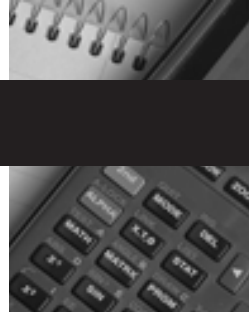

Circuits and Circuit Elements

Additional Practice A

Givens | *Solutions*

1. $R = 160\ \text{k}\Omega$
$R_1 = 2.0R$
$R_2 = 3.0R$
$R_3 = 7.5R$

$R_{eq} = R_1 + R_2 + R_3 = 2.0R + 3.0R + 7.5R = 12.5R$

$R_{eq} = (12.5)(160\ \text{k}\Omega) = \boxed{2.0 \times 10^3\ \text{k}\Omega}$

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2. $R = 5.0 \times 10^8\ \Omega$
$R_1 = \frac{1}{3}R$
$R_2 = \frac{2}{7}R$
$R_3 = \frac{1}{5}R$

$R_{eq} = R_1 + R_2 + R_3 = \frac{1}{3}R + \frac{2}{7}R + \frac{1}{5}R$

$R_{eq} = \frac{35 + 30 + 21}{105}R = \frac{86}{105}R = \frac{86}{105}(5.0 \times 10^8\ \Omega) = \boxed{4.1 \times 10^8\ \Omega}$

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3. $R_1 = 16\ \text{k}\Omega$
$R_2 = 22\ \text{k}\Omega$
$R_3 = 32\ \text{k}\Omega$
$R_{eq} = 82\ \text{k}\Omega$

$R_4 = R_{eq} - R_1 - R_2 - R_3 = 82\ \text{k}\Omega - 16\ \text{k}\Omega - 22\ \text{k}\Omega - 32\ \text{k}\Omega = \boxed{12\ \text{k}\Omega}$

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4. $R_1 = 3.0\ \text{k}\Omega$
$R_2 = 4.0\ \text{k}\Omega$
$R_3 = 5.0\ \text{k}\Omega$
$P = (0.0100)(3.2\ \text{MW}) = 0.032\ \text{MW}$

$R_{eq} = R_1 + R_2 + R_3 = 3.0\ \text{k}\Omega + 4.0\ \text{k}\Omega + 5.0\ \text{k}\Omega = 12.0\ \text{k}\Omega$

$P = \frac{(\Delta V)^2}{R}$

$\Delta V = \sqrt{PR_{eq}} = \sqrt{(3.2 \times 10^4\ \text{W})(1.20 \times 10^4\ \Omega)} = \boxed{2.0 \times 10^4\ \text{V}}$

---

5. $R_1 = 4.5\ \Omega$
$R_2 = 4.0\ \Omega$
$R_3 = 16.0\ \Omega$

$R_{12} = R_1 + R_2 = 4.5\ \Omega + 4.0\ \Omega = \boxed{8.5\ \Omega}$

$R_{13} = R_1 + R_3 = 4.5\ \Omega + 16.0\ \Omega = \boxed{20.5\ \Omega}$

$R_{23} = R_2 + R_3 = 4.0\ \Omega + 16.0\ \Omega = \boxed{20.0\ \Omega}$

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6. $R_1 = 2.20 \times 10^2\ \Omega$
$\Delta V_i = 1.20 \times 10^2\ \text{V}$
$\Delta V_f = 138\ \text{V}$

Because the current is unchanged, the following relationship can be written.

$\frac{V_i}{R_1} = \frac{V_f}{R_1 + R_2}$

$R_2 = \frac{V_f R_1 - V_i R_1}{V_i} = \frac{(138\ \text{V})(220\ \Omega) - (120\ \text{V})(220\ \Omega)}{120\ \text{V}}$

$R_2 = \frac{30\,400\ \text{V}\cdot\Omega - 26\,400\ \text{V}\cdot\Omega}{120\ \text{V}} = \frac{4000\ \text{V}\cdot\Omega}{120\ \text{V}} = \boxed{33\ \Omega}$

Givens *Solutions*

7. $R_1 = 3.6 \times 10^{-5}\ \Omega$

$R_2 = 8.4 \times 10^{-6}\ \Omega$

$I = 280\ \text{A}$

$R_{eq} = R_1 + R_2 = 3.6 \times 10^{-5}\ \Omega + 8.4 \times 10^{-6}\ \Omega = 4.4 \times 10^{-5}\ \Omega$

$P = I^2 R_{eq} = (280\ \text{A})^2(4.4 \times 10^{-5}\ \Omega) = \boxed{3.4\ \text{W}}$

Additional Practice B

1. $R_1 = 1.8\ \Omega$

$R_2 = 5.0\ \Omega$

$R_3 = 32\ \Omega$

$$R_{eq} = \left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right)^{-1} = \left(\frac{1}{1.8\ \Omega} + \frac{1}{5.0\ \Omega} + \frac{1}{32\ \Omega}\right)^{-1}$$

$$R_{eq} = \left(0.55\ \frac{1}{\Omega} + 0.20\ \frac{1}{\Omega} + 0.031\ \frac{1}{\Omega}\right)^{-1} = \left(0.78\ \frac{1}{\Omega}\right)^{-1} = \boxed{1.3\ \Omega}$$

2. $R = 450\ \Omega$

$R_1 = R$

$R_2 = 2.0R$

$R_3 = 0.50R$

$$R_{eq} = \left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right)^{-1} = \left(\frac{1}{450\ \Omega} + \frac{1}{900\ \Omega} + \frac{1}{220\ \Omega}\right)^{-1}$$

$$R_{eq} = \left(0.0022\ \frac{1}{\Omega} + 0.0011\ \frac{1}{\Omega} + 0.0045\ \frac{1}{\Omega}\right)^{-1} = \left(0.0078\ \frac{1}{\Omega}\right)^{-1} = \boxed{1.3 \times 10^2\ \Omega}$$

3. $R_1 = 2.48 \times 10^{-2}\ \Omega$

$R_{eq} = 6.00 \times 10^{-3}\ \Omega$

$$R_2 = \left(\frac{1}{R_{eq}} - \frac{2}{R_1}\right)^{-1} = \left(\frac{1}{6.00 \times 10^{-3}\ \Omega} - \frac{2}{2.48 \times 10^{-2}\ \Omega}\right)^{-1}$$

$$R_2 = \left(167\ \frac{1}{\Omega} - 80.6\ \frac{1}{\Omega}\right)^{-1} = \left(86\ \frac{1}{\Omega}\right)^{-1} = \boxed{0.012\ \Omega}$$

4. $R_1 = R$

$R_2 = 3R$

$R_3 = 7R$

$R_4 = 11R$

$R_{eq} = 6.38 \times 10^{-2}\ \Omega$

$$R_{eq} = \left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4}\right)^{-1} = \left(\frac{1}{R} + \frac{1}{3R} + \frac{1}{7R} + \frac{1}{11R}\right)^{-1}$$

$$R_{eq} = \left(\frac{231 + 77 + 33 + 21}{231R}\right)^{-1} = \left(\frac{362}{231R}\right)^{-1} = \left(\frac{1.57}{R}\right)^{-1}$$

$R = 1.57R_{eq} = 1.57(6.38 \times 10^{-2}\ \Omega) = \boxed{0.100\ \Omega}$

5. ratio $= 1.22 \times 10^{-2}\ \Omega/\text{m}$

$\ell = 1813\ \text{km}$

$R_1 = \frac{1}{2}R$

$R_2 = \frac{1}{4}R$

$R_3 = \frac{1}{5}R$

$R_4 = \frac{1}{20}R$

a. $R = (\text{ratio})(\ell) = (1.22 \times 10^{-2}\ \Omega/\text{m})(1.813 \times 10^6\ \text{m}) = \boxed{2.21 \times 10^4\ \Omega}$

b. $$R_{eq} = \left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4}\right)^{-1} = \left(\frac{2}{R} + \frac{4}{R} + \frac{5}{R} + \frac{20}{R}\right)^{-1}$$

$$R_{eq} = \left(\frac{31}{R}\right)^{-1} = \left(\frac{31}{1.00 \times 10^{10}\ \Omega}\right)^{-1} = \boxed{3.23 \times 10^8\ \Omega}$$

6. $\Delta V = 14.4\ \text{V}$

$P = 225\ \text{W}$

$$P = \frac{(\Delta V)^2}{R}$$

$$R = \frac{(\Delta V)^2}{P} = \frac{(14.4\ \text{V})^2}{225\ \text{W}} = \boxed{0.922\ \Omega}$$

$$R_{eq} = \left(\frac{4}{R}\right)^{-1} = \frac{R}{4} = \frac{0.922\ \Omega}{4} = 0.230\ \Omega$$

$$I = \frac{\Delta V}{R_{eq}} = \frac{14.4\ \text{V}}{0.230\ \Omega} = \boxed{62.6\ \text{A}}$$

Givens *Solutions*

7. $L = 3.22 \times 10^5$ km
$\ell = 1.00 \times 10^3$ km
ratio $= 1.0 \times 10^{-2}\ \Omega$/m
$\Delta V = 1.50$ V

$$R_{eq} = \mathrm{N}\left(\frac{1}{\mathrm{R}}\right) \quad \text{where } \mathrm{N} = \frac{L}{\ell} \text{ and } R = (\text{ratio})\ell$$

$$R_{eq} = \left[\frac{L}{(\text{ratio})\ell^2}\right]^{-1} = \left[\frac{3.22 \times 10^8 \text{ m}}{(1.0 \times 10^{-2}\ \Omega/\text{m})(1.00 \times 10^6 \text{ m})^2}\right]^{-1} = 31\ \Omega$$

$$I = \frac{\Delta V}{R_{eq}} = \frac{1.50 \text{ V}}{31\ \Omega} = \boxed{0.048 \text{ A}}$$

Additional Practice C

1. $R_1 = 6.60 \times 10^2\ \Omega$
$R_2 = 2.40 \times 10^2\ \Omega$
$R_3 = 2.00 \times 10^2\ \Omega$
$R_4 = 2.00 \times 10^2\ \Omega$

$$R_{12} = R_1 + R_2 = 660\ \Omega + 240\ \Omega = 900\ \Omega$$

$$R_{123} = \left(\frac{1}{R_{12}} + \frac{1}{R_3}\right)^{-1} = \left(\frac{1}{900\ \Omega} + \frac{1}{200\ \Omega}\right)^{-1}$$

$$R_{123} = \left(0.00111\,\frac{1}{\Omega} + 0.00500\,\frac{1}{\Omega}\right)^{-1} = \left(0.00611\,\frac{1}{\Omega}\right)^{-1} = 164\ \Omega$$

$$R_{eq} = R_{123} + R_4 = 164\ \Omega + 200\ \Omega = \boxed{364\ \Omega}$$

2. $\Delta V = 24$ V
$R_1 = 2.0\ \Omega$
$R_2 = 4.0\ \Omega$
$R_3 = 6.0\ \Omega$
$R_4 = 3.0\ \Omega$

$$R_{12} = R_1 + R_2 = 2.0\ \Omega + 4.0\ \Omega = 6.0\ \Omega$$

$$R_{34} = \left(\frac{1}{R_3} + \frac{1}{R_4}\right)^{-1} = \left(\frac{1}{6.0\ \Omega} + \frac{1}{3.0\ \Omega}\right)^{-1}$$

$$R_{34} = \left(0.17\,\frac{1}{\Omega} + 0.33\,\frac{1}{\Omega}\right)^{-1} = \left(0.50\,\frac{1}{\Omega}\right)^{-1} = 2.0\ \Omega$$

$$R_{eq} = \left(\frac{1}{R_{12}} + \frac{1}{R_{34}}\right)^{-1} = \left(\frac{1}{6.0\ \Omega} + \frac{1}{2.0\ \Omega}\right)^{-1}$$

$$R_{eq} = \left(0.17\,\frac{1}{\Omega} + 0.50\,\frac{1}{\Omega}\right)^{-1} = \left(0.67\,\frac{1}{\Omega}\right)^{-1} = 1.5\ \Omega$$

$$I = \frac{\Delta V}{R_{eq}} = \frac{24 \text{ V}}{1.5 \text{ V}} = \boxed{16 \text{ A}}$$

3. $R_1 = 2.5\ \Omega$
$R_2 = 3.5\ \Omega$
$R_3 = 3.0\ \Omega$
$R_4 = 4.0\ \Omega$
$R_5 = 1.0\ \Omega$
$\Delta V = 12$ V

$$R_{12} = R_1 + R_2 = 2.5\ \Omega + 3.5\ \Omega = 6.0\ \Omega$$

$$R_{123} = \left(\frac{1}{R_{12}} + \frac{1}{R_3}\right)^{-1} = \left(\frac{1}{6.0\ \Omega} + \frac{1}{3.0\ \Omega}\right)^{-1}$$

$$R_{123} = \left(0.17\,\frac{1}{\Omega} + 0.33\,\frac{1}{\Omega}\right)^{-1} = \left(0.50\,\frac{1}{\Omega}\right)^{-1} = 2.0\ \Omega$$

$$R_{45} = \left(\frac{1}{R_4} + \frac{1}{R_5}\right)^{-1} = \left(\frac{1}{4.0\ \Omega} + \frac{1}{1.0\ \Omega}\right)^{-1}$$

$$R_{45} = \left(0.25\,\frac{1}{\Omega} + 1.0\,\frac{1}{\Omega}\right)^{-1} = \left(1.2\,\frac{1}{\Omega}\right)^{-1} = 0.83\ \Omega$$

$$R_{eq} = R_{123} + R_{45} = 2.0\ \Omega + 0.83\ \Omega = \boxed{2.8\ \Omega}$$

$$I = \frac{\Delta V}{R} = \frac{12 \text{ V}}{2.8\ \Omega} = \boxed{4.3 \text{ A}}$$

II

Givens *Solutions*

4. $\Delta V = 1.00 \times 10^3\ \text{V}$
$R_1 = 1.5\ \Omega$
$R_2 = 3.0\ \Omega$
$R_3 = 1.0\ \Omega$

$$R_{12} = \left(\frac{1}{R_1} + \frac{1}{R_2}\right)^{-1} = \left(\frac{1}{1.5\ \Omega} + \frac{1}{3.0\ \Omega}\right)^{-1}$$

$$R_{12} = \left(0.67\,\frac{1}{\Omega} + 0.33\,\frac{1}{\Omega}\right)^{-1} = \left(1.00\,\frac{1}{\Omega}\right)^{-1} = 1.00\ \Omega$$

$$R_{eq} = R_{12} + R_3 = 1.00\ \Omega + 1.0\ \Omega = \boxed{2.0\ \Omega}$$

$$P = \frac{(\Delta V)^2}{R_{eq}} = \frac{(1.00 \times 10^3\ \text{V})^2}{2.0\ \Omega} = \boxed{5.0 \times 10^5\ \text{W}}$$

5. $\Delta V = 2.00 \times 10^3\ \text{V}$
$I = 1.0 \times 10^{-8}\ \text{A}$
$R_1 = r$
$R_2 = 3r$
$R_3 = 2r$
$R_4 = 4r$

$$R_{eq} = \frac{\Delta V}{I} = \frac{2.00 \times 10^3\ \text{V}}{1.0 \times 10^{-8}\ \text{A}} = \boxed{2.0 \times 10^{11}\ \Omega}$$

$$R_{12} = R_1 + R_2 = r + 3r = 4r$$

$$R_{34} = R_3 + R_4 = 2r + 4r = 6r$$

$$R_{eq} = \left(\frac{1}{R_{12}} + \frac{1}{R_{34}}\right)^{-1} = \left(\frac{1}{4r} + \frac{1}{6r}\right)^{-1}$$

$$R_{eq} = \left(\frac{3+2}{12r}\right)^{-1} = \left(\frac{5}{12r}\right)^{-1} = \frac{12}{5}r$$

$$r = \frac{5}{12}R_{eq} = \frac{5}{12}(2.0 \times 10^{11}\ \Omega) = \boxed{8.3 \times 10^{10}\ \Omega}$$

6. $P = 6.0 \times 10^5\ \text{W}$
$\Delta V = 220\ \text{V}$

$$R = \frac{(\Delta V)^2}{P} = \frac{(220\ \text{V})^2}{6.0 \times 10^5\ \text{W}} = \boxed{8.1 \times 10^{-2}\ \Omega}$$

$$R_{12} = R_{45} = 2R = 2(0.081\ \Omega) = 0.16\ \Omega$$

$$R_{12345} = \left(\frac{1}{R_{12}} + \frac{1}{R_3} + \frac{1}{R_{45}}\right)^{-1} = \left(\frac{1}{0.16\ \Omega} + \frac{1}{0.081\ \Omega} + \frac{1}{0.16\ \Omega}\right)^{-1}$$

$$R_{12345} = \left(6.2\,\frac{1}{\Omega} + 12\,\frac{1}{\Omega} + 6.2\,\frac{1}{\Omega}\right)^{-1} = \left(24\,\frac{1}{\Omega}\right)^{-1} = 0.042\ \Omega$$

$$R_{eq} = R_{12345} + R_6 = 0.042\ \Omega + 0.081\ \Omega = 0.123\ \Omega$$

$$P = \frac{(\Delta V)^2}{R_{eq}} = \frac{(220\ \text{V})^2}{0.123\ \Omega} = \boxed{3.9 \times 10^5\ \text{W}}$$

Additional Practice D

1. $R = 8.1 \times 10^{-2}\ \Omega$
$R_{eq} = 0.123\ \Omega$
$\Delta V = 220\ \text{V}$
$R_{12} = R_{45} = 0.16\ \Omega$
$R_{12345} = 0.042\ \Omega$

a. $$I = \frac{\Delta V}{R_{eq}} = \frac{220\ \text{V}}{0.123\ \Omega} = 1800\ \text{A}$$

$$\Delta V_{12345} = IR_{12345} = (1800\ \text{A})(0.042\ \Omega) = 76\ \text{V}$$

$$\Delta V_3 = \Delta V_{12345} = \boxed{76\ \text{V}}$$

$$I_3 = \frac{\Delta V_3}{R_3} = \frac{76\ \text{V}}{8.1 \times 10^{-2}\ \Omega} = \boxed{9.4 \times 10^2\ \text{A}}$$

Givens *Solutions*

b. $\Delta V_{12} = \Delta V_{12345} = 76\text{ V}$

$$I_{12} = \frac{\Delta V_{12}}{R_{12}} = \frac{76\text{ V}}{0.16\ \Omega} = 4.8 \times 10^2\text{ A}$$

$I_2 = I_{12} = \boxed{4.8 \times 10^2\text{ A}}$

$\Delta V_2 = I_2 R_2 = (4.8 \times 10^2\text{ A})(8.1 \times 10^{-2}\ \Omega) = \boxed{39\text{ V}}$

c. Same as part b:

$I_4 = \boxed{4.8 \times 10^2\text{ A}}$

$\Delta V_4 = \boxed{39\text{ V}}$

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2. $\Delta V = 12\text{ V}$

$R_1 = 2.5\ \Omega$

$R_3 = 3.0\ \Omega$

$R_4 = 4.0\ \Omega$

$R_5 = 1.0\ \Omega$

$R_{12} = 6.0\ \Omega$

$R_{123} = 2.0\ \Omega$

$R_{45} = 0.83\ \Omega$

$R_{eq} = 2.8\ \Omega$

$I = 4.3\text{ A}$

a. $\Delta V_{45} = IR_{45} = (4.3\text{ A})(0.83\ \Omega) = 3.6\text{ V}$

$\Delta V_5 = \Delta V_{45} = \boxed{3.6\text{ V}}$

$$I_5 = \frac{\Delta V_5}{R_5} = \frac{3.6\text{ V}}{1.0\ \Omega} = \boxed{3.1\text{ A}}$$

b. $\Delta V_{123} = IR_{123} = (4.3\text{ A})(2.0\ \Omega) = 8.6\text{ V}$

$\Delta V_{12} = \Delta V_{123} = 8.6\text{ V}$

$$I_1 = I_{12} = \frac{\Delta V_{12}}{R_{12}} = \frac{8.6\text{ V}}{6.0\ \Omega} = \boxed{1.4\text{ A}}$$

$\Delta V_1 = I_1 R_1 = (1.4\text{ A})(2.5\ \Omega) = \boxed{3.5\text{ V}}$

c. $I_{45} = I = 4.3\text{ A}$

$\Delta V_{45} = I_{45} R_{45} = (4.3\text{ A})(0.83\ \Omega) = 3.6\text{ V}$

$V_4 = \Delta V_{45} = \boxed{3.6\text{ V}}$

$$I_4 = \frac{\Delta V_4}{R_4} = \frac{3.6\text{ V}}{4.0\ \Omega} = \boxed{0.90\text{ V}}$$

d. $\Delta V_3 = \Delta V_{123} = \boxed{8.6\text{ V}}$

$$I_3 = \frac{\Delta V_3}{R_3} = \frac{8.6\text{ V}}{3.0\ \Omega} = \boxed{2.9\text{ A}}$$

II

Givens

3. $R_1 = 15\ \Omega$

$R_2 = 3.0\ \Omega$

$R_3 = 2.0\ \Omega$

$R_4 = 5.0\ \Omega$

$R_5 = 7.0\ \Omega$

$R_6 = 3.0\ \Omega$

$R_7 = 3.0 \times 10^1\ \Omega$

$\Delta V = 2.00 \times 10^3\ \text{V}$

Solutions

$R_{23} = R_2 + R_3 = 3.0\ \Omega + 2.0\ \Omega = 5.0\ \Omega$

$$R_{234} = \left(\frac{1}{R_{23}} + \frac{1}{R_4}\right)^{-1} = \left(\frac{1}{5.0\ \Omega} + \frac{1}{5.0\ \Omega}\right)^{-1}$$

$$R_{234} = \left(0.40\frac{1}{\Omega}\right)^{-1} = 2.5\ \Omega$$

$R_{56} = R_5 + R_6 = 7.0\ \Omega + 3.0\ \Omega = 10.0\ \Omega$

$$R_{567} = \left(\frac{1}{R_{56}} + \frac{1}{R_7}\right)^{-1} = \left(\frac{1}{10.0\ \Omega} + \frac{1}{30\ \Omega}\right)^{-1}$$

$$R_{567} = \left(0.100\ \frac{1}{\Omega} + 0.033\ \frac{1}{\Omega}\right)^{-1} = \left(0.133\ \frac{1}{\Omega}\right)^{-1} = 7.52\ \Omega$$

$R_{eq} = R_1 + R_{234} + R_{567} = 15\ \Omega + 2.5\ \Omega + 7.52\ \Omega = 25\ \Omega$

a. $$I = \frac{\Delta V}{R_{eq}} = \frac{2.00 \times 10^3\ \text{V}}{25\ \Omega} = 80\ \text{A}$$

$\Delta V_{234} = IR_{234} = (80\ \text{A})(2.5\ \Omega) = 2.0 \times 10^2\ \text{V}$

$\Delta V_4 = \Delta V_{234} = \boxed{2.0 \times 10^2\ \text{V}}$

$$I_4 = \frac{\Delta V_4}{R_4} = \frac{200\ \text{V}}{5.0\ \Omega} = \boxed{4.0 \times 10^1\ \text{A}}$$

b. $\Delta V_{23} = \Delta V_{234} = 200\ \text{V}$

$$I_{23} = \frac{\Delta V_{23}}{R_{23}} = \frac{200\ \text{V}}{5.0\ \Omega} = 40\ \text{A}$$

$I_3 = I_{23} = \boxed{4.0 \times 10^1\ \text{A}}$

$\Delta V_3 = I_3 R_3 = (40\ \text{A})(2.0\ \Omega) = \boxed{8.0 \times 10^1\ \text{V}}$

c. $I_{567} = I = 80\ \text{A}$

$V_{567} = I_{567} R_{567} = (80\ \text{A})(7.52\ \Omega) = 600\ \text{V}$

$\Delta V_{56} = \Delta V_{567} = 600\ \text{V}$

$$I_{56} = \frac{\Delta V_{56}}{R_{56}} = \frac{600\ \text{V}}{10.0\ \Omega} = 60\ \text{A}$$

$I_5 = I_{56} = \boxed{6.0 \times 10^1\ \text{A}}$

$\Delta V_5 = I_5 R_5 = (60\ \text{A})(7.0\ \Omega) = \boxed{4.2 \times 10^2\ \text{V}}$

d. $\Delta V_7 = \Delta V_{567} = \boxed{6.0 \times 10^2\ \text{V}}$

$$I_7 = \frac{\Delta V_7}{R_7} = \frac{600\ \text{V}}{30\ \Omega} = \boxed{2.0 \times 10^1\ \text{A}}$$