① a. $R_{eq} = 2R + 2R \| [2R + (2R \| 4R)]$

$= 2R + 2R \| [2R + \frac{4}{3}R]$

$= 2R + 2R \| [\frac{10}{3}R]$

$= 2R + \frac{5}{4}R$

$$\boxed{R_{eq} = \frac{13}{4}R = 3.25R}$$

b. $V_{CD} = 5V\left(\frac{\frac{5}{4}R}{\frac{13}{4}R}\right)$

$$\boxed{V_{CD} = \frac{25}{13}V = 1.923V}$$

$V_{EF} = V_{CD}\left(\frac{4/3\,R}{10/3\,R}\right)$

$= \frac{2}{5}V_{CD}$

$$\boxed{V_{EF} = \frac{10}{13}V = 0.769V}$$

② ~~$V_4 = V_{supply}$~~

a. $V_4 = V_S\left(\frac{R_4}{R_1 + R_2 \| R_3 + R_4}\right)$

$$\boxed{V_4 = V_S\left(\frac{R_4}{R_1 + \frac{R_2R_3}{R_2+R_3} + R_4}\right)}$$

b. $i_2 = i_3 = 1A$

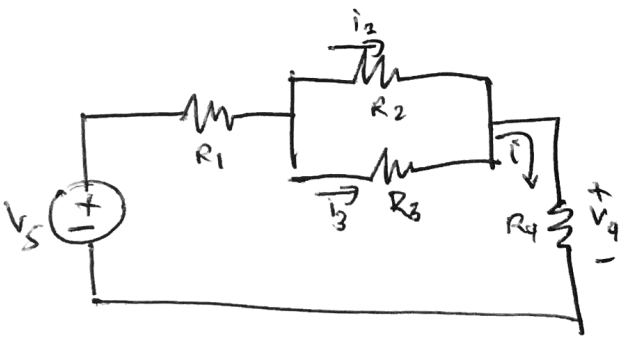
$i_1 = i_2 + i_3 = 2i_2$

$i = 2A$

$V_4 = i(R_4)$

$= 2A(10)$

$$\boxed{V_4 = 20V}$$

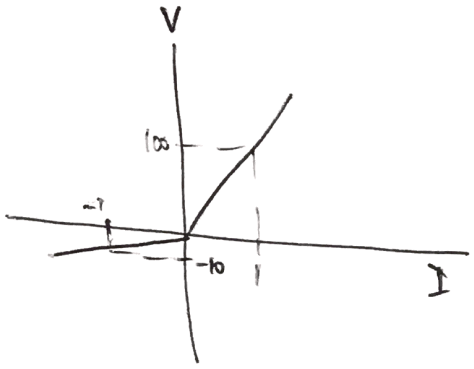


$V_S = 2A(R_{eq})$

$= 2A(10\Omega + 5\Omega + 10\Omega)$

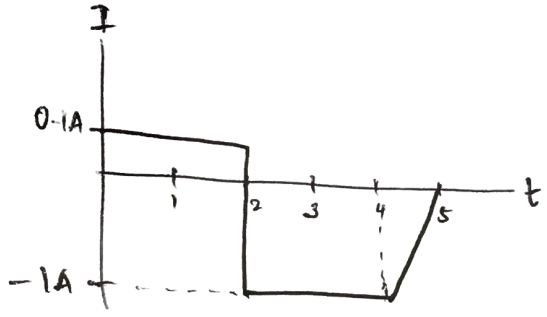
$$\boxed{V_S = 50V}$$

(3)



$$V = \begin{cases} 100I & \text{for } I \geq 0 \\ 10I & \text{for } I < 0 \end{cases}$$

a.



b. $P = VI$

$E = \int P\,dt \Rightarrow$ area under the curve

$\approx P\Delta t$

$0 \leq t < 2s$

$I = 0.1A$

$V = 10V$

$P = 1W$

$E = 2J$

$2 \leq t < 4$

$I = -1A$

$V = -10V$

$P = 10W$

$E = 20J$

$4 \leq t \leq 5$; let $t_0 = t - 4$

$V = -10 + 10t_0$

$I = -1 + t_0$

$$E = \int_0^1 (-10 + 10t_0)(-1 + t_0)\,dt_0$$

$$= 10\int_0^1 (-1 + t_0)^2\,dt_0$$

$$= 10\int_0^1 (1 - 2t_0 + t_0^2)\,dt_0$$

$$= 10\left(t_0 - t_0^2 + \frac{t_0^3}{3}\right)\Big|_{t_0=0}^{t_0=1}$$

$$= 10\left(1 - 1 + \tfrac{1}{3}\right)$$

$$= \frac{10}{3}\,J$$

$$E = 2J + 20J + \frac{10}{3}J$$

$$\boxed{E = 25\tfrac{1}{3}\,J}$$

④

a.

$-10 + 10 i_A + 20(i_A - i_C) + 10(i_A - i_B) = 0$

$-10 + 10(i_B - i_A) + 20(i_B - i_C) + 10 i_B = 0$

$20 i_C + 20(i_C - i_B) + 20(i_C - i_A) = 0$

Simplifying:

$4 i_A - i_B - 2 i_C = 1$

$-i_A + 4 i_B - 2 i_C = 1$

$-i_A - i_B + 3 i_C = 0$

$i_A = \frac{3}{5} A = 0.6A$

$i_B = \frac{3}{5} A = 0.6A$

$i_C = \frac{2}{5} A = 0.4 A$

b. $P_{R1} = i_A^2 R_1$

$= (0.6)^2 (10)$

$P_{R1} = 3.6W$

$P_{R2} = (i_A - i_B)^2 R_2$

$P_{R2} = 0$

$P_{R3} = i_B^2 R_3$

$P_{R3} = 3.6W$

$P_{R4} = (i_A - i_C)^2 R_4$

$= (0.2)^2 (20)$

$P_{R4} = 0.8W$

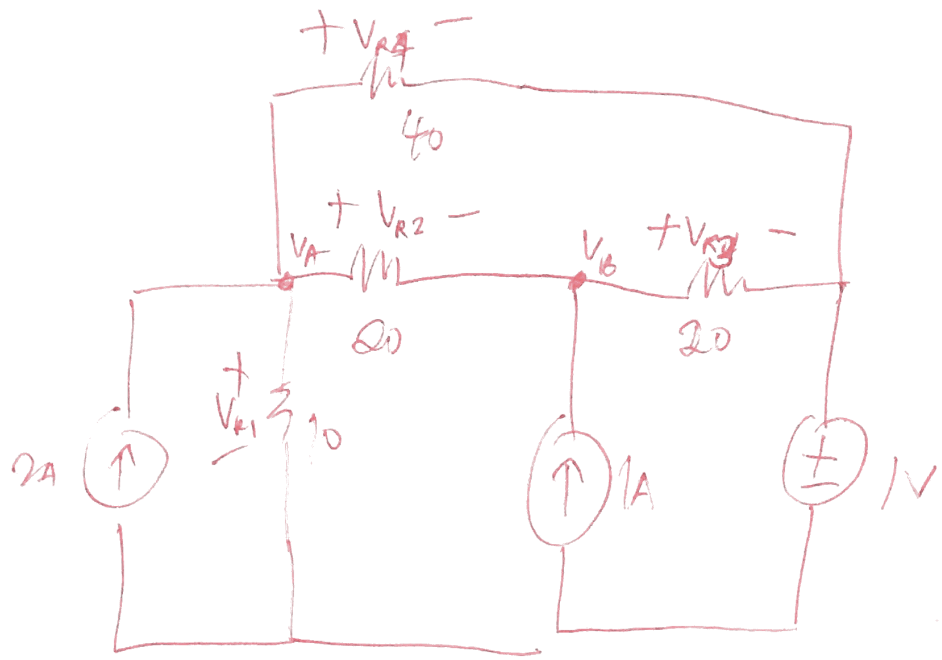
$P_{R5} = (i_B - i_C)(R_5)$

$P_{R5} = 0.8W$

$P_{R6} = i_C^2 (R_6)$

$P_{R6} = 3.2 W$

(5)



node A

$$-2 + \frac{V_A}{10} + \frac{V_A - V_B}{20} + \frac{V_A - 1}{40} = 0 \rightarrow -80 + 4V_A + 2V_A - 2V_B + V_A - 1 = 0$$

$$7V_A - 2V_B = 81$$

node B

$$\frac{V_B - V_A}{20} - 1 + \frac{V_B - 1}{20} = 0 \rightarrow 2V_B - V_A = 21$$

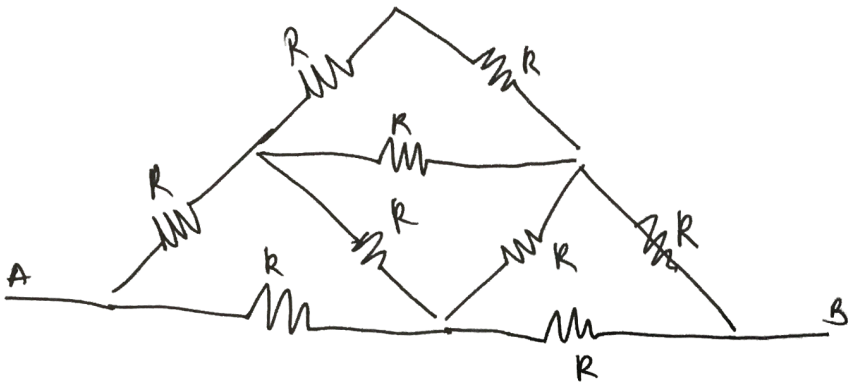
$$7V_A - 2V_B = 81$$
$$-V_A + 2V_B = 21$$

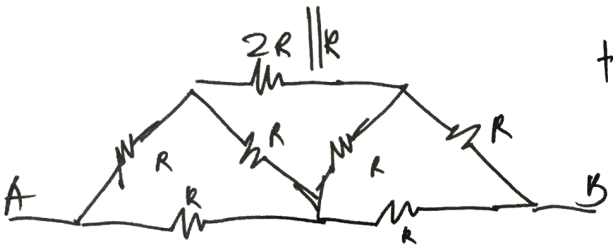
$$6V_A = 102$$

$$V_A = 17\,V \qquad V_B = 19\,V$$

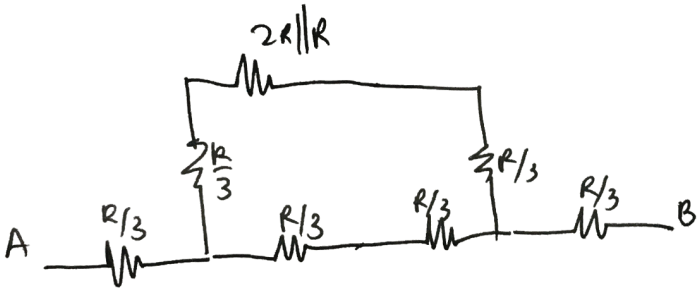
$V_{R1} = 17\,V$	$V_{R3} = 18V$
$V_{R2} = -2V$ or $2V$	$V_{R4} = 10V$

(6)





top part is simplified



both deltas at the bottom are transformed to Y

a.)

$$R_{eq} = \frac{R}{3} + \left(\frac{R}{3} + 2R \| R + \frac{R}{3}\right) \Big\| \left(\frac{R}{3} + \frac{R}{3}\right) + \frac{R}{3}$$

$$= \frac{2R}{3} + \frac{4R}{3} \Big\| \frac{2R}{3} +$$

$$= \frac{2R}{3} + \frac{4R}{9}$$

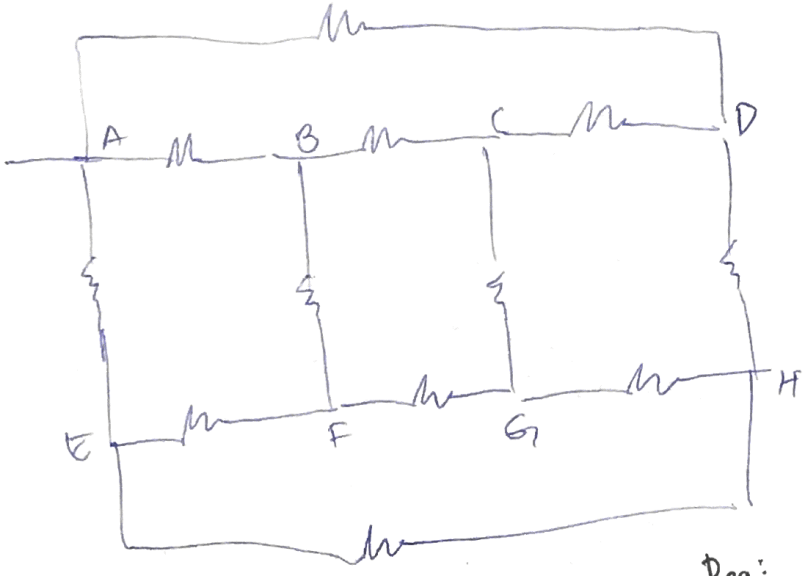
$$\boxed{R_{eq} = \frac{10R}{9}}$$

b.) $R = \frac{9}{10} R_{eq}$

if $R_{eq} = 10k\Omega$

$$\boxed{R = 9k\Omega}$$

(7)



$V_A = V_S$

$V_G = 0$

Using symmetry of cube:

$V_B = V_D = V_E$

$V_C = V_F = V_H$

node voltage @ B

$$\frac{V_B - V_A}{R} + \frac{V_B - V_C}{R} + \frac{V_B - V_F}{R} = 0$$

$3V_B - V_C - V_F = V_A = V_S$

$3V_B - 2V_C = V_S$

node voltage @ C

$$\frac{V_C - V_B}{R} + \frac{V_C - V_D}{R} + \frac{V_C - V_G}{R} = 0 \quad (V_G = 0)$$

$3V_C = V_B + V_D$

$3V_C = 2V_B$

$V_C = \frac{2}{3}V_B$

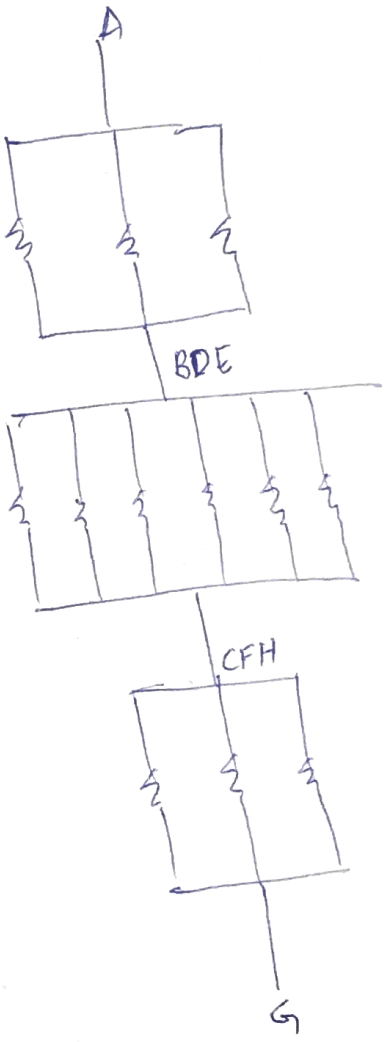
$3V_B - 2\left(\frac{2}{3}V_B\right) = V_S$

$\frac{5}{3}V_B = V_S$

$$\boxed{V_B = V_E = V_D = \frac{3}{5}V_S}$$

$$\boxed{V_C = V_F = V_H = \frac{2}{5}V_S}$$

Req:



$$R_{eq} = (R \| R \| R) + (R \| R \| R \| R \| R \| R) + (R \| R \| R)$$

$$= \frac{R}{3} + \frac{R}{6} + \frac{R}{3}$$

$$= \frac{5}{6}R \longrightarrow 10k = \frac{5}{6}R$$

$$\boxed{R = 12k\Omega}$$

(8)

a. loop 3:

$$20(i_3 - i_1) + \underbrace{\frac{V_x}{2}}_{-V_x/2} - V_x = 0 \qquad -V_x = 10(i_3 - i_2)$$

$$V_x = 10(i_2 - i_3)$$

$$20(i_3 - i_1) - \frac{10}{2}(i_2 - i_3) = 0$$

Eq.1 ∴ $-20i_1 - 5i_2 + 25i_3 = 0$

loop 4:

$$-\frac{V_x}{2} + 10(i_4 - i_1) + 5i_4 = 0$$

$$-5(i_2 - i_3) + 10(i_4 - i_1) + 5i_4 = 0$$

Eq.2: $-10i_1 - 5i_2 + 5i_3 + 15i_4 = 0$

b. i_1

Eq.3: $i_2 - i_1 = 2\,A$

$$\boxed{i_1 = i_2 - 2}$$

c. Eq.4: outer most loop

$-5 + 10i_1 + 5i_4 = 0$

Eq.4: $2i_1 + i_4 = 1$

$$i_1 = \frac{7}{40}\,A = 0.175\,A$$

$$i_2 = \frac{87}{40}\,A = 2.175\,A$$

$$i_3 = \frac{23}{40}\,A = 0.575\,A$$

$$i_4 = \frac{13}{20}\,A = 0.65A$$

$V_x = 10(i_2 - i_3)$

$= 10(2.175A - 0.575\,A)$

$$\boxed{V_x = 16V}$$