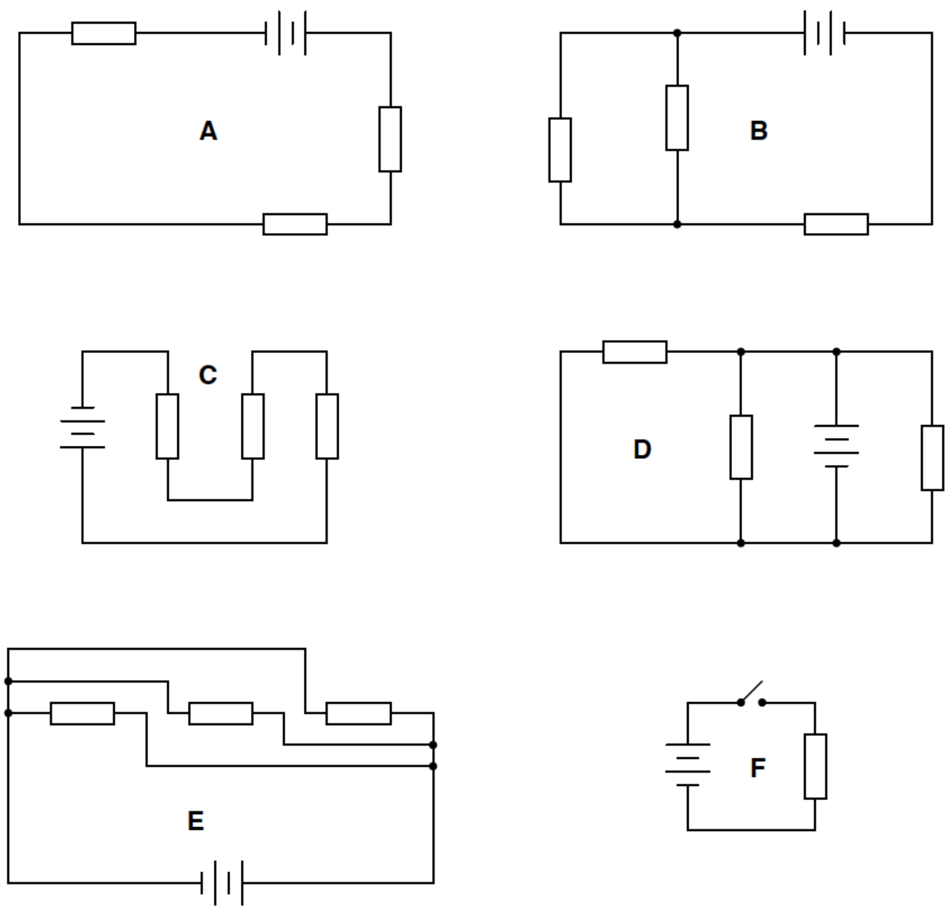
Parallel DC Circuits

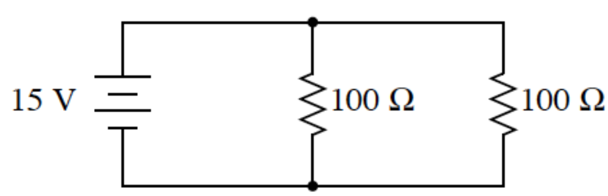
Question 1

Identify which of these circuits is a *parallel* circuit (there may be more than one shown!):



Question 2

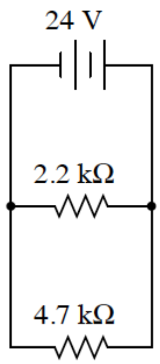
Determine the amount of voltage impressed across each resistor in this circuit:



Hint: locate all the points in this circuit that are electrically common to one another!

Question 3

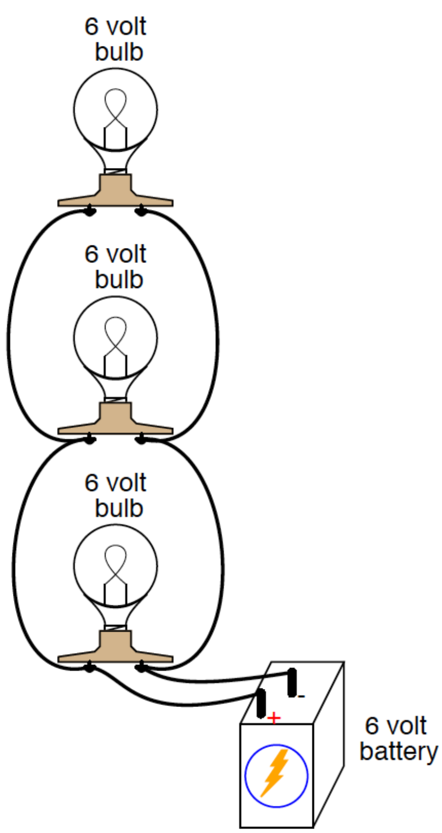
According to Ohm's Law, how much current goes through each of the two resistors in this circuit?



Draw the paths of all currents in this circuit.

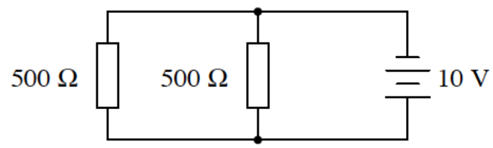
Question 4

Qualitatively compare the voltage and current for each of the three light bulbs in this circuit (assume the three light bulbs are absolutely identical):



Question 5

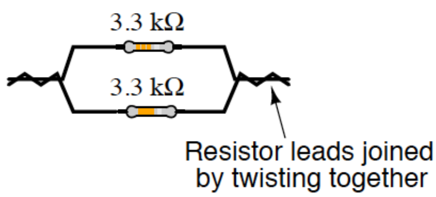
Calculate the total amount of current that the battery must supply to this parallel circuit:



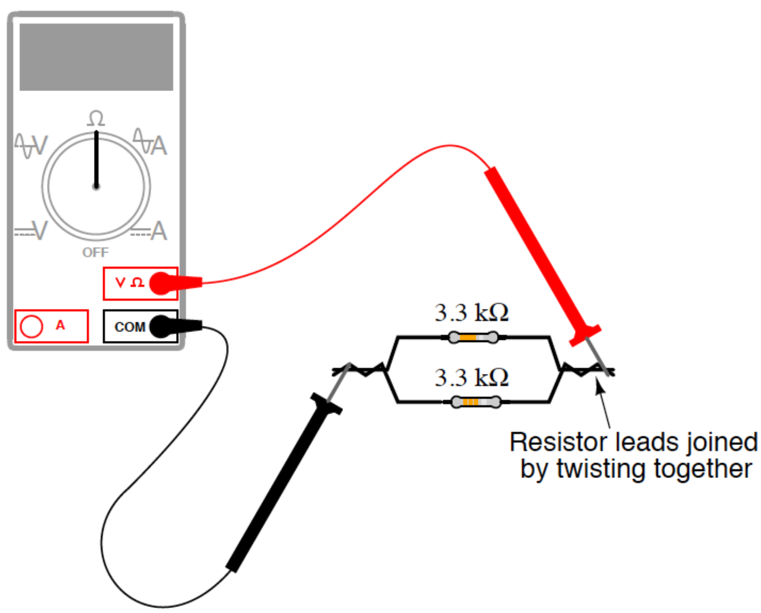
Now, using Ohm's Law, calculate total resistance (R_{total}) from total (source) voltage V_{total} and total (source) current I_{total}.

Question 6

Suppose I connect two resistors in parallel with one another, like this:



How much electrical resistance would you expect an ohmmeter to indicate if it were connected across the combination of these two parallel-connected resistors?



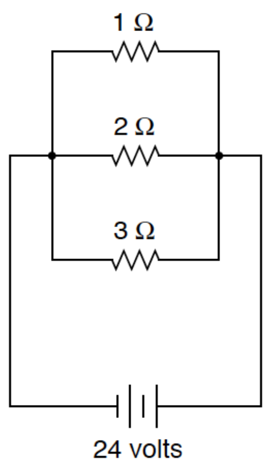
Explain the reasoning behind your answer, and try to formulate a generalization for all combinations of parallel resistances.

Question 7

There are two well-known formulae for calculating the total resistance of parallel-connected resistances. One of these works only for two resistances, while the other works for any number of parallel resistances. Write these two formulae, and give examples of their use.

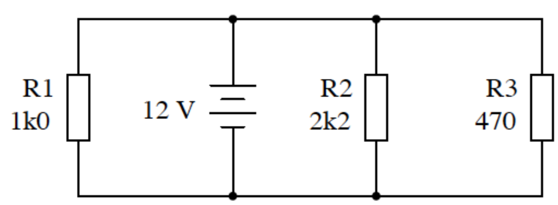
Question 8

In this circuit, three resistors receive the same amount of voltage (24 volts) from a single source. Calculate the amount of current "drawn" by each resistor, as well as the amount of power dissipated by each resistor:



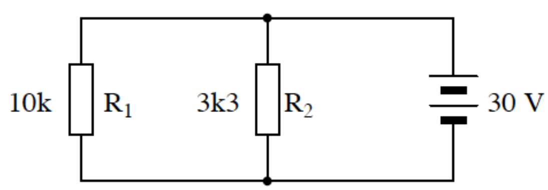
Question 9

Explain, step by step, how to calculate the amount of current (I) that will go through each resistor in this parallel circuit, and also the voltage (V) dropped by each resistor:



Question 10

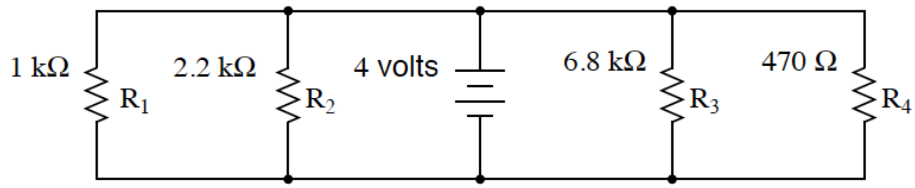
Complete the table of values for this circuit:



	R_1	R_2	Total
V			
I			
R			
P			

Question 11:

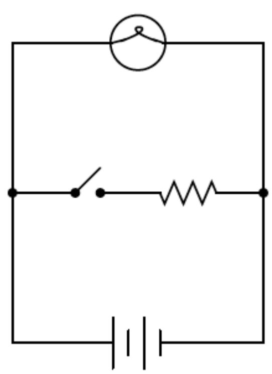
Complete the table of values for this circuit:



	R_1	R_2	R_3	R_4	Total
V					
I					
R	1 kΩ	2.2 kΩ	6.8 kΩ	470 Ω	
P					

Question 12

What will happen to the brightness of the light bulb if the switch in this circuit is suddenly closed?



Question 13

In a parallel circuit, certain general rules may be stated with regard to quantities of voltage, current, resistance, and power. Express these rules, using your own words:

"In a parallel circuit, voltage . . ."

"In a parallel circuit, current . . ."

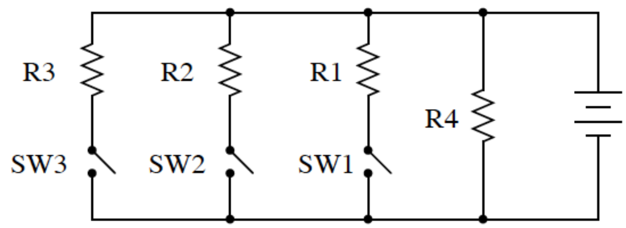
"In a parallel circuit, resistance . . ."

"In a parallel circuit, power . . ."

For each of these rules, explain *why* it is true.

Question 14

What will happen in this circuit as the switches are sequentially turned on, starting with switch number 1 and ending with switch number 3?

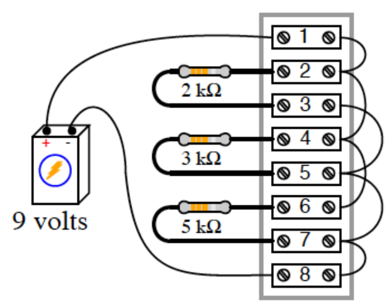


Describe how the successive closure of these three switches will impact:

- The voltage drop across each resistor
- The current through each resistor
- The total amount of current drawn from the battery
- The total amount of circuit resistance "seen" by the battery

Question 15

The circuit shown here is commonly referred to as a *current divider*. Calculate the voltage dropped across each resistor, the current drawn by each resistor, and the total amount of electrical resistance "seen" by the 9-volt battery:



- Current through the 2 kΩ resistor =
- Current through the 3 kΩ resistor =
- Current through the 5 kΩ resistor =
- Voltage across each resistor =
- R_{total} =

Can you think of any practical applications for a circuit such as this?

Answer Key

Answer 1

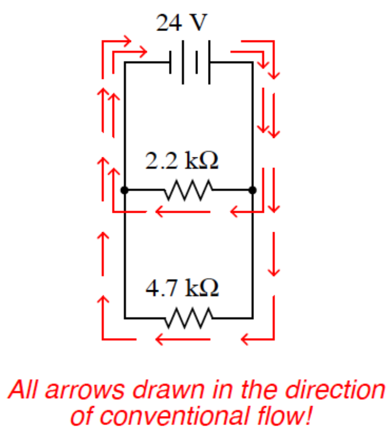
Circuits **D** and **E** are *parallel* circuits.

Answer 2

Each resistor has 15 volts across it in this circuit.

Answer 3

$I_{R(2.2k)} = 10.91$ mA
$I_{R(4.7k)} = 5.11$ mA



Follow-up question: how much *total* current does the battery supply to the circuit, given these individual resistor currents?

Answer 4

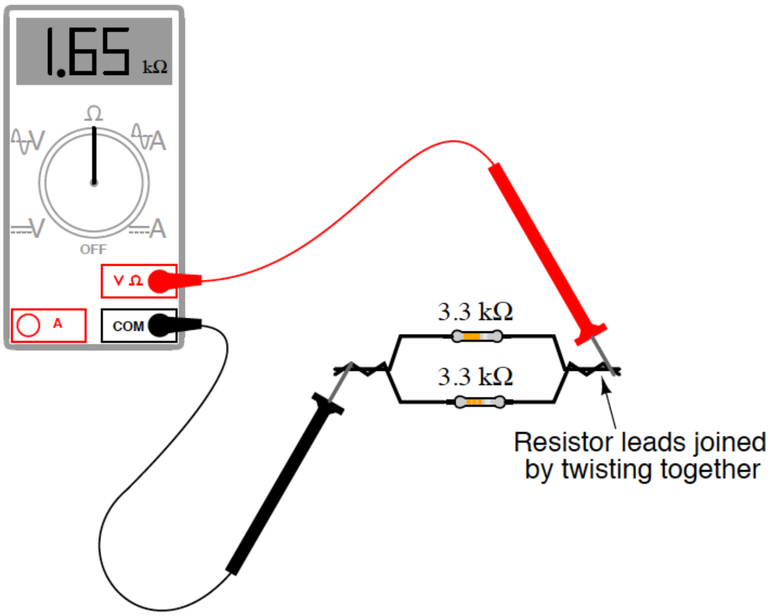
The voltage dropped across each of the lights bulbs is guaranteed to be equal. The current through each of the light bulbs, in this particular case (with identical bulbs), happens to be equal.

Answer 5

$I_{total} = 40.0$ mA
$R_{total} = 250\ \Omega$

Follow-up question: without appealing to Ohm's Law, explain why the total resistance is one-half as much as either of the individual resistances.

Answer 6



Follow-up question: how much resistance would you expect the ohmmeter to register if there were *three* similarly-sized resistors connected in parallel instead of two? What if there were *four* resistors?

Answer 7

$$R_{parallel} = \frac{R_1 R_2}{R_1 + R_2}$$

$$R_{parallel} = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \cdots \frac{1}{R_n}}$$

Answer 8

$$I_{1\Omega} = 24 \text{ amps}$$
$$I_{2\Omega} = 12 \text{ amps}$$
$$I_{3\Omega} = 8 \text{ amps}$$

$$P_{1\Omega} = 576 \text{ watts}$$
$$P_{2\Omega} = 288 \text{ watts}$$
$$P_{3\Omega} = 192 \text{ watts}$$

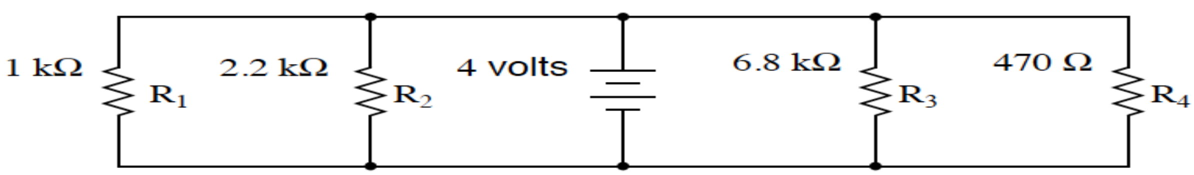
Answer 9

$$I_{R1} = 12 \text{ mA} \; ; V_{R1} = 12 \text{ V}$$
$$I_{R2} = 5.45 \text{ mA} \; ; V_{R2} = 12 \text{ V}$$
$$I_{R3} = 25.5 \text{ mA} \; ; V_{R3} = 12 \text{ V}$$

Answer 10

	R_1	R_2	Total
V	30 V	30 V	30 V
I	3 mA	9.09 mA	12.09 mA
R	10 kΩ	3.3 kΩ	2.481 kΩ
P	90 mW	272.7 mW	362.7 mW

Answer 11



	R_1	R_2	R_3	R_4	Total
V	4 V	4 V	4 V	4 V	4 V
I	4 mA	1.82 mA	588.2 μA	8.51 mA	14.92 mA
R	1 kΩ	2.2 kΩ	6.8 kΩ	470 Ω	268.1 Ω
P	16 mW	7.27 mW	2.35 mW	34.0 mW	59.67 mW

Answer 12

Ideally, there will be no change whatsoever in the light bulb's brightness when the switch is closed, because voltage sources are supposed to maintain constant voltage output regardless of loading. As you might have supposed, though, the additional current "drawn" by the resistor when the switch is closed might actually cause the lamp to dim slightly, due to the battery voltage "sagging" under the additional load. If the battery is well oversized for the application, though, the degree of voltage "sag" will be inconsequential.

Answer 13

"In a parallel circuit, voltage *is equal across all components.*"

"In a parallel circuit, current*s add to equal the total.*"

"In a parallel circuit, resistance*s diminish to equal the total.*"

"In a parallel circuit, power *dissipations add to equal the total.*"

Answer 14

I won't explain what happens when each of the switches is closed, but I will describe the effects of the first switch closing:

As the first switch (SW1) is closed, the voltage across resistor R1 will increase to full battery voltage, while the voltages across the remaining resistors will remain unchanged from their previous values. The current through resistor R1 will increase from zero to whatever value is predicted by Ohm's Law (full battery voltage divided by that resistor's resistance), and the current through the remaining resistors will remain unchanged from their previous values. The amount of current drawn from the battery will increase. Overall, the battery "sees" less total resistance than before.

Answer 15

- Current through the 2 kΩ resistor = 4.5 mA
- Current through the 3 kΩ resistor = 3 mA
- Current through the 5 kΩ resistor = 1.8 mA
- Voltage across each resistor = 9 volts
- R_{total} = 967.74 Ω

How much current is drawn from the battery in this circuit? How does this figure relate to the individual resistor currents, and to the total resistance value?