ V}}{200 \Omega} = \mathbf{0.38 \text{ A}}$$

$$42. \quad I_{\text{eq}} = \frac{(4 \text{ A})(4.7 \Omega) + (1.6 \text{ A})(3.3 \Omega)}{4.7 \Omega + 3.3 \Omega} = \frac{18.8 \text{ V} + 5.28 \text{ V}}{8 \Omega} = 3.01 \text{ A}$$

$$R_{\text{eq}} = 4.7 \Omega + 3.3 \Omega = 8 \Omega$$

$$I_L = \frac{R_{\text{eq}}(I_{\text{eq}})}{R_{\text{eq}} + R_L} = \frac{8 \Omega(3.01 \text{ A})}{8 \Omega + 2.7 \Omega} = \mathbf{2.25 \text{ A}}$$

$$V_L = I_L R_L = (2.25 \text{ A})(2.7 \Omega) = \mathbf{6.08 \text{ V}}$$

$$43. \quad I_{\text{eq}} = \frac{\leftarrow (4 \text{ mA})(8.2 \text{ k}\Omega) + (8 \text{ mA})(4.7 \text{ k}\Omega) - (10 \text{ mA})(2 \text{ k}\Omega)}{8.2 \text{ k}\Omega + 4.7 \text{ k}\Omega + 2 \text{ k}\Omega}$$

$$= \frac{32.8 \text{ V} + 37.6 \text{ V} - 20 \text{ V}}{14.9 \text{ k}\Omega} = 3.38 \text{ mA}$$

$$R_{\text{eq}} = 8.2 \text{ k}\Omega + 4.7 \text{ k}\Omega + 2 \text{ k}\Omega = 14.9 \text{ k}\Omega$$

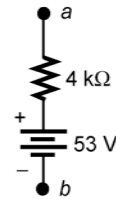
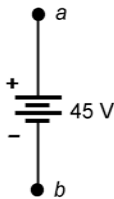
$$I_L = \frac{E_{\text{eq}} I_{\text{eq}}}{R_{\text{eq}} + R_L} = \frac{(14.9 \text{ k}\Omega)(3.38 \text{ mA})}{14.9 \text{ k}\Omega + 6.8 \text{ k}\Omega} = \mathbf{2.32 \text{ mA}}$$

$$V_L = I_L R_L = (2.32 \text{ mA})(6.8 \text{ k}\Omega) = \mathbf{15.78 \text{ V}}$$

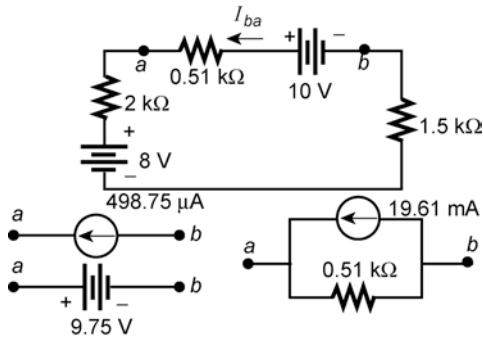
$$44. \quad 15 \text{ k}\Omega \parallel (8 \text{ k}\Omega + 7 \text{ k}\Omega) = 15 \text{ k}\Omega \parallel 15 \text{ k}\Omega = 7.5 \text{ k}\Omega$$

$$V_{ab} = \frac{7.5 \text{ k}\Omega(60 \text{ V})}{7.5 \text{ k}\Omega + 2.5 \text{ k}\Omega} = 45 \text{ V}$$

$$I_{ab} = \frac{45 \text{ V}}{15 \text{ k}\Omega} = 3 \text{ mA}$$



45.

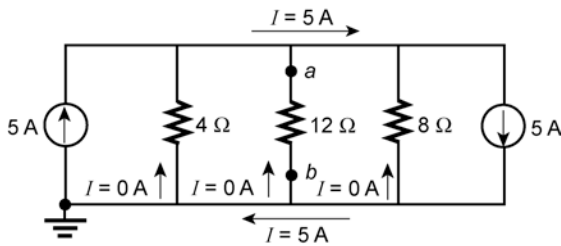


$$I_{ba} = \frac{10 \text{ V} - 8 \text{ V}}{2 \text{ k}\Omega + 0.51 \text{ k}\Omega + 1.5 \text{ k}\Omega} = 498.75 \mu\text{A}$$

$$V_{0.51\text{k}\Omega} = (498.75 \mu\text{A})(0.51 \text{ k}\Omega) = 0.25 \text{ V}$$

$$V_{ab} = 10 \text{ V} - 0.25 \text{ V} = 9.75 \text{ V}$$

46.



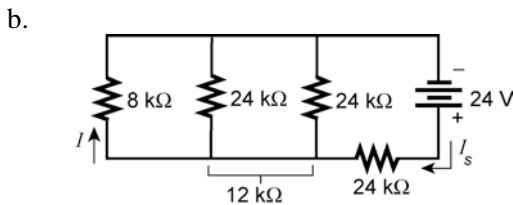
$$V_{ab} = 0 \text{ V (short)}$$

$$I_{ab} = 0 \text{ A (open)}$$

R_2 any resistive value

$\therefore R_2 = \text{short-circuit, open-circuit, any value}$

47. a. $I_s = \frac{24 \text{ V}}{8 \text{ k}\Omega + \frac{24 \text{ k}\Omega}{3}} = 1.5 \text{ mA}, I = \frac{I_s}{3} = 0.5 \text{ mA}$

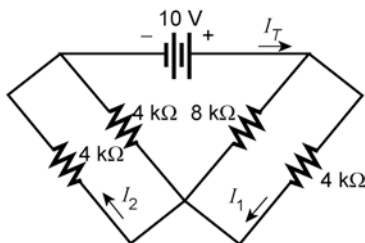


$$I_s = \frac{24 \text{ V}}{24 \text{ k}\Omega + 8 \text{ k}\Omega \parallel 12 \text{ k}\Omega} = 0.83 \text{ mA}$$

$$I = \frac{12 \text{ k}\Omega(I_s)}{12 \text{ k}\Omega + 8 \text{ k}\Omega} = 0.5 \text{ mA}$$

c. yes

48. (a)



$$I_T = \frac{10 \text{ V}}{4 \text{ k}\Omega \parallel 8 \text{ k}\Omega + 4 \text{ k}\Omega \parallel 4 \text{ k}\Omega}$$

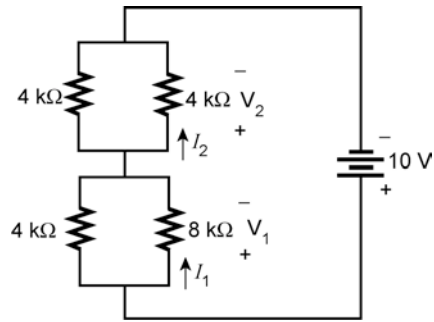
$$= \frac{10 \text{ V}}{2.67 \text{ k}\Omega + 2 \text{ k}\Omega}$$

$$= \frac{10 \text{ V}}{4.67 \text{ k}\Omega} = 2.14 \text{ mA}$$

$$I_1 = \frac{8 \Omega(I_T)}{8 \Omega + 4 \Omega} = 1.43 \text{ mA}, I_2 = I_T/2 = 1.07 \text{ mA}$$

$$I = I_1 - I_2 = 1.43 \text{ mA} - 1.07 \text{ mA} = 0.36 \text{ mA}$$

(b)



$$V_1 = \frac{(8 \text{ k}\Omega \parallel 4 \text{ k}\Omega)(10 \text{ V})}{8 \text{ k}\Omega \parallel 4 \text{ k}\Omega + 4 \text{ k}\Omega \parallel 4 \text{ k}\Omega} = 5.72 \text{ V}$$

$$I_1 = \frac{V_1}{8 \text{ k}\Omega} = 0.71 \text{ mA}$$

$$V_2 = E - V_1 = 10 \text{ V} - 5.72 \text{ V} = 4.28 \text{ V}$$

$$I_2 = \frac{V_2}{4 \text{ k}\Omega} = 1.07 \text{ mA}$$

$$I = I_2 - I_1 = 1.07 \text{ mA} - 0.71 \text{ mA} = \mathbf{0.36 \text{ mA}}$$

49. a.
$$I_{R_2} = \frac{R_1(I)}{R_1 + R_2 + R_3} = \frac{3 \Omega(6 \text{ A})}{3 \Omega + 2 \Omega + 4 \Omega} = 2 \text{ A}$$
$$V = I_{R_2} R_2 = (2 \text{ A})(2 \Omega) = \mathbf{4 \text{ V}}$$

b.
$$I_{R_1} = \frac{R_2(I)}{R_1 + R_2 + R_3} = \frac{2 \Omega(6 \text{ A})}{3 \Omega + 2 \Omega + 4 \Omega} = 1.33 \text{ A}$$
$$V = I_{R_1} R_1 = (1.33 \text{ A})(3 \Omega) = \mathbf{4 \text{ V}}$$