184_notes:level_up_sol

Level Up Answers

Level 0

Circuit A:

$$R_{eq} = R_1 + R_2 + R_3 = 9\Omega$$

$$V_3 > V_2 > V_1$$

$$I_1 = I_2 = I_3$$

Circuit B:

$$C_{eq} = (\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3})^{-1} = 2.3mF$$

$$Q_1 = Q_2 = Q_3$$

$$V_1 > V_2 > V_3$$

Circuit C:

$$C_{eq} = C_1 + C_2 + C_3 = 21mF$$

$$V_1 = V_2 = V_3$$

$$Q_3 > Q_2 > Q_1$$

Circuit D:

$$R_{eq} = (\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3})^{-1} = 0.92\Omega$$

$$V_1 = V_2 = V_3$$

$$I_1 > I_2 > I_3$$

Level 1

Circuit A: $R_{eq} = 350\Omega$

Circuit B: $R_{eq} = 400\Omega$

Circuit C: $C_{eq} = 235\mu F$

Circuit D: $C_{eq} = 176.25\mu F$

Level 2

Circuit A:

Results:

CIRCUIT A	V	I	R	P
R_1	1 V	6 A	0.116 Ω	6 W
R_2	2 V	6A	0.33 Ω	12 W
R_3	2 V	3 A	0.67 Ω	6 W
R_4	2 V	3 A	0.67 Ω	6 W
R_5	4 V	3 A	1.33 Ω	12 W
bat	7 V	6 A	_	42 W

Power Ranking: $P_1 = P_2 > P_1 = P_3 = P_4$

Circuit B:

Results:

CIRCUIT B	V	I	R	P
R_1	12 V	2 A	6 Ω	24 W
R_2	9 V	2 A	4.5 Ω	18 W
R_3	4 V	2 A	2 Ω	8 W
R_4	3 V	2 A	1.5 Ω	6 W
R_5	8 V	2 A	4 Ω	16 W
bat	12 V	6 A	_	72 W

Power Ranking: $P_1 > P_5 > P_2 > P_3 > P_4$

Circuit C

Results:

CIRCUIT C	V	I	R	P
R_1	2 V	3 A	0.67 Ω	6 W
R_2	2V	3A	0.67 Ω	6 W
R_3	2.5 V	6A	0.417 Ω	15 W
R_4	4 V	1 A	4 Ω	4 W
R_5	4 V	5 A	0.8 Ω	20 W
bat	8.5 V	6 A	–	51 W

Power Ranking: $P_5 > P_3 > P_1 = P_2 > P_4$

Circuit D

Results:

CIRCUIT D	V	I	R	P
R_1	12 V	3 A	4 Ω	36 W
R_2	1.5 V	1 A	1.5 Ω	1.5 W
R_3	10.5 V	1 A	10.5 Ω	10.5 W
R_4	4 V	4 A	1 Ω	16 W
R_5	3 V	4 A	0.75 Ω	12 W
bat	19 V	4 A	–	76 W

Power Ranking: $P_1 > P_4 > P_5 > P_3 > P_2$

Level 3

Circuit A

Results:

CIRCUIT A	V (Volts)	Q (Coulombs)	C (Farads)	U (Joules)
C_1	6.14	1.84m	300µ	5.65m
C_2	2.86	0.29m	100µ	0.415m
C_3	2.86	1.3m	470µ	1.86m
C_4	1.43	0.215m	150µ	0.154m
C_5	1.43	0.215m	150µ	0.154m
bat	9	1.84m	–	8.28m

Circuit B

Results:

CIRCUIT B	V (Volts)	Q (Coulombs)	C (Farads)	U (Joules)
C_1	16	0.016	1m	0.128
C_2	11.54	0.116	10m	0.669
C_3	4.46	0.089	20m	0.198
C_4	1.8	0.027	15m	0.0243
C_5	2.7	0.027	10m	0.0365
bat	16	0.132	_	1.06

Circuit C

Results:

CIRCUIT C	V (Volts)	Q (Coulombs)	C (Farads)	U (Joules)
C_1	1.78	1.78E-7	100nF	1.58E-7
C_2	1.22	1.22E-7	100nF	7.44E-8
C_3	0.25	5.53E-8	220nF	6.91E-9
C_4	0.97	9.7E-9	10nF	4.7E-9
C_5	0.97	4.56E-8	47nF	2.21E-8
bat	3	1.78E-7	_	2.67E-7

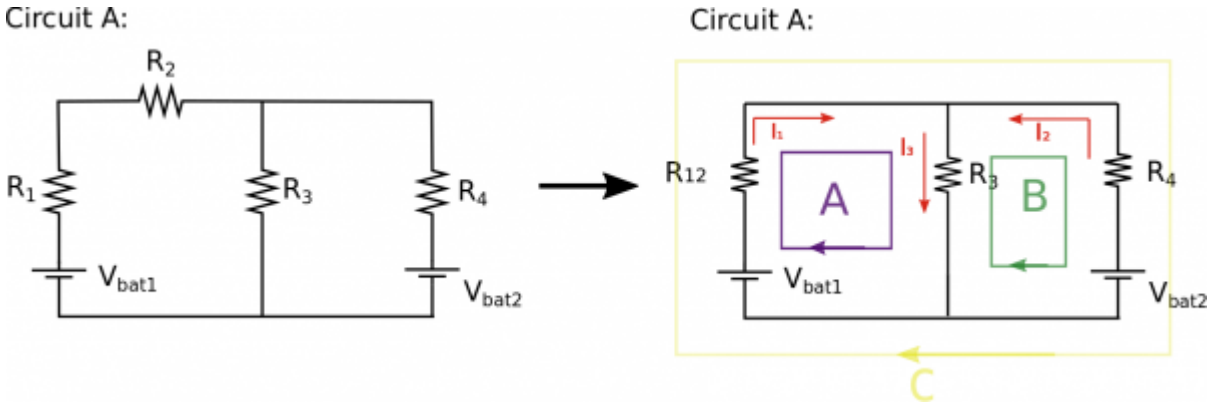
Circuit D

Results:

CIRCUIT D	V (Volts)	Q (Coulombs)	C (Farads)	U (Joules)
C_1	3.4	0.034	10mF	0.058
C_2	1.6	0.034	22mF	0.027
C_3	2.03	0.095	47mF	0.096
C_4	2.97	0.0297	10mF	0.044
C_5	2.97	0.0653	22mF	0.097
bat	5	0.13	_	0.325

Level 4

Circuit A



Given:

$V_1 = 9V, V_2 = 6V, R = 100\Omega$

Simplify Circuit:

- R_1 and R_2 in series, $R_1 + R_2 = 200\Omega$

Node Rule:

- $I_1 + I_2 = I_3$

Loop Rule:

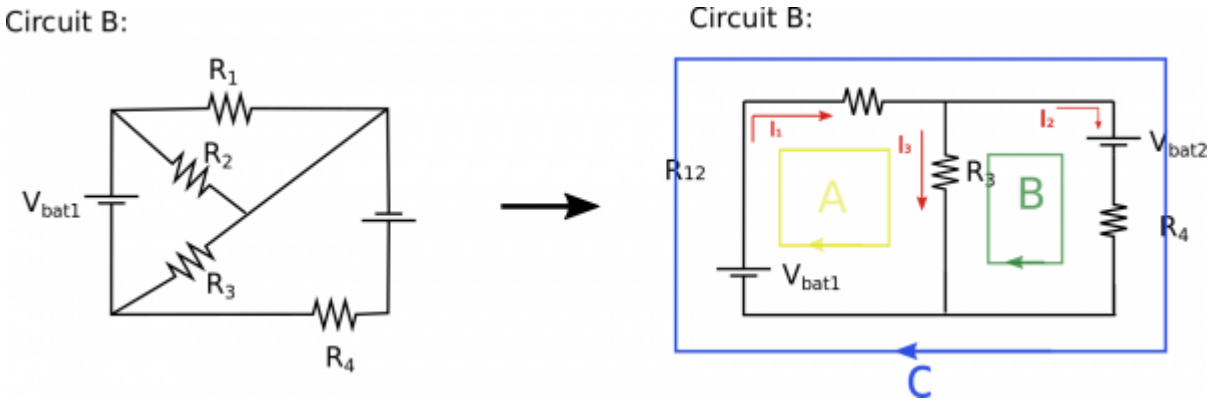
- Loop A: $V_1 - I_1 R_{12} - I_3 R_3 = 0$
- Loop B: $I_3 R_3 - I_2 R_4 - V_2 = 0$
- Loop C: $V_1 - I_1 R_{12} - I_2 R_4 - V_2 = 0$

Solution:

$I_1 = 0.024A, I_2 = 0.018A, I_3 = 0.042A$

*note can use wolfram/online/calc to evaluate I from loop AND node rule equations

Circuit B



Given:

$V_1 = 9V, V_2 = 6V, R = 100\Omega$

Simplify Circuit:

- $R_1 \parallel R_2, R_{12} = 50\Omega$

Node Rule:

- $I_1 = I_2 + I_3$

Loop Rule:

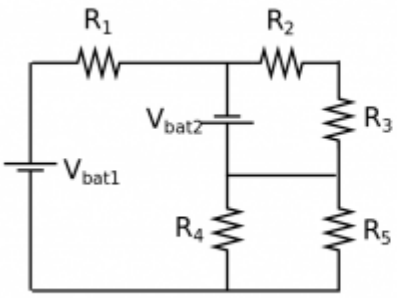
- Loop A: $V_1 - I_1 R_{12} - I_3 R_3 = 0$
- Loop B: $V_2 - I_2 R_4 + I_3 R_3 = 0$
- Loop C: $V_1 - I_1 R_{12-V_2} - I_2 R_4 = 0$

Solution:

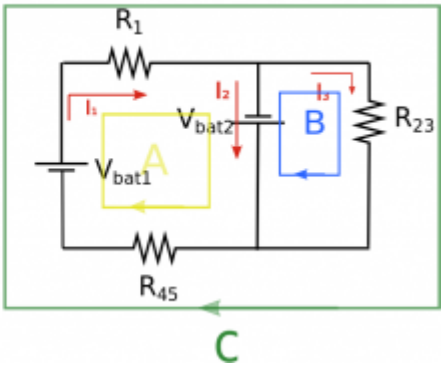
$I_1 = 0.12A, I_2 = 0.09A, I_3 = 0.03A$

Circuit C

Circuit C:



Circuit C:



Given:

$V_1 = 9V, V_2 = 6V, R = 100\Omega$

Simplify Circuit:

- R_2 and R_3 in series, $R_2 + R_3 = 200\Omega$
- $R_4 \parallel R_5$, $R_{12} = 50\Omega$

Node Rule:

- $I_1 = I_2 + I_3$

Loop Rule:

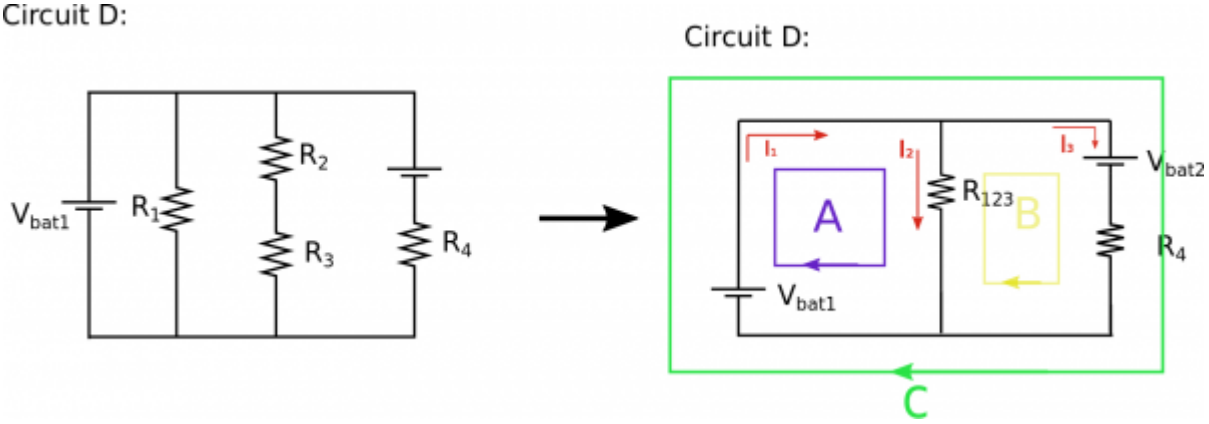
- Loop A: $V_1 - I_1 R_1 + V_2 - I_1 R_{45} = 0$
- Loop B: $-V_2 - I_3 R_{23} = 0$
- Loop C: $V_1 - I_1 R_1 - I_3 R_{23} - I_1 R_{45} = 0$

Solution:

$I_1 = 0.06A, I_2 = 0.09A, I_3 = -0.03A$

Circuit D

Circuit D:



Given:

$V_1 = 9V, V_2 = 6V, R = 100\Omega$

Simplify Circuit:

- R_2 and R_3 in series, $R_2 + R_3 = 200\Omega$
- $R_1 || R_{23}$, $R_{12} = 66.667\Omega$

Node Rule:

- $I_1 = I_2 + I_3$

Loop Rule:

- Loop A: $V_1 - I_1 R_{123} - 0$
- Loop B: $I_2 R_{123} - V_2 - I_3 R_4 = 0$
- Loop C: $V_1 - V_2 - I_3 R_4 = 0$

Solution:

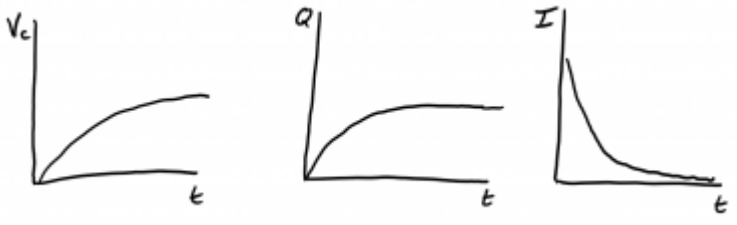
$I_1 = 0.165A, I_2 = 0.135A, I_3 = 0.03A$

Level Bonus

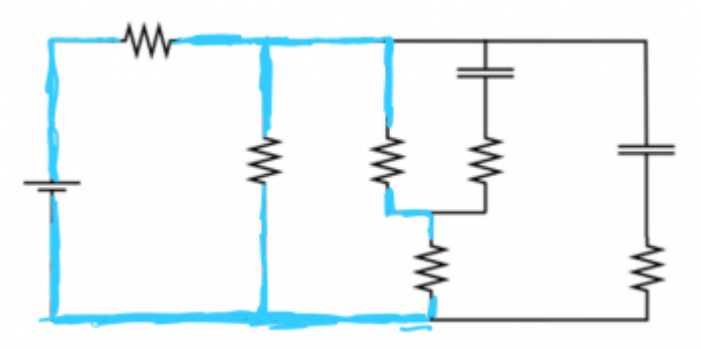
a) Initially there is current in all branches of the circuit (uncharged capacitors act like wires - current can pass through).

b) $I_i = 0.00436A$

c)



d) Current goes through all branches without a capacitor (charge capacitors act like a break in the circuit - no current)



e) $I_f = 0.0036A$

f) If the switch is opened, the capacitors would discharge through the resistors below.