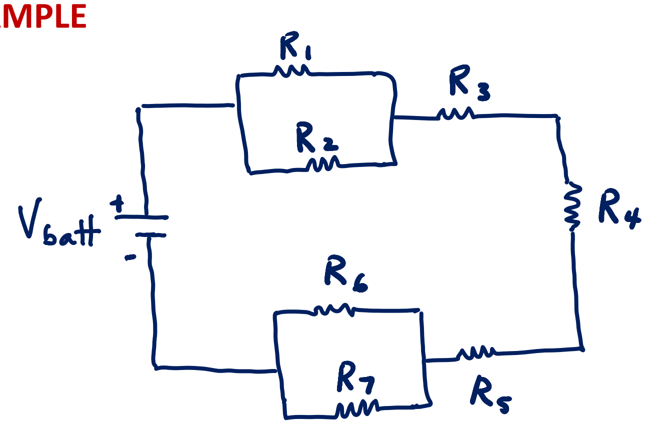
COMBINED SERIES-PARALLEL CIRCUIT EXAMPLE

GIVEN: Consider the circuit shown, where

$R_1=20\Omega$	$R_2=20\Omega$	$R_3=5\Omega$
$R_4=10\Omega$	$R_5=15\Omega$	$R_6=25\Omega$
$R_7=100\Omega$	$V_{batt}=120V$	



REQUIRED:

(a) The current leaving the battery.

(b) The power supplied by the battery.

(c) The voltage across R_5.

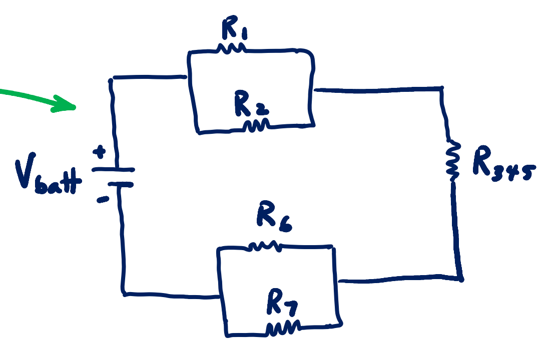
SOLUTION:

(a) First, combine the three resistors that are in series.

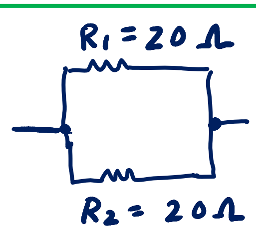
$$R_{345} = R_3 + R_4 + R_5 = 5\Omega + 10\Omega + 15\Omega$$

$$R_{345} = 30\Omega$$

We can now redraw the circuit as shown.

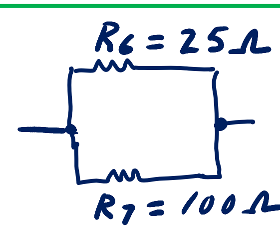


We can now combine all resistors in parallel. By inspection, we note that R_1 and R_2 are in parallel, and R_6 and R_7 are in parallel.



$$R_{12} = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2}} = \frac{1}{\frac{1}{20\Omega} + \frac{1}{20\Omega}} = \frac{1}{\frac{2}{20\Omega}}$$

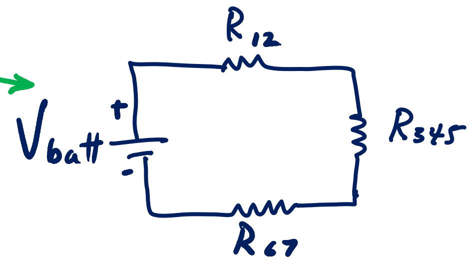
$$R_{12} = 10\Omega$$



$$R_{67} = \frac{1}{\frac{1}{R_6} + \frac{1}{R_7}} = \frac{1}{\frac{1}{25\Omega} + \frac{1}{100\Omega}} = \frac{1}{\frac{5}{100\Omega}}$$

$$R_{67} = 20\Omega$$

Again, we can redraw the circuit.

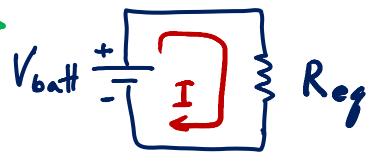


We can now find R_{eq} by combining all series resistors.

$$R_{eq} = R_{12} + R_{345} + R_{67} = 10\Omega + 30\Omega + 20\Omega$$

$$R_{eq} = 60\Omega$$

Redrawing the circuit once more . . ..



Now that we know R_{eq}, we can find the current.

$$V = IR \leftarrow \text{OHM'S LAW}$$

$$I = \frac{V_{batt}}{R_{eq}} = \frac{120\,V}{60\,\Omega}$$

$$I = 2A$$

(b) Now that we know the current leaving the battery AND the battery voltage, we can easily compute the power.

$$P_{batt} = V_{batt} \cdot I = 120V \cdot 2A$$

$$P_{batt} = 240\,W$$

(c) The voltage drop across R_5 can be computed using Ohm's Law (we already know the current through R_5 as well as the resistance of R_5).

$$V_{R5} = IR_5 = 2A \cdot 15\Omega \qquad V_{R5} = 30V$$

DISCUSSION:

- The answers seem reasonable.
- The combinations of series resistors resulted in equivalent resistances which were greater than any single resistor in the combination, as expected ($R_{345} > R_3$, R_4, R_5)
- The combination of parallel resistors resulted in equivalent resistances less than any single resistor in the combination, as expected.
- The voltage across R_5 was less than the voltage supplied by the battery, as expected.