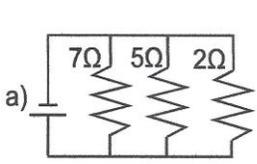
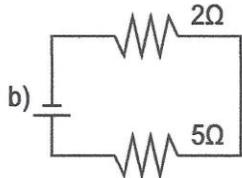


CIRCUITS WORKSHEET

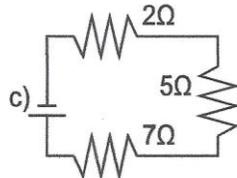
1. Determine the equivalent (total) resistance for each of the following circuits below.



$$\begin{aligned} \frac{1}{R_{eq}} &= \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \\ &= \frac{1}{7} + \frac{1}{5} + \frac{1}{2} = \frac{59}{70} \\ R_{eq} &= \frac{70}{59} = 1.2\Omega \end{aligned}$$

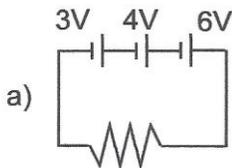


$$\begin{aligned} R_{eq} &= R_1 + R_2 \\ &= 2 + 5 \\ R_{eq} &= 7\Omega \end{aligned}$$

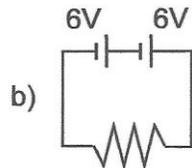


$$\begin{aligned} R_{eq} &= R_1 + R_2 + R_3 \\ &= 2 + 5 + 7 \\ R_{eq} &= 14\Omega \end{aligned}$$

2. Determine the total voltage (electric potential) for each of the following circuits below.



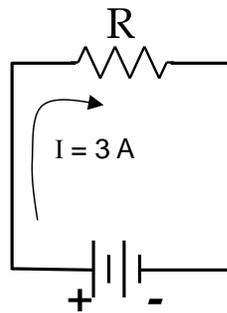
13V



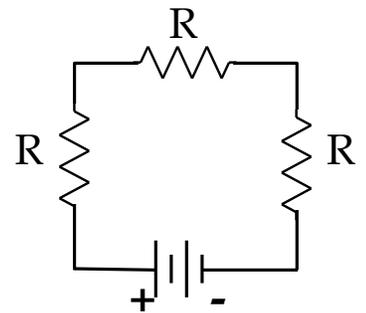
12 V

3. In a series circuit there is just one path so the charge flow is constant everywhere (charge is not lost or gained). Circuit B was made by adding 2 more identical resistors in series to circuit A

- a) How is the charge flow out of the battery (and back into it) affected by adding more bulbs in series? **Charge flow or current decreases as total resistance increases**



Circuit A



Circuit B

- b) If the resistors were light bulbs, how do you expect the brightness of the bulbs to be affected by adding more bulbs in series?

Brightness gets dimmer since less current or charge passing through each bulb AND smaller voltage drop across each bulb (the voltage gain at the battery is now distributed among 3 bulbs as opposed to just one).

- c) How is the brightness in the 2 circuits related to charge flow or current?

The brightness is directly related to current since the less charge flowing through each bulb each second, the less energy/charge is lost and converted to light

- d) How does the current in circuit B compare to circuit A?

Circuit B has three times the total resistance (same V) so current supplied by battery drops three fold. Circuit B would have only 1A of current.

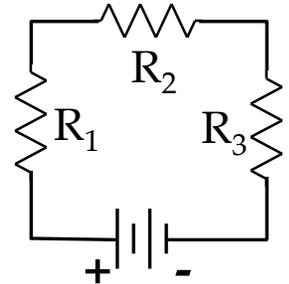
e) How is current (I) related to the resistance of the circuit?

The current is inversely related to the total resistance of the circuit (Ohm's Law)

f) If the resistance of a circuit is quadrupled, by what factor does the current change? 1/4th

g) Fill out the table for the circuit diagramed at the right.

Circuit Position	Voltage (V)	Current (A)	Resistance (Ω)	Power (W)
1	1.0	0.10	10.0	0.1
2	2.0	0.10	20.0	0.2
3	3.0	0.10	30.0	0.3
Total	6.00	0.10	60	0.6



h) Is there a relationship between resistance and voltage drop in a series circuit? If so, state it.

Ohm's Law: $V = IR$

c) If the resistors were light bulbs, explain in terms of charge flow (current) and energy per charge (voltage) which bulb would be brightest / dimmest.

The brightness of the bulb is related to

- ΔV (amount of electrical energy lost and converted to heat/light) and

- I (the higher the current through the bulb, the more charge per sec converting energy to light)

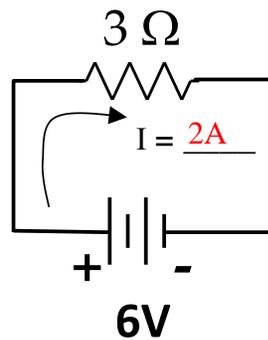
In this case, the current through each resistor is the same, so ΔV determines the brightness. Since the voltage drop across the **30 Ω** resistor is greatest, it would be the **brightest** bulb. Conversely, since the voltage drop across the **10 Ω** resistor is least, it would be the **dimmest** bulb.

4. In a parallel circuit, there is more than one loop or pathway so charge flow gets split up or recombined at junction points. Therefore current is not the same at every point in the circuit

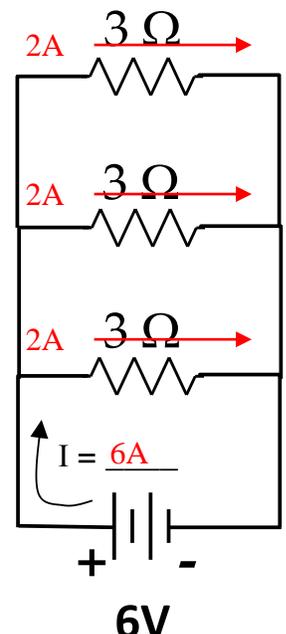
a) How does the current through the one resistor in circuit A, compare to the current through each resistor in circuit B? (Use Kirchoff Loop rule on circuit B to look at the current in each path.)

The current through each resistor in circuit B is the same as the current through the resistor in circuit A ($I = V/R$. V across R in circuit B is same as circuit A)

b) How does the sum of the currents through the three bulbs in circuit B compare to current from the battery in circuit A? Since the current across each bulb in circuit B is the same as in circuit A and there are three pathways, the sum of the currents in B is 3x current in circuit A



Circuit A



Circuit B

c) How is the current out of the battery (and back into it) affected by adding resistors in parallel? Explain
Charge flow out of the battery would increase since there are more pathways for current to go

d) If the resistors were light bulbs, how does the brightness of each bulb in circuit B compare to the brightness of the single bulb in circuit A,?

The brightness of the bulb is related to

- ΔV (amount of electrical energy lost and converted to heat/light) and
- I (the higher the current through the bulb, the more charge per sec converting energy to light)

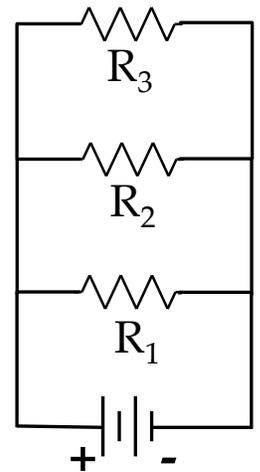
In this case, the voltage drop across each resistor in circuit B is same as voltage drop across R. The current through each resistor in circuit B is also the same as the current through R in circuit A. Therefore, the brightness of the bulbs in B would be same as brightness of bulb in A

e) How is the resistance of a circuit affected by adding additional pathways?

Total Resistance decreases (because more pathways for the charge to flow)

f) Fill out the table for the circuit diagramed at the right.

Circuit Position	Voltage (V)	Current (A)	Resistance (Ω)	Power (W)
1	6.00	0.60	10.0	3.6
2	6.00	0.30	20.0	1.8
3	6.00	0.20	30.0	1.2
Total	6.00	1.1	5.5 (V_{bat}/I_{bat})	6.6



g) How does the voltage drop across each branch in a parallel circuit compare?

The voltage drop across each branch is the SAME in a parallel circuit.

h) If the resistors were light bulbs, explain in terms of charge flow (current) and energy per charge (voltage) which bulb would be brightest / dimmest.

The brightness of the bulb is related to

- ΔV (amount of electrical energy lost and converted to heat/light) and
- I (the higher the current through the bulb, the more charge per sec converting energy to light)

In this case, the voltage drop across each resistor is the same, so I determines the brightness. Since the current through the 10Ω resistor is greatest, it would be the **brightest bulb. Conversely, since the current through the 30Ω resistor is least, it would be the **dimmest** bulb.**

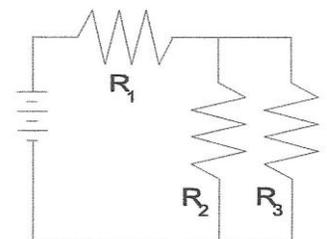
Notice that the resistance doesn't determine brightness since the 30Ω bulb was brightest when connected to the others in series.

5. Consider the circuit at right. Assume the resistors are identical.

a) Rank the resistors according to the flow of charge through them.

Current is drawn from the battery and then splits at the branch point.

Since charge is conserved in the circuit (Kirchoff's junction rule), the current going into the junction is equal to the sum of the currents coming



out. Since R_2 and R_3 are identical, the current splits equally down the R_2 and R_3 pathway ($I_2 = I_3$). At the next branch point, the current recombines to the original total current and this is what goes through R_1 .

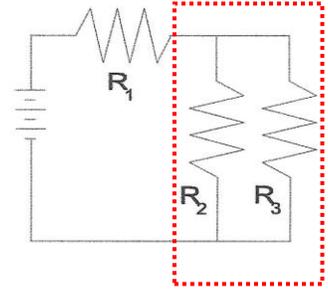
$$I_2 = I_3 < I_1$$

- b) Imagine that the resistors in parallel (R_2 and R_3) were a single resistor. How would the combined equivalent resistance of R_{23} compare to the resistance of R_1 ?

The resistors in the box are in parallel so the equivalent resistance is

$$\frac{1}{R_{eq}} = \frac{1}{R} + \frac{1}{R} = \frac{2}{R} \Rightarrow R_{eq} = R/2$$

The equivalent resistance is half of R_1



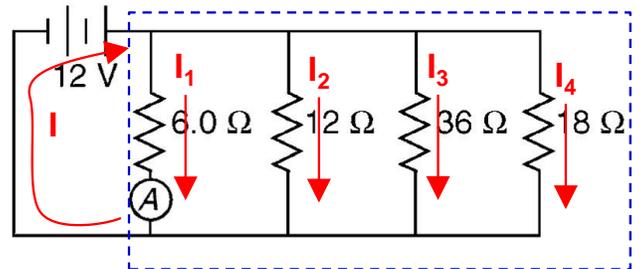
- c) Now let $R_1 = 10 \Omega$, $R_2 = 20 \Omega$, and $R_3 = 30 \Omega$. Fill out the table for the circuit

Circuit Position	Voltage (V)	Current (A)	Resistance (Ω)	Power (W)
1	2.7	0.27	10.0	0.73
2	3.3	0.165	20.0	0.54
3	3.3	0.11	30.0	0.36
Total	6.00	0.27 (current thru battery)	22 (R_{eq})	1.62

Questions 6 and 7 refer to the following: The diagram to the right represents an electric circuit consisting of four resistors and a 12-volt battery

- 6) What is the equivalent resistance of the circuit shown?

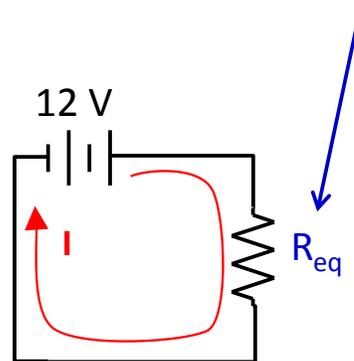
$$\begin{aligned} \frac{1}{R_{eq}} &= \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4} \\ &= \frac{1}{6} + \frac{1}{12} + \frac{1}{36} + \frac{1}{18} = \frac{12}{36} \\ R_{eq} &= \frac{36}{12} = 3\Omega \end{aligned}$$



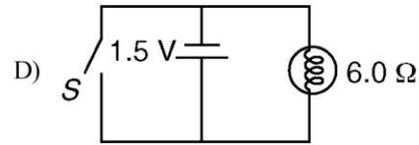
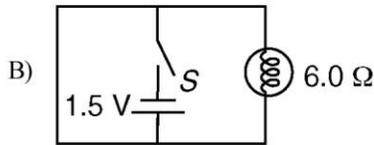
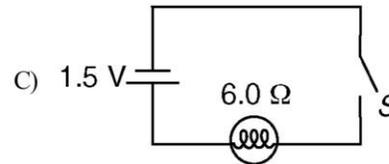
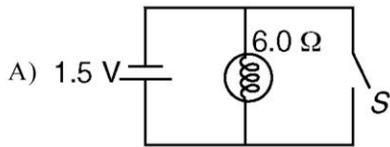
- 7) What is the current measured by ammeter A shown in the diagram?

KLR on loop with 12V battery and 6Ω resistor
KLR

$$\begin{aligned} \sum \Delta V &= 0 \\ \Delta V_{bat} - \Delta V_6 &= 0 \\ 12 &= \Delta V_6 \\ 12 &= I_1(6) \\ I_1 &= 2A \end{aligned}$$



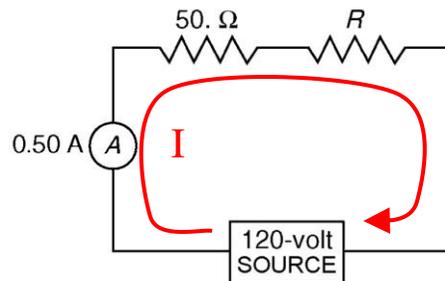
8) A 6.0-ohm lamp requires 0.25 ampere of current to operate. In which circuit below would the lamp operate correctly when switch S is closed?



It would only operate in **C**. In A and D, closing the switch would introduce a pathway of zero resistance. ALL of the current would go down the path of no resistance leaving NO current passing through the lamp (the circuit would be short circuited). In B, once the switch was closed and the circuit included the battery, ALL of the current would go down the path of no resistance leaving no current passing through the lamp (short circuit).

Questions 9 and 10 refer to the following:

A 50.-ohm resistor, an unknown resistor R , a 120-volt source, and an ammeter are connected in a complete circuit. The ammeter reads 0.50 ampere.



9) Calculate the equivalent resistance of the circuit shown.

$$\Delta V_{bat} = IR_{eq}$$

$$120 = 0.5R_{eq}$$

$$R_{eq} = 240\Omega$$

10) Determine the resistance of resistor R shown in the diagram.

Resistors in series

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

$$240 = 50 + R$$

$$R = 190\Omega$$

OR could use KLR

$$\sum \Delta V = 0$$

$$\Delta V_{bat} - \Delta V_{50} - \Delta V_R = 0$$

$$120 = \Delta V_{50} + \Delta V_R$$

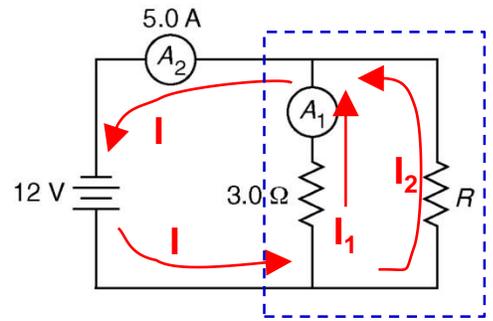
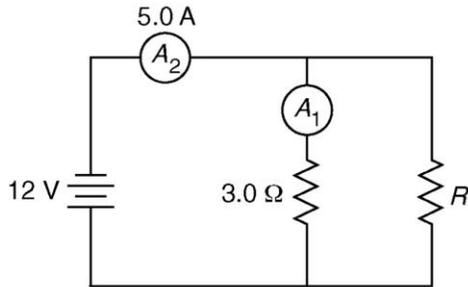
$$120 = I(50) + IR$$

$$120 = 0.5(50) + 0.5R$$

$$R = 190\Omega$$

Questions 11 through 13 refer to the following:

A 3.0-ohm resistor, an unknown resistor, R , and two ammeters, A_1 and A_2 , are connected as shown below with a 12-volt source. Ammeter A_2 reads a current of 5.0 amperes.



11) Determine the equivalent resistance of the circuit shown.

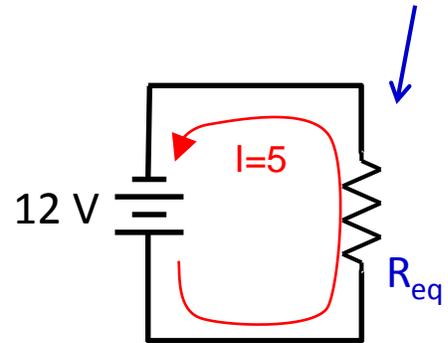
$$\Delta V_{bat} = IR_{eq}$$

$$12 = 5R_{eq}$$

$$R_{eq} = 12/5 = 2.4\Omega$$

12) Calculate the current measured by ammeter A_1 in the diagram shown.

Original circuit KLR on the loop containing battery and 3Ω resistor



$$\sum \Delta V = 0$$

$$\Delta V_{bat} - \Delta V_3 = 0$$

$$12 = \Delta V_3$$

$$12 = I_1(3)$$

$$I_1 = 4A$$

13) Calculate the resistance of the unknown resistor, R in the diagram shown.

Resistors in parallel

OR

KJR

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

$$I = I_1 + I_2$$

$$5 = 4 + I_2$$

$$I_2 = 1A$$

$$\frac{5}{12} = \frac{1}{3} + \frac{1}{R}$$

KLR on outer loop

$$\sum \Delta V = 0$$

$$\Delta V_{bat} - \Delta V_R = 0$$

$$\frac{1}{R} = \frac{1}{12}$$

$$R = 12\Omega$$

$$12 = \Delta V_R$$

$$12 = I_2 R$$

$$12 = 1R$$

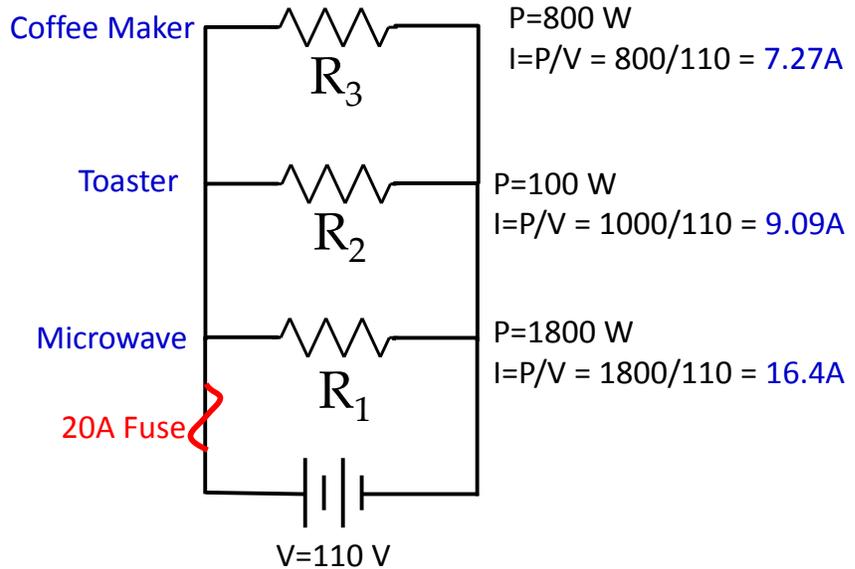
$$R = 12\Omega$$

14. A 110-V household circuit that contains an 1800-W microwave, a 1000-W toaster, and an 800-W coffeemaker is connected to a 20-A fuse. Determine the current. Will the fuse melt if the microwave and the coffeemaker are both on?

Each appliance is parallel to the 110 V power supply, so the voltage drop across each is 110V

Knowing the power of each appliance and the V across each, we can find the current through each device using $P = IV$

When the microwave and coffeemaker are on, a total current of $23.7\text{A} = 7.27 + 16.4\text{A}$ is drawn from power supply. This exceeds the max current of the 20A fuse so it will melt and the current through the circuit will stop.



15. Determine the equivalent resistance of two resistors of $12\ \Omega$ and $18\ \Omega$ when they are connected

a) in parallel

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

$$= \frac{1}{12} + \frac{1}{18} = \frac{5}{36}$$

$$R_{eq} = 36/5\ \Omega = 7.2\ \Omega$$

b) in series

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

$$= 12 + 18$$

$$R_{eq} = 30\ \Omega$$

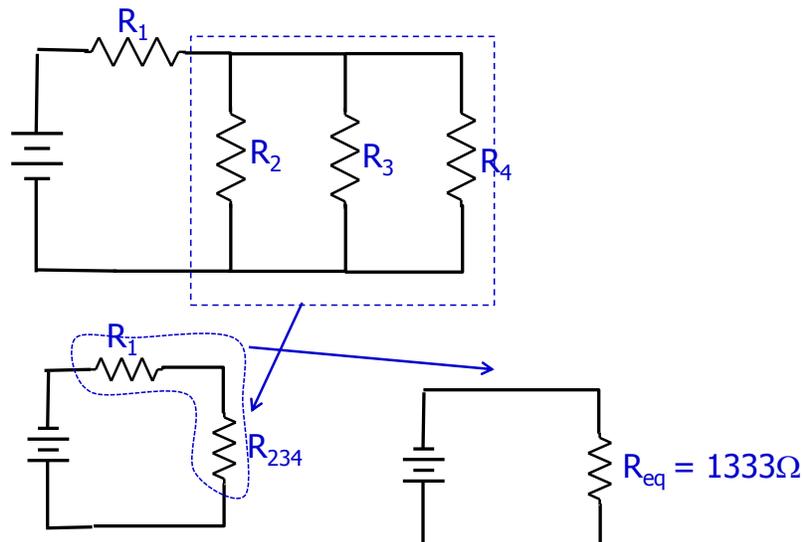
16) Assume that you have five one thousand ohm ($1000\ \Omega$) resistors.

In series, $1000\ \Omega$ would make R_{eq} in multiples of 1000

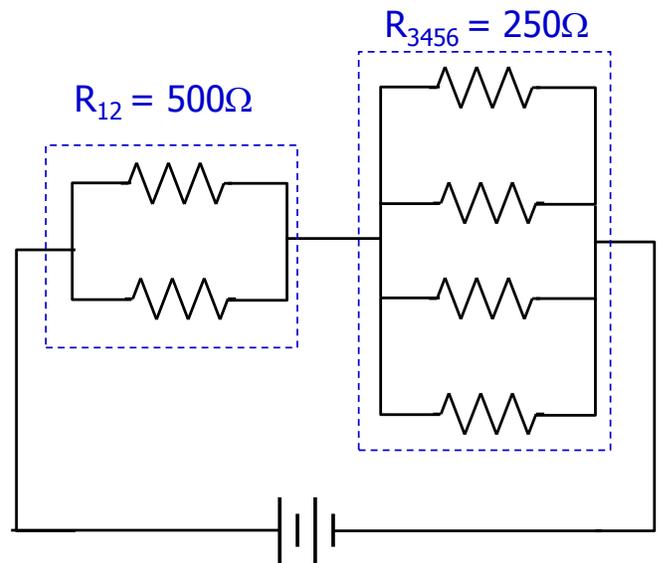
In parallel, $1000\ \Omega$ would make $1000/2$ (for 2 in parallel), $1000/3$ (for 3 in parallel), $1000/4$ (for 4 in parallel), ...

a) Devise a circuit with an equivalent resistance of $1333\ \text{ohms}$.

Need 3 in parallel ($R_{eq}=333\ \text{W}$) which is in series with another



- b) Devise a circuit with an equivalent resistance of 750 ohm. **Cant do unless have six 1000 Ω resistors**
(500 Ω with 2 in parallel) in series with (250 Ω made with 4 in parallel)



- c) Using all five resistors, what is the smallest resistance that can be constructed?
Smallest Req would be with all 5 in parallel

$$\frac{1}{R_{eq}} = \frac{1}{1000} + \frac{1}{1000} + \frac{1}{1000} + \frac{1}{1000} + \frac{1}{1000} = \frac{5}{1000} = \frac{1}{200}$$

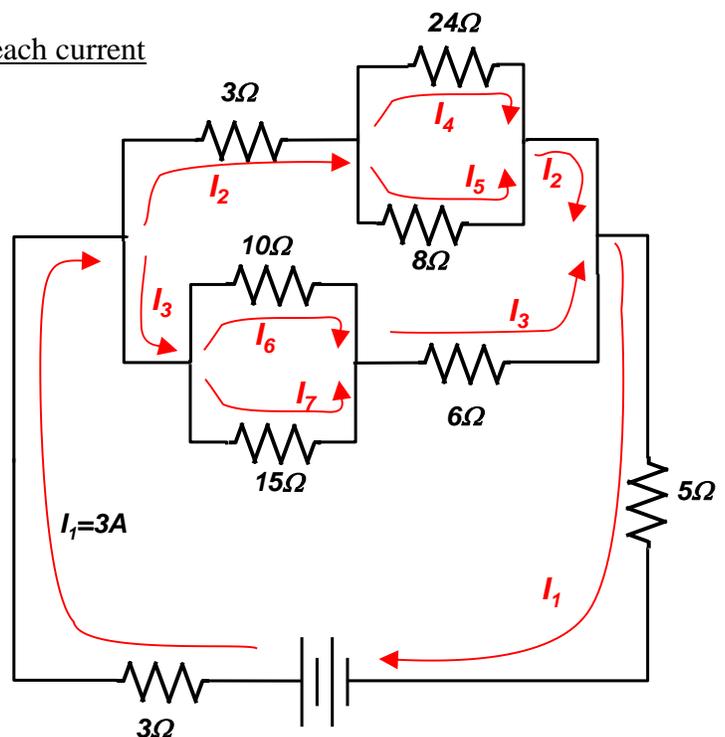
$$R_{eq} = 200\Omega$$

- d) Using all five resistors, what is the largest resistance that can be constructed?
 • **Largest Req would be with all 5 in series**

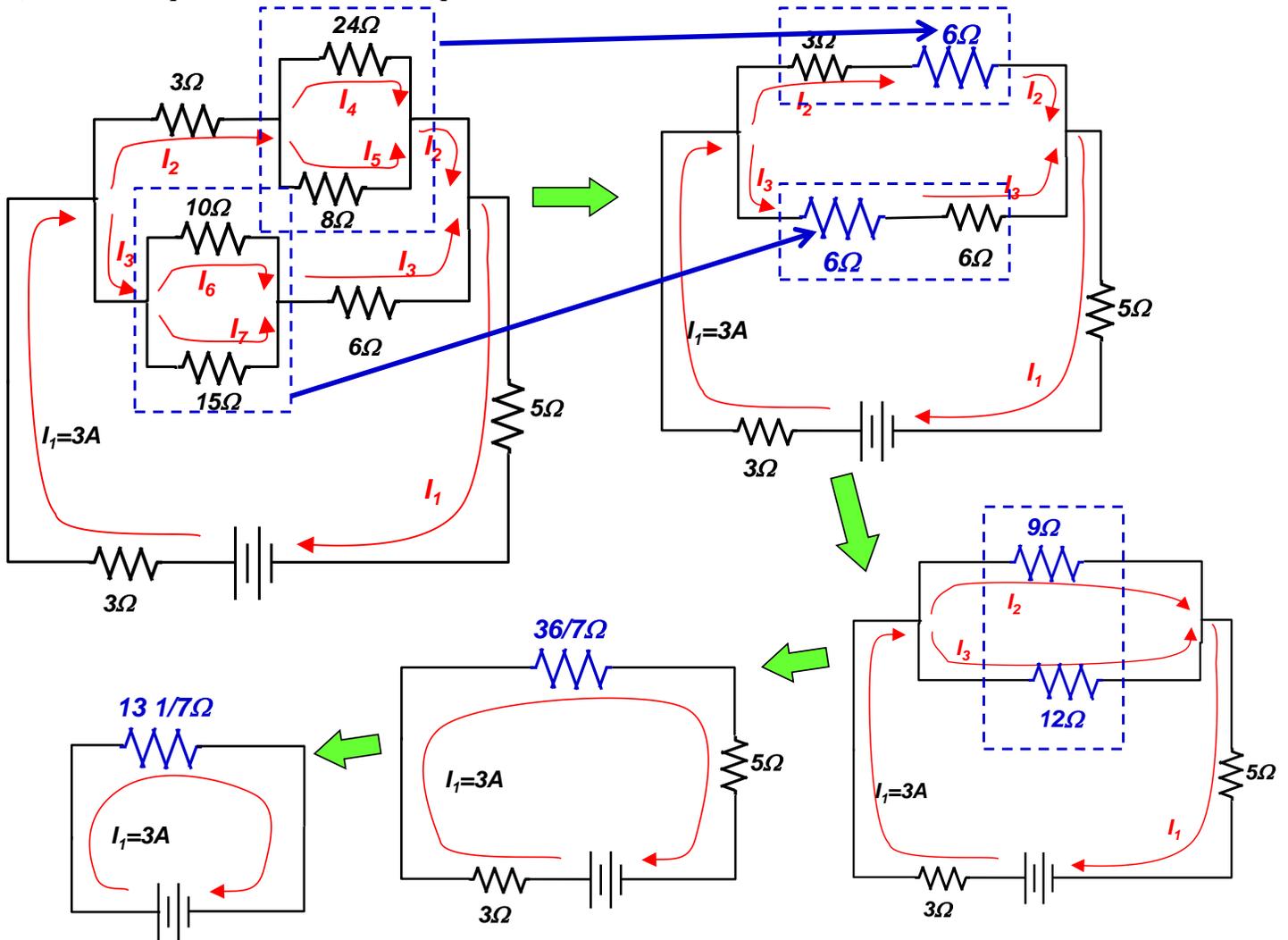
$$R_{eq} = 1000 + 1000 + 1000 + 1000 + 1000 = 5000\Omega$$

17. Given the circuit at right:

- a) Draw the current flow on the circuit. Label each current



b) Find the equivalent resistance, R_{eq} , of the circuit



From the last equivalent circuit, applying KLR:

$$V_{bat} = I_1 R_{eq}$$

$$= (3)(13.143)$$

$$V_{bat} = 39.43V$$

$I_1 = 3A$ is the current that goes through the battery and the 3Ω and 5Ω resistors. Knowing I and R for those, can find V through the 3Ω and 5Ω resistors by Ohms Law.

I_2 : Can use the 2nd circuit above. KLR outer loop $\sum \Delta V = 0$

$$\Delta V_{bat} - \Delta V_3 - \Delta V_3 - \Delta V_6 - \Delta V_5 = 0$$

$$39.43 - I_1(3) - I_2(3) - I_2(6) - I_1(5) = 0$$

$$39.43 - 3(3) - I_2(3) - I_2(6) - 3(5) = 0$$

$$15.43 = 9I_2$$

$$I_2 = 1.71A$$

I_3 : KJR:

$$I_1 = I_2 + I_3$$

$$3 = 1.71 + I_3$$

$$I_3 = 1.29A$$

c) Complete the table

R (Ω)	ΔV (v)	I (A)	P (W)
Battery	39.43		
3	9.0	3	27
3	5.14	1.714	8.81
24	10.3	0.429	4.42
8	10.3	1.286	13.26
10	7.71	0.771	5.94
15	7.71	0.514	3.96
6	7.71	1.286	9.92
5	15	3	45