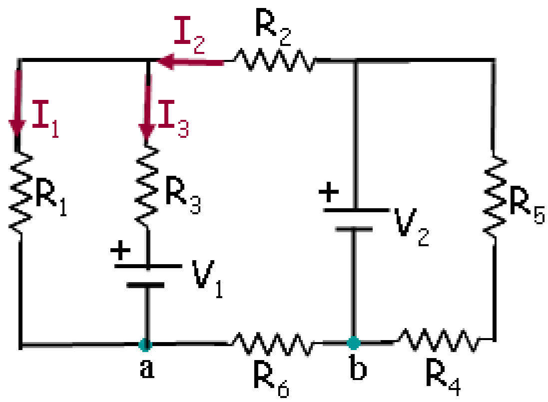
A circuit is constructed with six resistors and two batteries as shown. The battery voltages are V_1 = 18 V and V_2 = 12 V. The positive terminals are indicated with a + sign, The values for the resistors are: R_1 = R_5 = 61 Ω, R_2 = R_6 = 141 Ω R_3 = 50 Ω, and R_4 = 135 Ω. The positive directions for the currents I_1, I_2 and I_3 are indicated by the directions of the arrows.



1) What is V_4, the magnitude of the voltage across the resistor R_4?

$$V_4 = I_4 R_4 = \frac{V_2}{R_4 + R_5} R_4$$

V4=(12 V)(135 Ω)/(135+61)Ω = 8.26 V

2) What is I_3, the current that flows through the resistor R_3? A positive value for the current is defined to be in the direction of the arrow

$$I_2 = I_1 + I_3$$

$$I_1 R_1 - V_1 - I_3 R_3 = 0$$

$$I_2 R_2 + I_3 R_3 + V_1 + I_2 R_6 - V_2 = 0 \Rightarrow$$

$$I_3 = \frac{R_1}{\left(R_1 R_3 + (R_1 + R_3)(R_2 + R_6)\right)} \left(V_2 - V_1 \left(1 + \frac{R_2 + R_6}{R_1} \right) \right)$$

I3=(61Ω)/((61)(50)+(61+50)(141+141))ΩΩ (12 V-18 V(1+(141+141)/61)Ω) = -.158 A

3) What is I_2, the current that flows through the resistor R_2? A positive value for the current is defined to be in the direction of the arrow.

$$I_2 = \left(\frac{V_1}{R_1} + I_3 \frac{R_1 + R_3}{R_1} \right)$$

I2=18 V/61 Ω + (-.158 A)(61+50)Ω/61 Ω =.007 A

4) What is I_1, the current that flows through the resistor R_1? A positive value for the current is defined to be in the direction of the arrow.

$$I_1 = I_2 - I_3$$

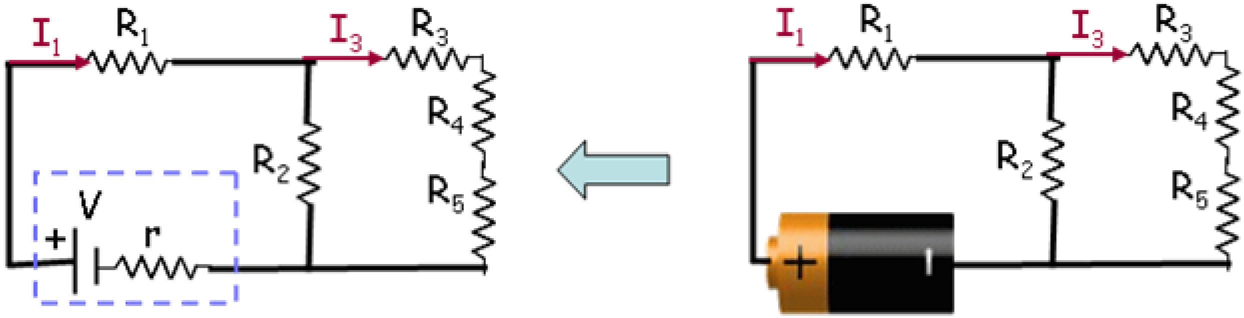
I1=.0068 A – (-.158 A)= .165 A

5) What is V(a) – V(b), the potential difference between the points a and b?

$$V(a) - V(b) = I_2 R_6$$

V(a)-V(b)=(.0068 A)(141Ω)=.9588 V

A circuit is constructed with five resistors and one real battery as shown above right. We model. The real battery as an ideal emf V = 12 V in series with an internal resistance r as shown above left. The values for the resistors are: $R_1 = R_3 = 57\ \Omega$, $R_4 = R_5 = 103\ \Omega$ and $R_2 = 108\ \Omega$. The measured voltage across the terminals of the batery is $V_{battery} = 11.75$ V.



1) What is I_1, the current that flows through the resistor R_1?

$$V_b = I_1 R_{equiv}$$

$$R_{equiv} = R_1 + \frac{R_2 R_{345}}{R_2 + R_{345}} \Rightarrow I_1 = \frac{V_b}{R_{equiv}}$$

And R345=R3+R4+R5=263 Ω

Requiv=57 Ω + (108Ω *263Ω)/(108+263)Ω =133.56Ω

I1=11.75 V/133.56 Ω = 87.97mA (note the m prefix!)

2) What is r, the internal resistance of the battery?

$$V_{battery} = V - I_1 r \Rightarrow r = \frac{V - V_b}{I_1} = R_{equiv}\frac{V - V_b}{V}$$

R=133.56 Ω (12-11.75)V/12V = 2.8 Ω

3) What is I_3, the current through resistor R_3?

$$V_b = I_1 R_1 + I_3 R_{345} \Rightarrow I_3 = \frac{V_b - I_1 R_1}{R_{345}}$$

I3=(11.75V-.087A(57Ω))/263 Ω = 25.6 mA

4) What is P_2, the power dissipated in resistor R_2?

$$P_2 = I_2^2 R_2 = \frac{V_2^2}{R_2} = \frac{(I_3 R_{345})^2}{R_2}$$

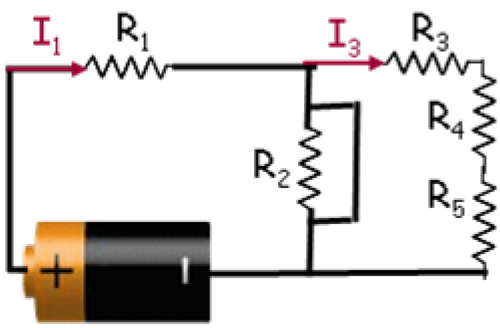
P2=(.0256 A*263Ω)^2/108 Ω=.420 W

5) What is V_2, the magnitude of the voltage across the resistor R_2?

$$V_2 = I_3 R_{345}$$

V2=.0256 A * 263 Ω = 6.73 V

6)



Resistor R_2 is now shorted out as shown. How does the magnitude of the voltage across the battery change?

Right Answer:
1

Feedback:
Your answer is correct! Shorting R_2 changes the equivalent resistance of the circuit. In particular, shorting R_2decreases the equivalent resistance of the circuit. Therefore, more current will be drawn, causing the voltage drop across the internal resistance to increase, which, in turn, causes the voltage seen across the terminals of the battery to decrease!