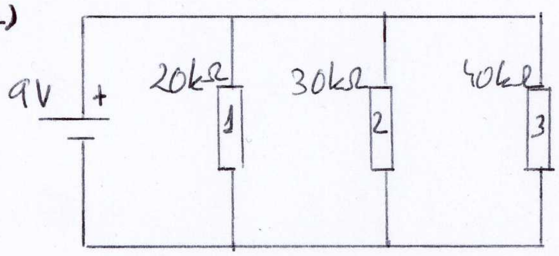
(29) a)



R_1, R_2 and R_3 are three resistors in a parallel connection:

Equivalent resistance:

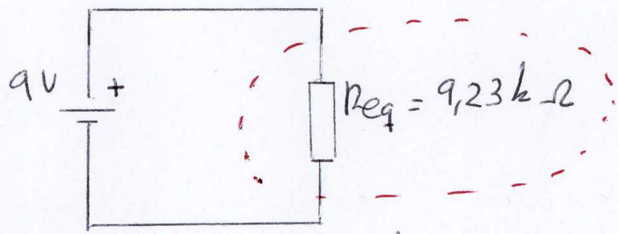
$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

$$\frac{1}{R_{eq}} = \frac{1}{20} + \frac{1}{30} + \frac{1}{40} = \frac{6+4+3}{120}$$

$$\frac{1}{R_{eq}} = \frac{13}{120} \longrightarrow R_{eq} = \frac{120}{13}$$

$$\boxed{R_{eq} = 9{,}23\,k\Omega}$$

b)



In order to calculate the total current we apply Ohm's law to the resistor

↳ Voltage across the resistor is 9V because it's the only resistor in this circuit, so V is the same as the value of voltage across the the battery

$$V = IR \longrightarrow I = \frac{V}{R} = \frac{9\,V}{9{,}23\,k\Omega}$$

$$\boxed{I = 0{,}975\,mA}\ *$$

* This is a very low value. The reason for that is that the resistance values in the resistors is very high.

c) 1. Voltage across each resistor in the original circuit is the same (because they are in a parallel connection)

2. Electrons only go through one resistor on a circle on the circuit so $\longrightarrow$ $V_1 = V_2 = V_3 = 9\,V$

In order to calculate current through each resistor we must apply Ohm's law:

$$I = \frac{V}{R} \rightarrow \boxed{\begin{aligned} I_1 &= \frac{V}{R_1} = \frac{9}{20} = 0{,}45\,mA \\ I_2 &= \frac{V}{R_2} = \frac{9}{30} = 0{,}30\,mA \\ I_3 &= \frac{V}{R_3} = \frac{9}{40} = 0{,}225\,mA \end{aligned}}$$

As you can see: $I_{TOT} = I_1 + I_2 + I_3$

$$0{,}975 = 0{,}45 + 0{,}30 + 0{,}225 = 0{,}975$$

d) As we have said in section c) $\boxed{V = 9V}$

e) Battery $P = I . V = 0{,}975\,mA . 9V = \boxed{8{,}775\,mW}$

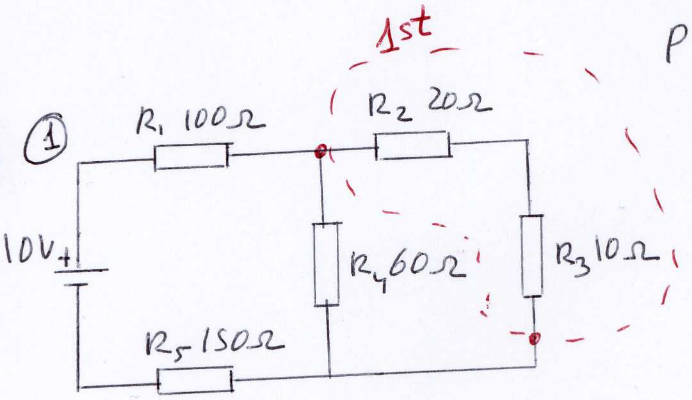
Resistors

$$\begin{aligned} P_1 &= I_1 . V = 0{,}45 \cdot 9 = 4{,}05\,mW \\ P_2 &= I_2 . V = 0{,}3 \cdot 9 = 2{,}7\,mW \\ P_3 &= I_3\ V = 0{,}225 \cdot 9 = 2{,}025\,mW \end{aligned}$$

As you can check $P = P_1 + P_2 + P_3$

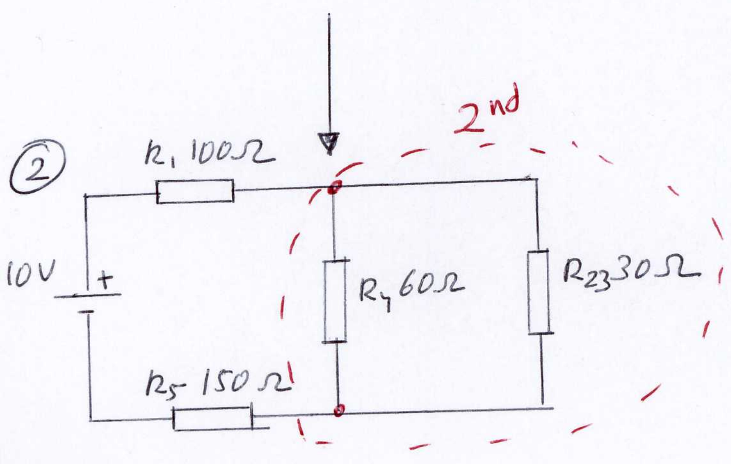
$$P = 4{,}05 + 2{,}7 + 2{,}025 = 8{,}775\,mW$$

30.



We start simplifying R_2 and R_3 because they are in a series connection

$$R_{23} = R_2 + R_3 = 20 + 10 = 30\Omega$$



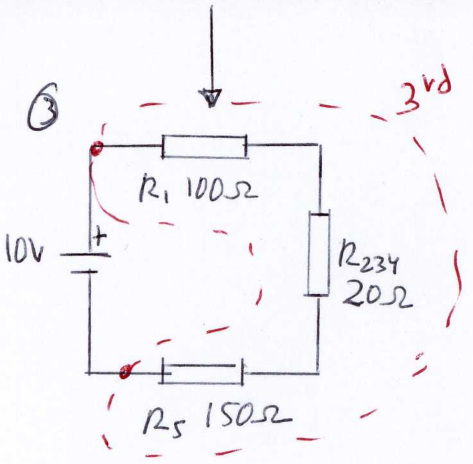
Now we simplify R_4 and R_{23}. they are in a parallel connection

$$\frac{1}{R_{234}} = \frac{1}{R_4} + \frac{1}{R_{23}} = \frac{1}{60} + \frac{1}{30}$$

$$\frac{1}{R_{234}} = \frac{1+2}{60} = \frac{3}{60} \rightarrow R_{234} = \frac{60}{3}$$

$$R_{234} = 20\Omega$$

(3)

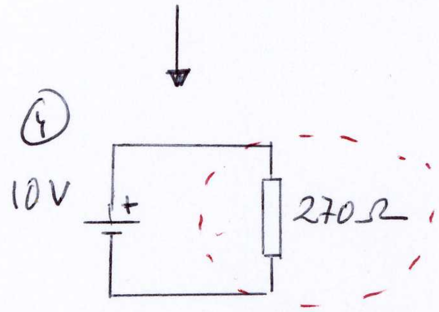


Finally we simplify this three resistors (R_1, R_{234}, R_5) in series connection

$$R_{eq} = R_1 + R_{234} + R_5$$

$$R_{eq} = 100 + 20 + 150 = \boxed{270\Omega}$$

(4)



We are applying Ohm's law to calculate current through the resistor

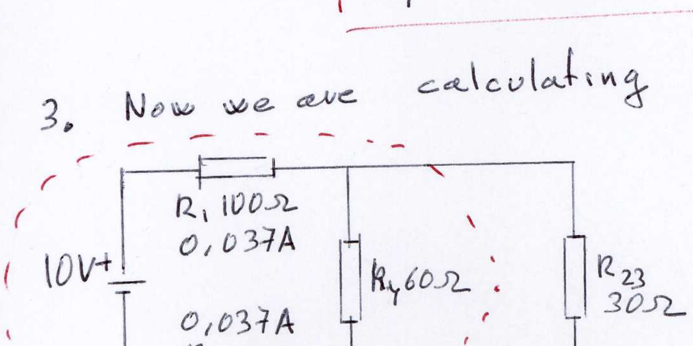
$$V = IR \rightarrow I = \frac{V}{R} = \frac{10}{270} = 0{,}037\ A$$

Now that we have solved the equivalent circuit, we need to move backwards in order to find the other current values.

1. Current through the 10V battery is the same as the current through the equivalent resistor because they are in series connection
2. If you take a look to circuit (3) you will see that current in the battery has to be the same as current through R_1, R_{234} and R_4 because they are in a series connection

$$\boxed{I_1 = I_{234} = I_5 = 0{,}037\ A}$$

3. Now we are calculating I_4. Take a look to circuit (2)



In order to calculate I_4 using ohm's law we need to calculate V_4 first

$$V_{battery} = V_1 + V_4 + V_5 \rightarrow$$

$$V_4 = V_{battery} - V_1 - V_5$$

We already know R_1 and I_1 $\longrightarrow$ $V_1 = I_1 R_1 = 0{,}037 \cdot 100 = 3{,}7\,V$

R_5 and I_5 $\longrightarrow$ $V_5 = I_5 R_5 = 0{,}037 \cdot 150 = 5{,}55\,V$

So :

$$V_4 = 10 - 3{,}7 - 5{,}55 = 0{,}75\,V$$

And

$$I_4 = \frac{V_4}{R_4} = \frac{0{,}75}{60} = 0{,}0125\,A$$

$$\boxed{I_4 = 0{,}0125\,A}$$

4. This is very simple.

$$I_1 = I_4 + I_{23} \longrightarrow I_{23} = I_1 - I_4$$

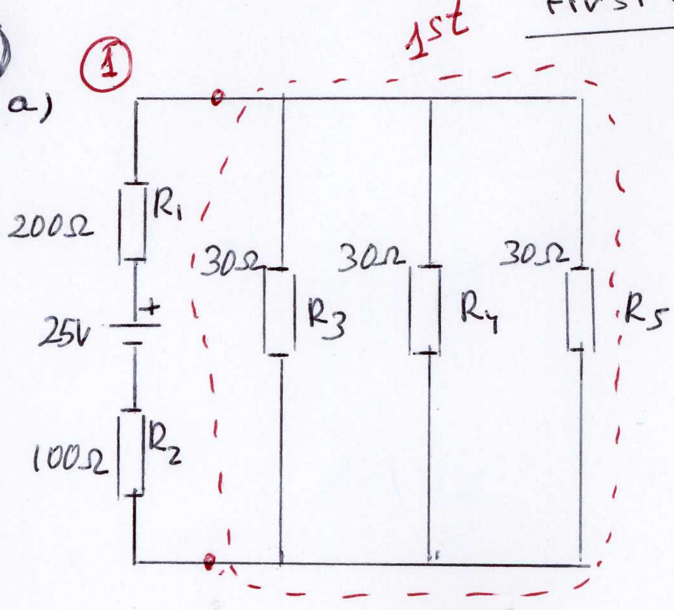
$$I_{23} = 0{,}037 - 0{,}0125 = 0{,}0245\,A$$

$$I_{23} = \boxed{I_2 = I_3 = 0{,}0245\,A}$$

because series connection.

First circuit

3) a) 1



1st R_3, R_4 and R_5 is a parallel connection, so:

$$\frac{1}{R_{345}} = \frac{1}{R_3} + \frac{1}{R_4} + \frac{1}{R_5}$$

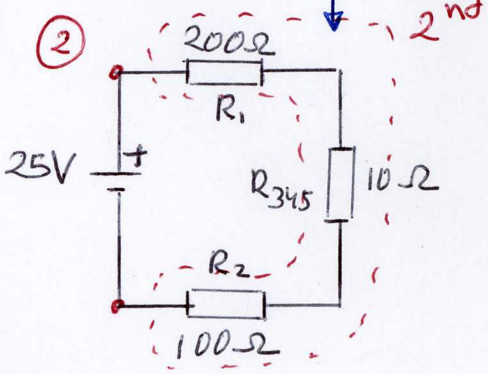
$$\frac{1}{R_{345}} = \frac{1}{30} + \frac{1}{30} + \frac{1}{30} = \frac{3}{30}$$

Inverting the outcome:

$$\frac{1}{R_{345}} \rightarrow \frac{R_{345}}{1} = \frac{30}{3} \rightarrow R_{345} = 10\,\Omega$$

Simplifying

2



2nd R_1, R_{345} and R_2 is a series connection, so:

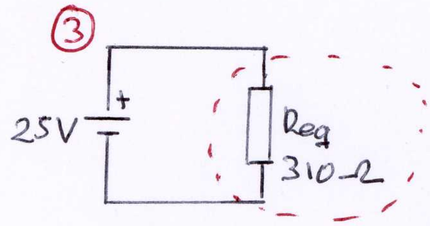
$$R_{eq} = R_1 + R_{345} + R_2$$

$$R_{eq} = 200 + 10 + 100 = 310\,\Omega$$

$$\boxed{R_{eq} = 310\,\Omega}$$

b)

Simplifying



By being all these circuits equivalents current ~~across~~ through this last equivalent resistor is the same as current in all the other batteries.

$$V = IR$$

$$I = \frac{V}{R} \longrightarrow I = \frac{25}{310} = 0{,}081\ A$$

$$\boxed{I = 81\,mA}$$

c) We need to find current ~~across~~ through all five resistor but

$I_1 = I_2 = I_{battery}$ by being in a series connection

$$\boxed{I_1 = I_2 = 81\,mA}$$

It would be possible to calculate I_3, I_4 and I_5 following the same technique we have described in exercise 30 but if you stop and think for a moment you can see that R_3, R_4 and R_5 are in a parallel connection and their resistance values are just the same.. That means that the total current it is going to divide in three equal parts

$$I_3 = I_4 = I_5 = \frac{I_{battery}}{3} = \frac{81}{3} = 27\,mA$$

$$\boxed{I_3 = I_4 = I_5 = 27\,mA}$$

d) and e)

knowing all R and I values this section is very simple:

$$V = I \cdot R \qquad P = I \cdot V$$

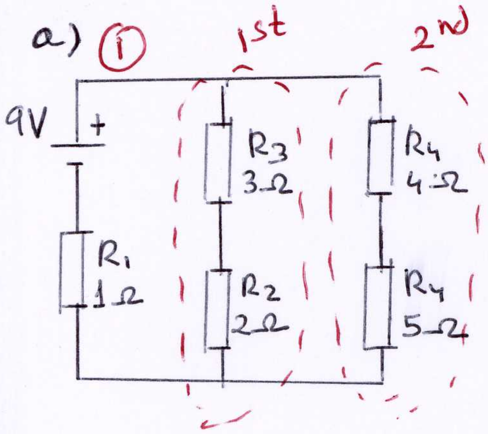
We just have to complete the table

	R (Ω)	I (mA)	V (V)	P (W)
1	200	81	16,2	1,312
2	100	81	8,1	0,656
3	30	27	0,81	0,022
4	30	27	0,81	0,022
5	30	27	0,81	0,022

They are identical.

Second circuit

a)



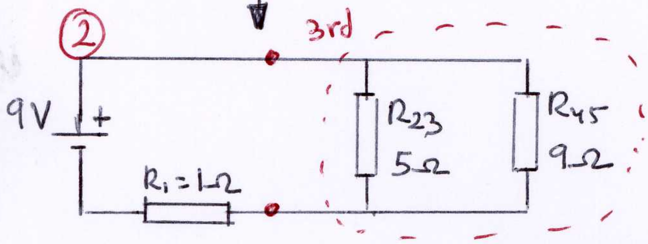
1st R_2 and R_3 is a series connection

$$R_{23} = R_2 + R_3 = 2 + 3 = 5\,\Omega$$

2nd R_4 and R_5 is again a series connec.

$$R_{45} = R_4 + R_5 = 4 + 5 = 9\,\Omega$$

Simplifyng



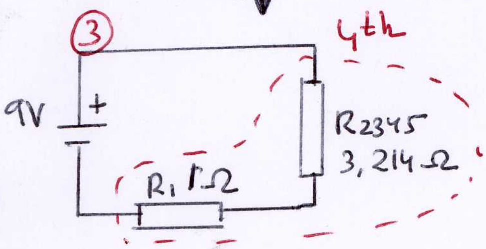
3rd R_{23} and R_{45} is a parallel connection

$$\frac{1}{R_{2345}} = \frac{1}{R_{23}} + \frac{1}{R_{45}} = \frac{1}{5} + \frac{1}{9} = \frac{14}{45}$$

Inverting:

$$\frac{R_{2345}}{1} = \frac{45}{14} \qquad R_{2345} = 3{,}214\,\Omega$$

Simplifying

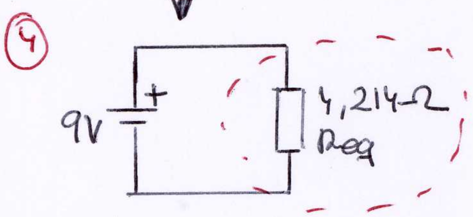


4th this is a series connection:

$$R_{eq} = R_1 + R_{2345} = 1 + 3{,}214$$

$$\boxed{R_{eq} = 4{,}214\,\Omega}$$

b)



By being all 4 circuit equivalents is the same current across Req is the same as current ~~across~~ through the batteries in all four systems

$$V = I.R \longrightarrow I = \frac{V}{R} = \frac{9}{4{,}214} \rightarrow \boxed{I = 2{,}14\,A}$$

c) We have to calculate current ~~across~~ through all five resistors.

I_1 is the same as Ibattery as they are in series

$$I_1 = I_{battery} = \boxed{2{,}14\,A = I_1}$$

I_2 and I_3 are going to be the same because they are in a series connection

Applying Ohms law to R_{23} in circuit 2

$$V_{23} = I_{23} \cdot R_{23} \longrightarrow I_{23} = \frac{V_{23}}{R_{23}}$$

But we have a problem. We need to calculate first V_{23}.

Take alook to circuit number 2 & 3

3 R_1 and R_{2345} are in a series connection so:

$$V_{battery} = V_1 + V_{2345}$$

2 R_{23} and R_{45} are in a parallel connection so:

$$V_{23} = V_{45} = V_{2345}$$

That means that by calculating V_1 we can obtain V_{23} and also V_{45}

$$V_1 \longrightarrow V_1 = I_1 R_1 = 2{,}14 \cdot 1 = 2{,}14\,V$$

$$V_{2345} = V_{battery} - V_1 = 9 - 2{,}14 = 6{,}86\,V$$

So:

$$I_{23} = \frac{V_{2345}}{R_{23}} = \frac{6{,}86}{5} = 1{,}372\ A$$

$$\boxed{I_2 = I_3 = 1{,}372\ A}$$

We can now calculate I_3 and I_4 in the same way

$$I_{45} = \frac{V_{2345}}{R_{45}} = \frac{6{,}86}{9} = 0{,}762\ A$$

$$\boxed{I_4 = I_5 = 0{,}762\ A}\ *$$

* If you take a moment to understand the problem it would be also possible to do:

$$I_4 = I_{battery} - I_2$$

d) and e)

Just like we did in ~~section~~ part 1 with the first circuit we just to complete the table

	$R\,(\Omega)$	$I\,(A)$	$V\,(V)$		$P\,(W)$
1	1	2,14	2,14		4,58
2	2	1,372	2,744	6,86	3,76
3	3	1,372	4,116		5,65
4	4	0,762	3,048	6,86	2,32
5	5	0,762	3,81		2,90

$V = I.R$

(32.) This exercise is the same as exercise 30. The only difference is that there are two batteries in a series connection.

We need to simplify those batteries.

$$V_{eq} = V_{battery\,1} + V_{battery\,2} \; *$$

$$\boxed{V_{eq} = 11 + 9 = 20\,V}$$

You can now solve the system following the same techique as the one described on exercise 30.

* We are adding voltages because the negative pole of one of the batteries is connected to the positive pole on the othe battery.