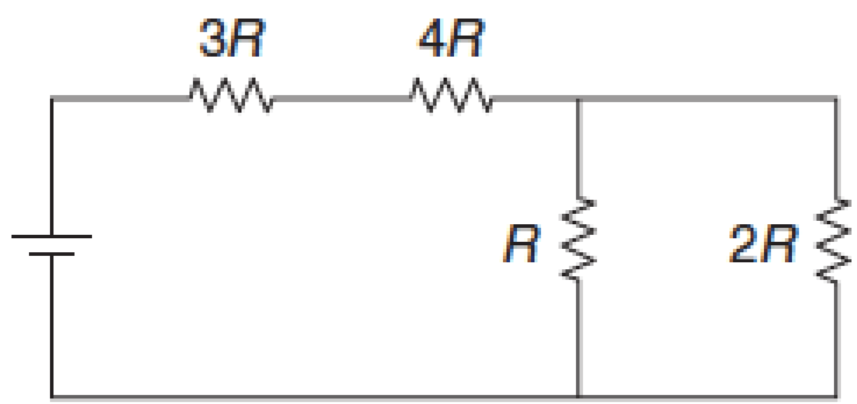
Exercise 3



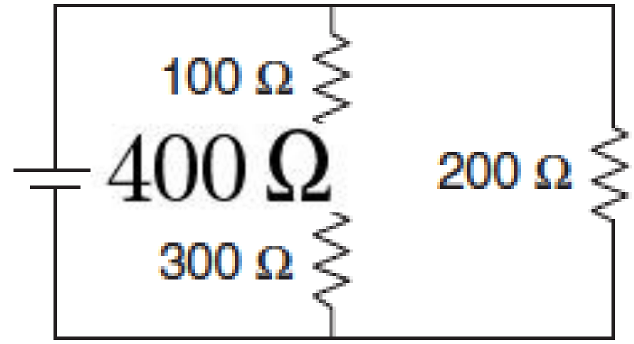
1. The figure above shows four resistors connected in a circuit with a battery. Which of the following correctly ranks the potential difference, ΔV, across the four resistors?

(A) $\Delta V_{4R} > \Delta V_{3R} > \Delta V_{2R} > \Delta V_{R}$

(B) $\Delta V_{4R} > \Delta V_{3R} > \Delta V_{2R} = \Delta V_{R}$ ✓. B

(C) $\Delta V_{4R} = \Delta V_{3R} > \Delta V_{R} > \Delta V_{2R}$

(D) $\Delta V_{2R} = \Delta V_{R} > \Delta V_{3R} > \Delta V_{4R}$



2. The figure above shows three resistors connected in a circuit with a battery. Which of the following correctly ranks the energy E dissipated in the three resistors during a given time interval?

(A) $E_{300\Omega} > E_{200\Omega} > E_{100\Omega}$

(B) $E_{300\Omega} > E_{100\Omega} > E_{200\Omega}$

(C) $E_{200\Omega} > E_{300\Omega} > E_{100\Omega}$

(D) $E_{200\Omega} > E_{100\Omega} > E_{300\Omega}$

$$P = \frac{V^2}{R_{eq}}$$

$$P_{100+300} < P_{200}$$

$$P = RI^2$$

$$\implies P_{100} < P_{300}$$

$$\implies P_{200} > P_{300} > P_{100}$$

(C)

If two household lightbulbs rated 60W and 100W are connected in series to household power, which will be brighter?

$$P = \frac{V^2}{R}$$

$$\frac{V_{plug}^{\;2}}{R_{100W}} = 100\,W \quad \Longrightarrow R_{100W} = \frac{V_{plug}^{\;2}}{100}$$

$$R_{60W} = \frac{V_{plug}^{\;2}}{60}$$

$$\frac{R_{100W}}{R_{60W}} = \frac{60}{100} = 0.6$$

<u>The 100 W bulb has a lower resistance</u>

<u>Connected in series: the current is the same</u>

$P = RI^2$ current is the same $\Longrightarrow P_{100W} < P_{60W}$

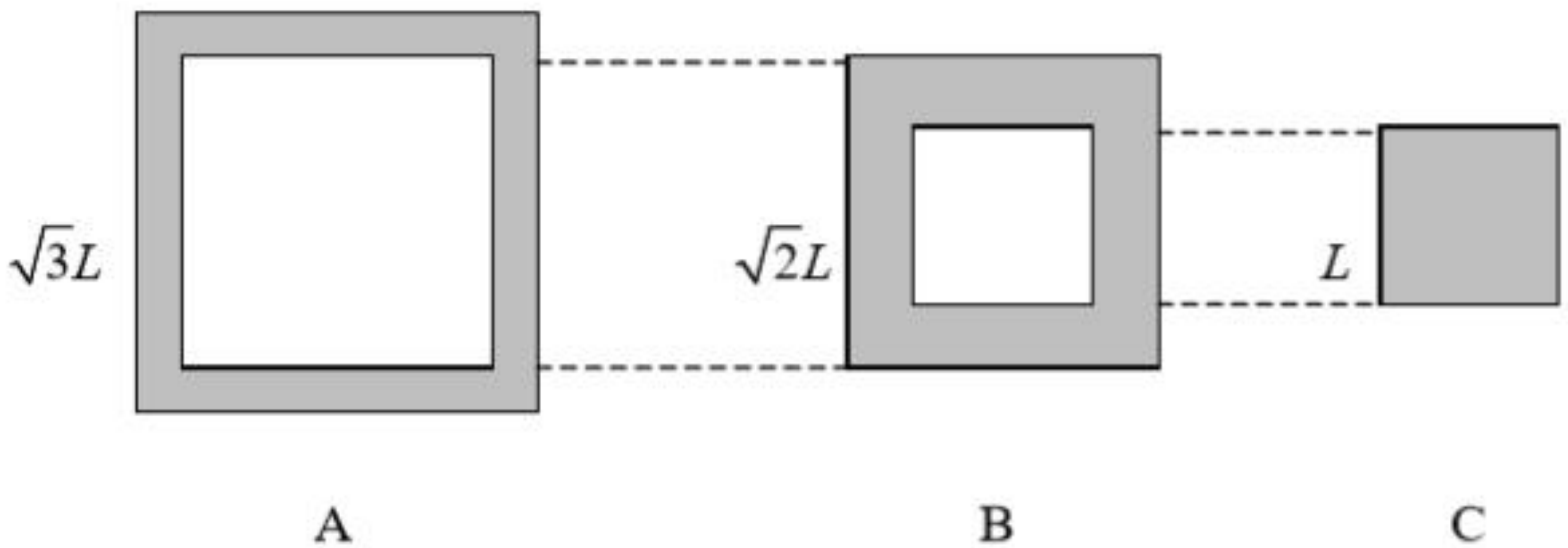
What is the difference between ***resistance*** and ***resistivity***?

(a) Resistance is a property of the material, while resistivity depends on the amount, size, and shape of the material.
(b) Resistivity is a property of the material, while resistance depends on the amount, size, and shape of the material.
(c) Resistance is a property of ohmic devices, while resistivity is a property of non-ohmic devices.
(d) Resistivity is a property of ohmic devices, while resistance is a property of non-ohmic devices.

A set of resistors is placed in ***series*** with a source of constant potential difference. Which of the following must be the same for each resistor?

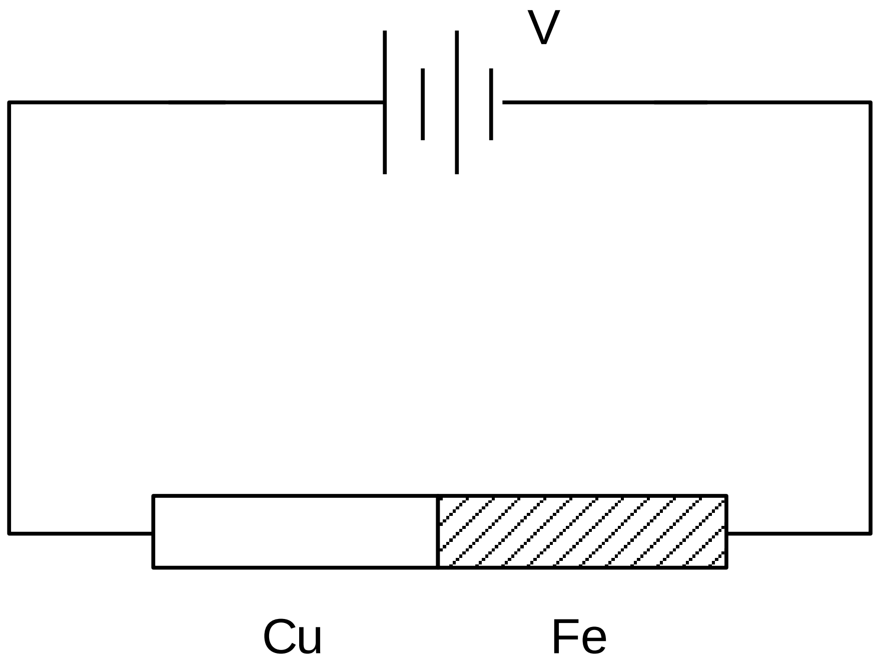
(a) Potential difference across it
(b) Current through it
(c) Power dissipated in it
(d) Resistance of it

The figure below shows cross sections through three long conductors of the same length and material, with square cross-sections of edge as shown. Conductor B will fit snugly within conductor A, and conductor C will fit snugly within conductor B. Rank the three conductors according to their end-to-end resistance, greatest first.



(A) A - B - C (Conductor A has the greatest resistance, and conductor C has the least resistance.)
(B) A - C - B
(C) B - A - C
(D) B - C - A
(E) C - A - B
(F) C - B - A
(G) All three have the same resistance. √

A copper rod and an iron rod are joined end-to-end and connected to a voltage source, as shown in the graph. Both rods have a cross-sectional area of 0.01 cm^2. Each is 1 meter long. Which of the following statements are correct?



(1)The copper rod dissipates more electric power than the iron rod

(2)The iron rod has a greater potential drop than the copper rod has

(3)Free electrons move from iron to copper

<2 3>

The current in the 6-ohm resistor in the circuit is 0.5 ampere. The voltage V applied to the circuit is

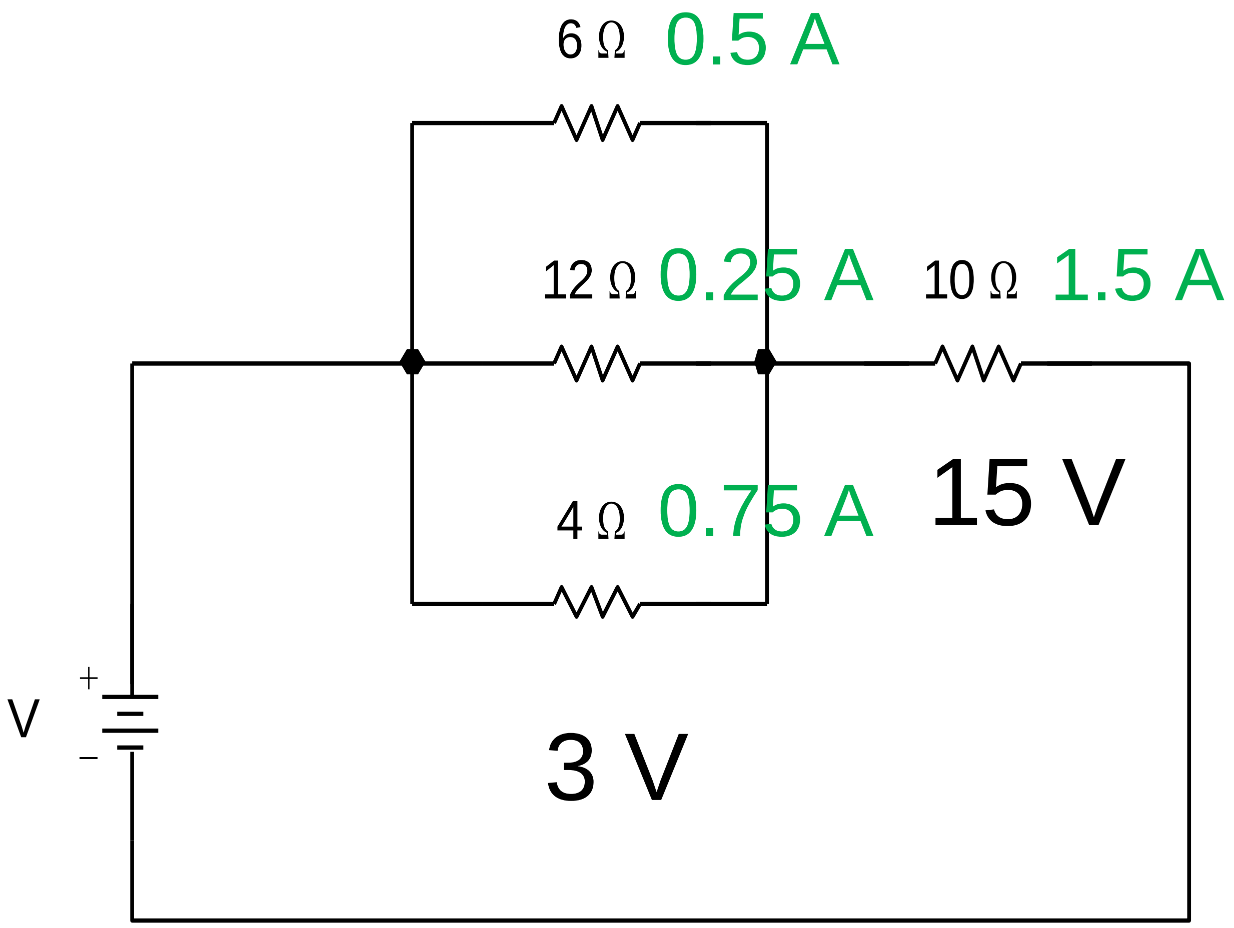
(A)6 V

(B)10 V

(C)18 V √

(D)24V

(E)27 V



(C)

Which of the following equations is a valid Kirchhoff current equation for the circuit?

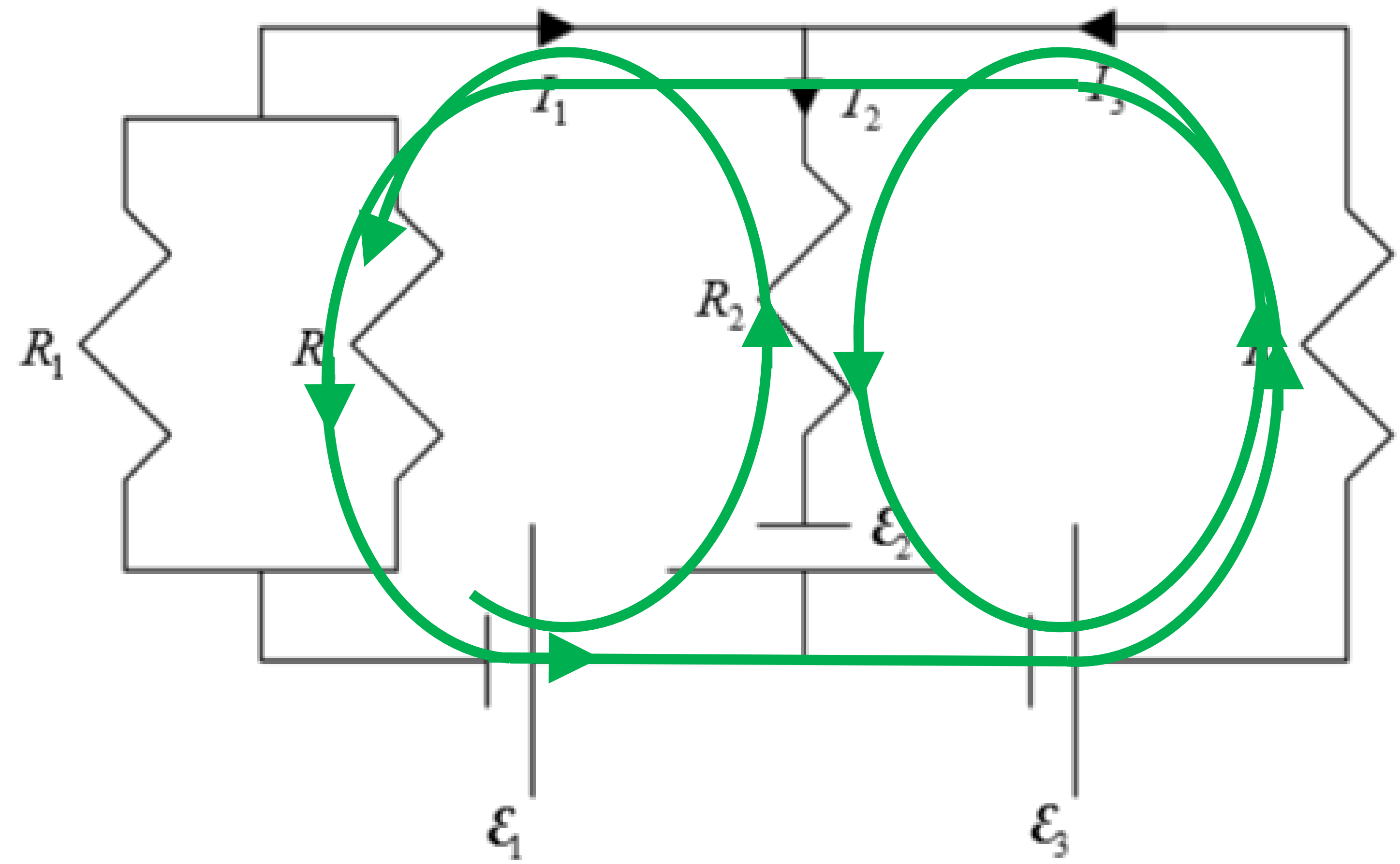
(A) $I_1 + I_2 + I_3 = 0$

(B) $I_1 + I_2 = I_3$

(C) $I_1 + I_3 = I_2$ √

(D) $I_2 + I_3 = I_1$

(E) none of the above



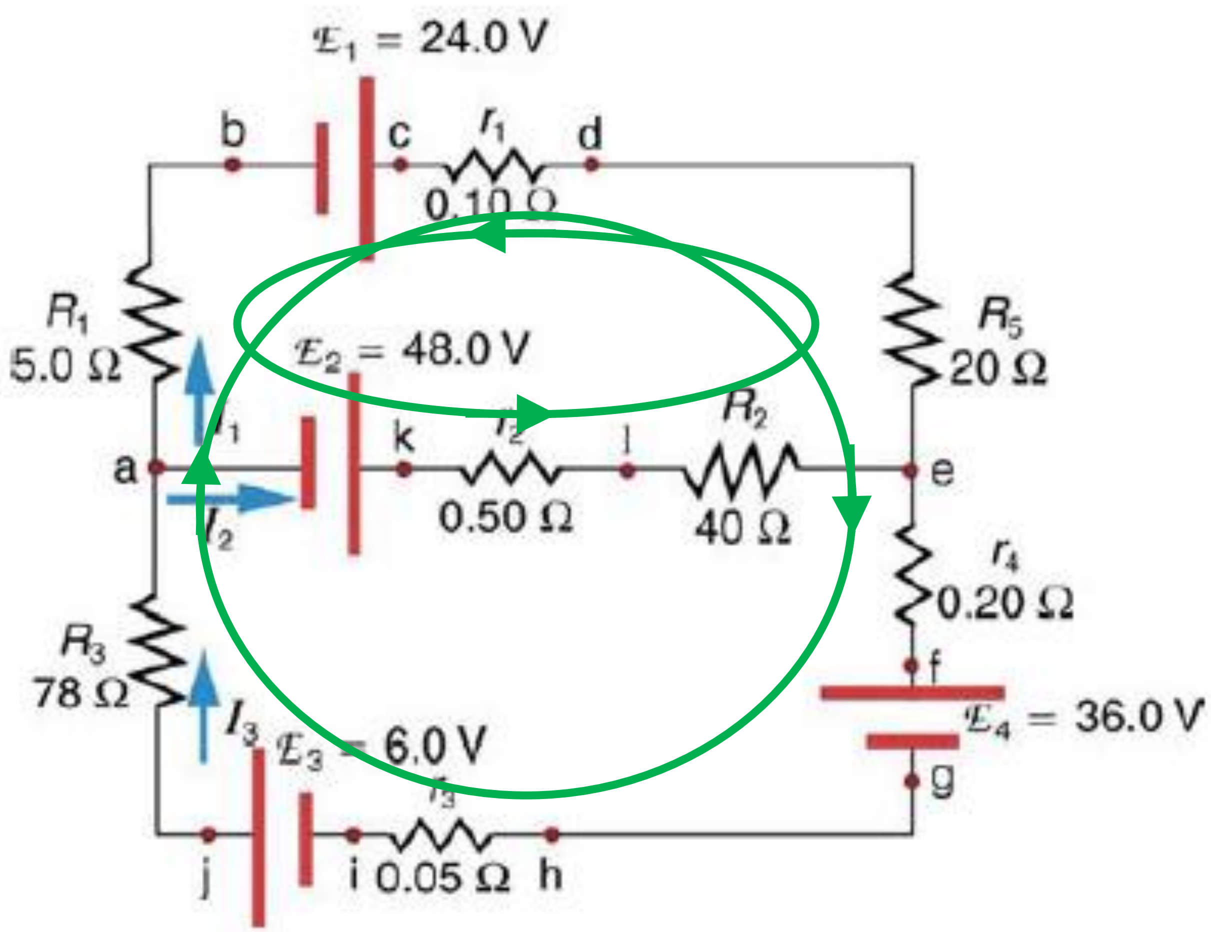
Which of the following equations is **not** a valid Kirchhoff voltage equation for the circuit?

(A) $+\mathcal{E}_1 - \mathcal{E}_2 + I_2R_2 + I_1R_1 = 0$ √

(B) $+\mathcal{E}_1 + \mathcal{E}_3 - I_3R_3 + \frac{1}{2} I_1R_1 = 0$

(C) $+\mathcal{E}_2 + \mathcal{E}_3 - I_3R_3 - I_2R_2 = 0$

Find the currents flowing in the circuit



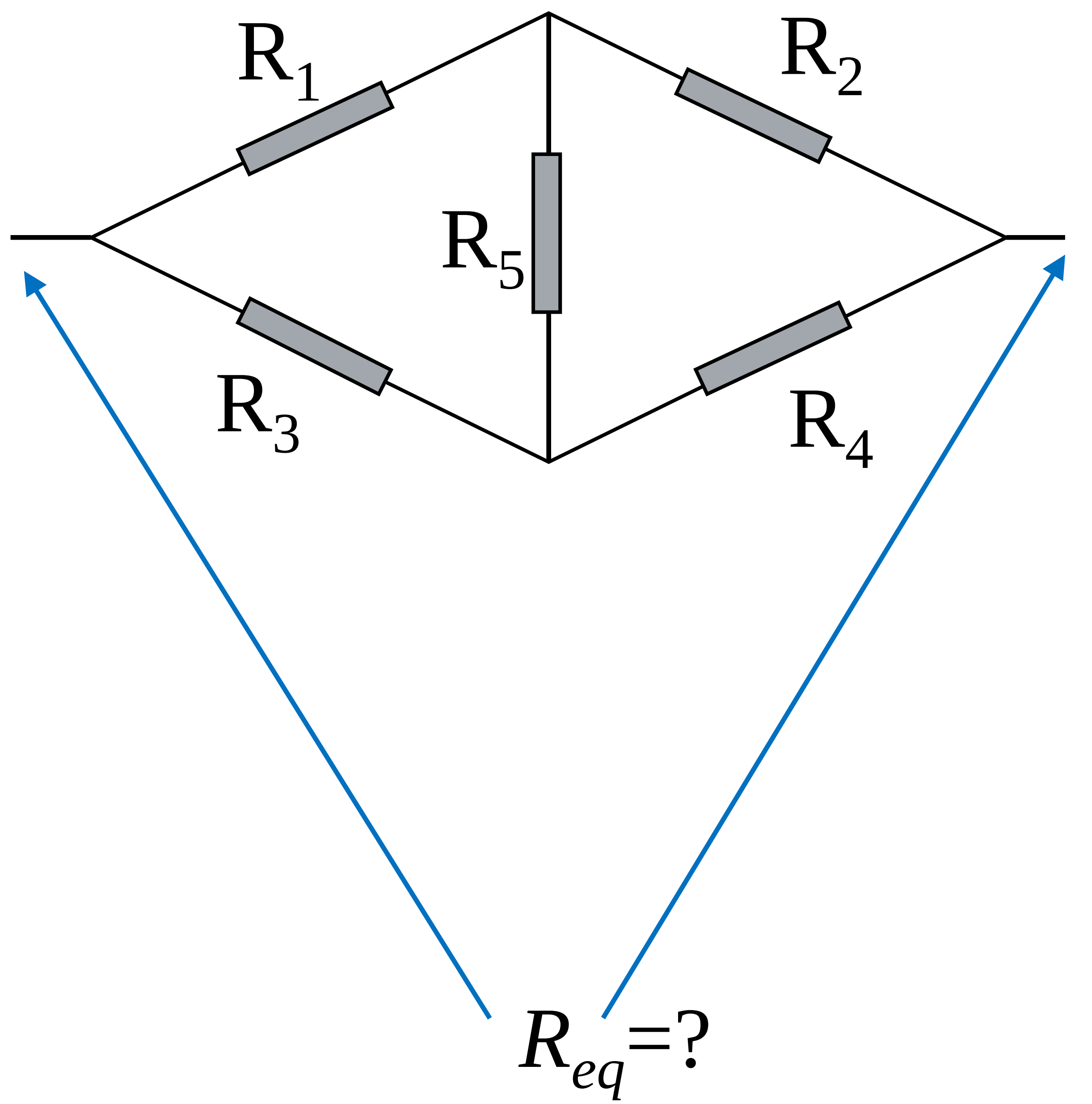
$$
\begin{cases}
I_1 = -0.345\ A \\
I_2 = 0.379\ A \\
I_3 = 0.036\ A
\end{cases}
$$

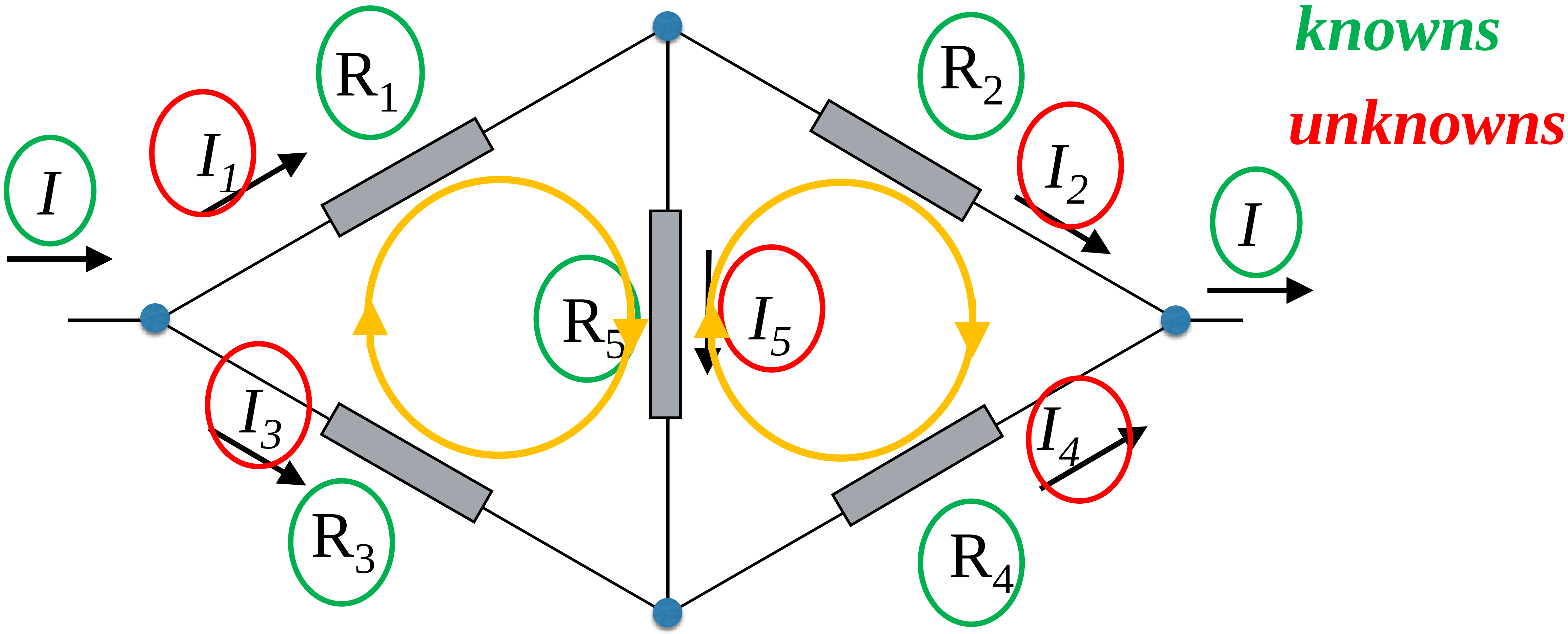
$$I_3 = I_1 + I_2$$

$$\xi_2 - r_2 I_2 - R_2 I_2 + R_5 I_1 + r_1 I_1 - \xi_1 + R_1 I_1 = 0$$

$$-R_1 I_1 + \xi_1 - r_1 I_1 - R_5 I_1 - R_4 I_3 - \xi_4 - r_3 I_3 + \xi_3 - R_3 I_3 = 0$$

A (resistance) bridge circuit – what is the equivalent resistance?





Junctions: $I = I_1 + I_3$ $\quad I = I_2 + I_4$

$I_5 = I_1 - I_2$ $\quad I_5 = I_4 - I_3$ — *dependent*

loops: $-R_1 I_1 - R_5 I_5 + R_3 I_3 = 0$

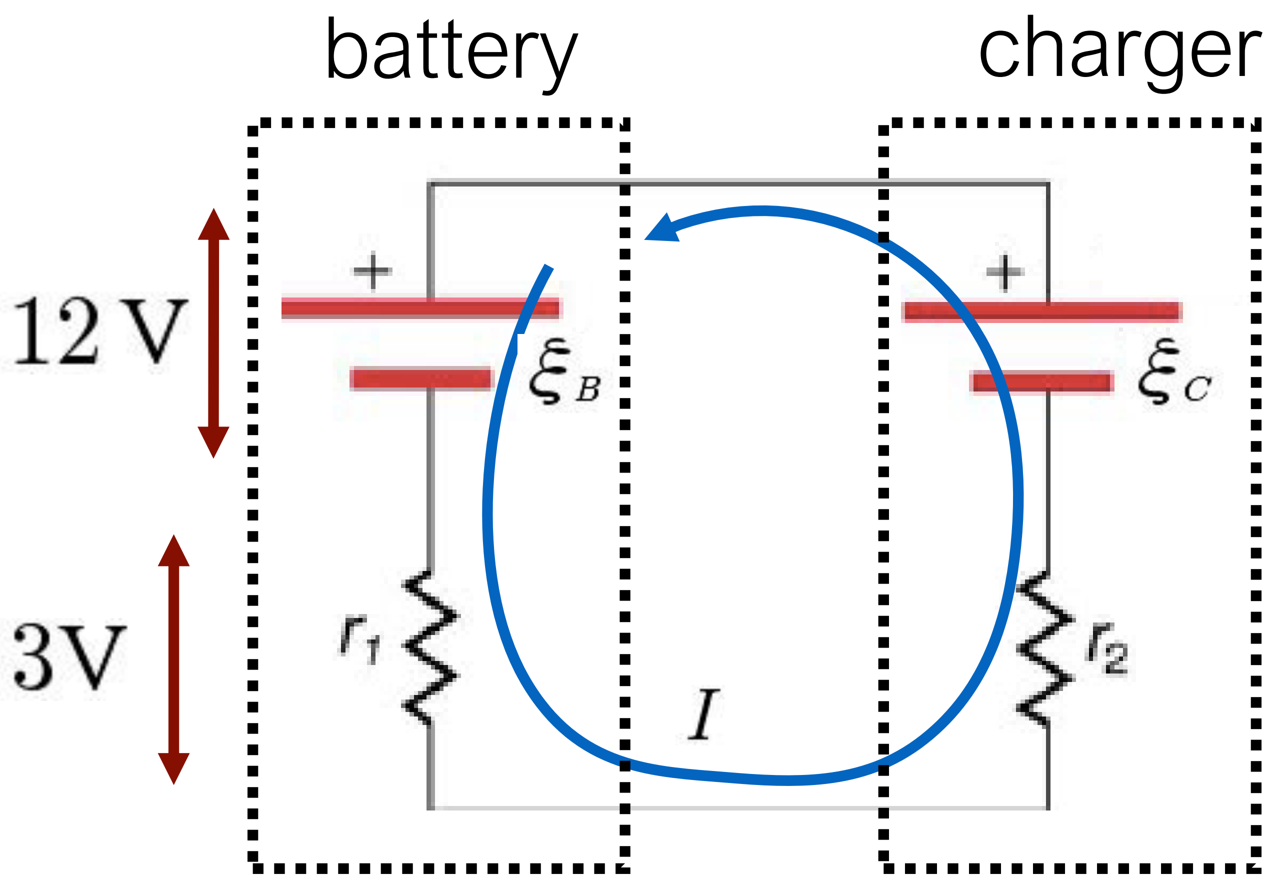
$-R_2 I_2 + R_4 I_4 + R_5 I_5 = 0$

$$R_{eq} = \frac{I_1 R_1 + I_2 R_2}{I}$$

$$\boxed{R_{eq} = \frac{R_1R_2R_3 + R_1R_3R_4 + R_1R_3R_5 + R_1 R_4R_5 + R_1 R_2R_4 + R_2 R_3R_5 + R_2 R_4R_5 + R_2 R_3R_4}{R_1R_2 + R_1R_4 + R_1R_5 + R_2R_5 + R_5R_4 + R_2R_3 + R_3R_4 + R_3R_5}}$$

20. A car battery with a 12-V emf and an internal resistance of $0.050\ \Omega$ is being charged with a current of 60 A. Note that in this process the battery is being charged.

(a) What is the potential difference across its terminals?



$$\xi = 12\text{ V}$$

$$r_1 = 0.05\,\Omega$$

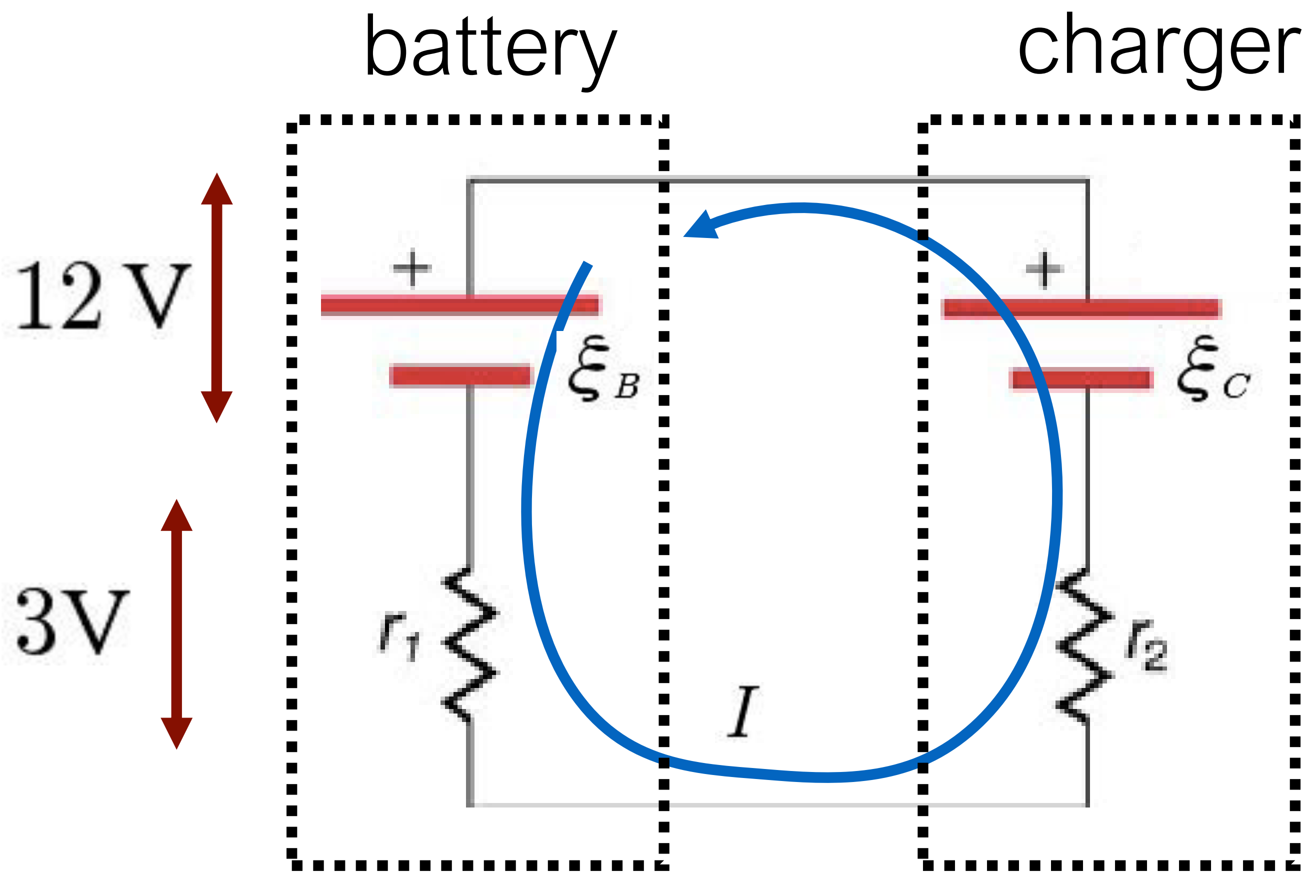
$$I = 60\text{ A}$$

$$r_1 I = 0.05\,\Omega \times 60\text{ A} = 3\text{V}$$

$$V = 12\text{ V} + 3\text{ V} = 15\text{ V}$$

(b) At what rate is thermal energy being dissipated in the battery?

$$P_{r1} = (r_1 I)I = 0.05\,\Omega \times (60\ A)^2 = 180\text{W}$$



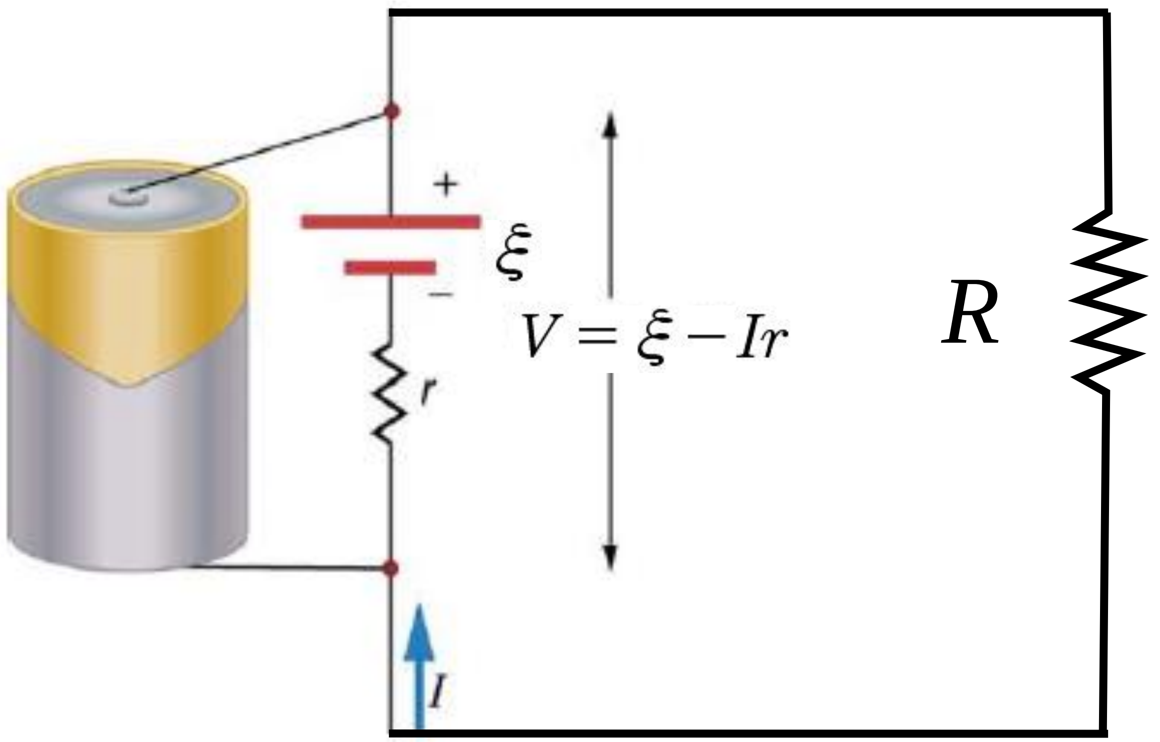
(c) At what rate is electric energy being converted to chemical energy?

current inside the battery: $I = 60\,\mathrm{A}$

potential difference inside the battery: $V = 12\,\mathrm{V}$

$$P_{\mathrm{batt}} = 12\,\mathrm{V} \times 60\,\mathrm{A} = 720\,\mathrm{W}$$

(d) What are the answers to (a) and (b) when the battery is used to supply 60 A to the starter motor?



$$I = 60\ \text{A}$$

$$\xi = 12\ \text{V}$$

$$r_1 = 0.05\ \Omega$$

potential difference across the terminals:

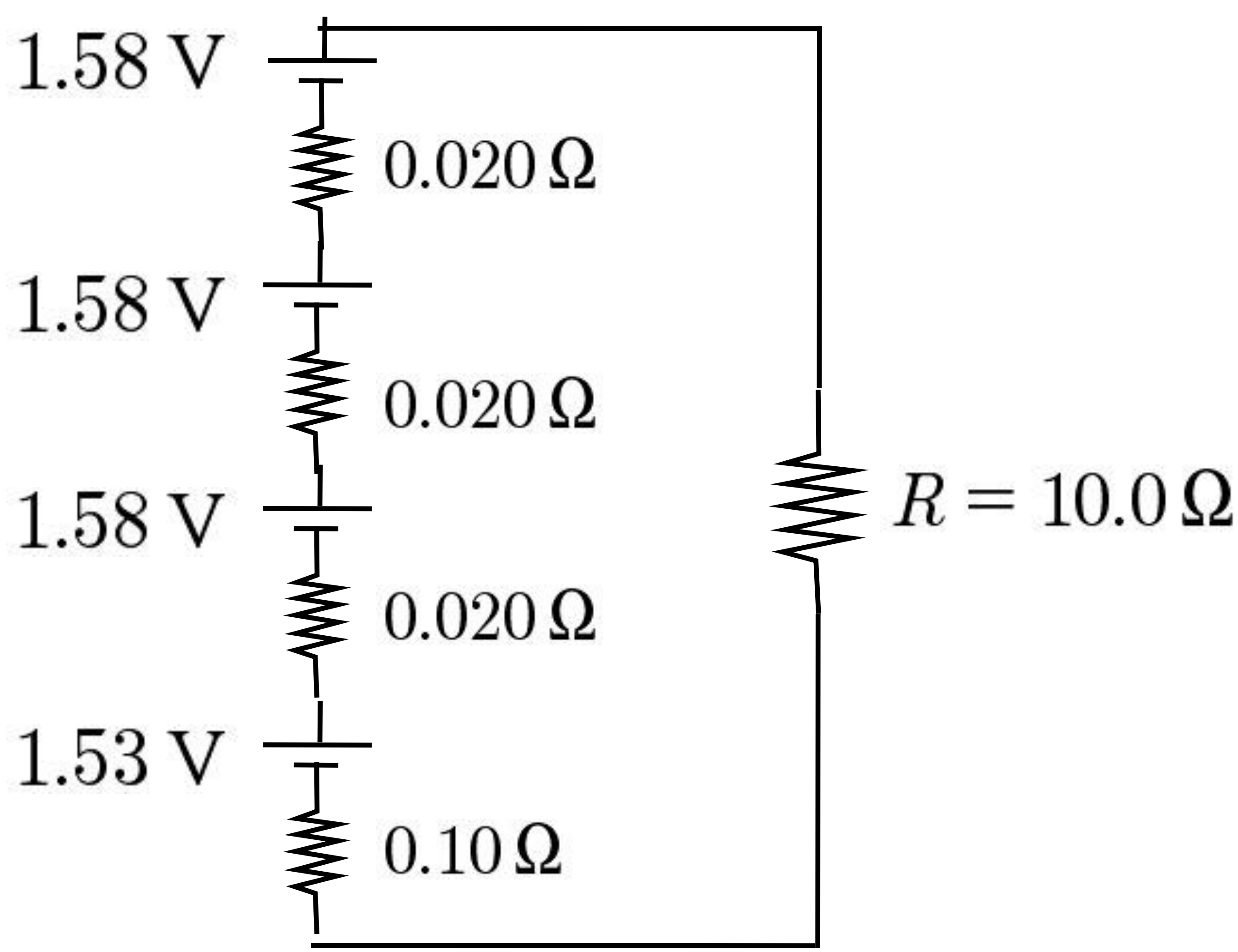
$$V = \xi - Ir_1 = 12\ \text{V} - (60\ \text{A})\, 0.05\Omega = 9\ \text{V}$$

thermal energy dissipated in the battery:

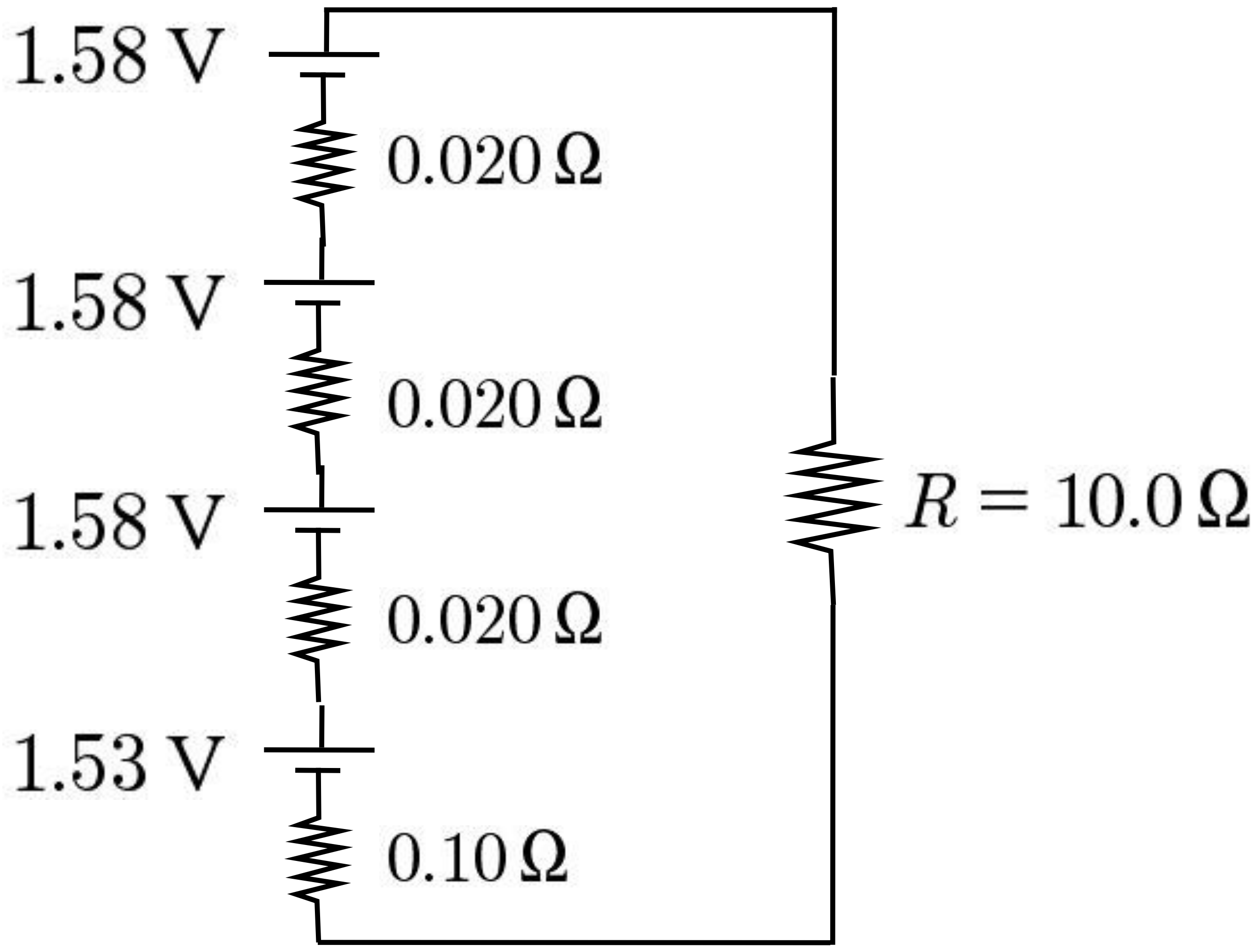
$$P = r_1 I^2 = 0.05\Omega \times (60A)^2 = 180\ \text{W}$$

24. A child's electronic toy is supplied by three 1.58-V alkaline cells having internal resistances of $0.0200\ \Omega$ in series with a 1.53-V carbon-zinc dry cell having a $0.100\text{-}\Omega$ internal resistance. The load resistance is $10.0\ \Omega$.

(a) Draw a circuit diagram of the toy and its batteries



(b) What current flows?

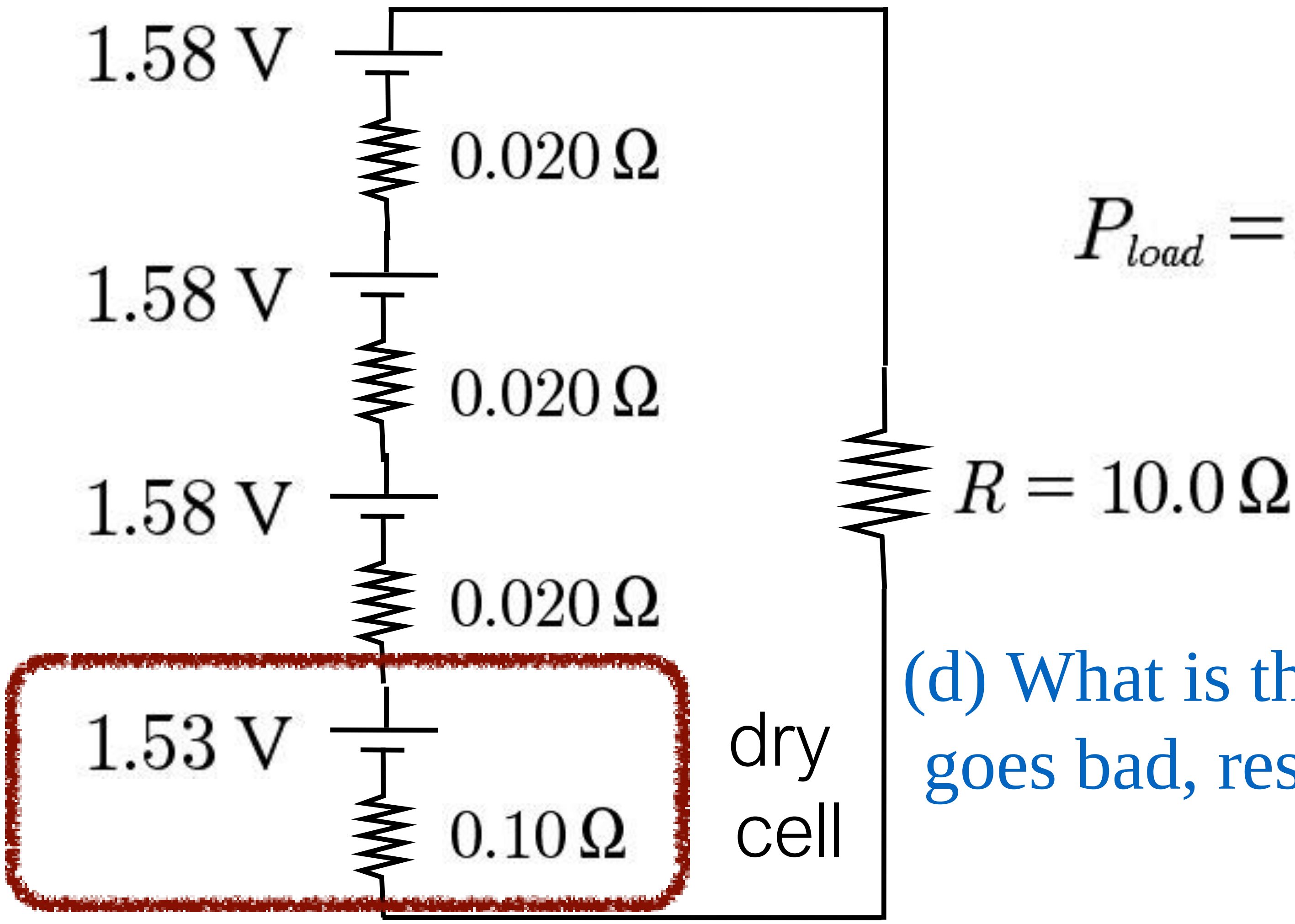


$$\xi_{tot} = (3\,\text{x}1.58\text{ V}) + 1.53\text{ V} = 6.27\text{ V}$$

$$R_{tot} = (3\,\text{x}0.02\,\Omega) + 0.1\,\Omega + 10\Omega = 10.16\,\Omega$$

$$I = \frac{6.27\text{ V}}{10.16\,\Omega} = 0.62\text{ A}$$

(c) How much power is supplied to the load?



$$I = 0.62\ \mathrm{A}$$

$$P_{load} = RI^2 = 10.0\Omega\,(0.62\ \mathrm{A})^2 = 3.8\ \mathrm{W}$$

(d) What is the internal resistance of the dry cell if it goes bad, resulting in only 0.500 W supplied to the load?

$$P = RI^2 = 0.5\ W \qquad I = 0.22\ A$$

$$R_{tot} = (10.06\ \Omega + r) = \frac{\mathcal{E}}{I} = 28.12\ \Omega \qquad r = 18.06\ \Omega$$

A battery having an EMF of 3.0 V and an internal resistance of 0.1 Ω is used to power a light bulb, which consumes an electric power of 5.6 W. Now another identical light bulb is connected to the battery, in parallel with the first light bulb. What is the total power consumed by the two light bulbs?

(A) 13.5 W

(B) 11.2 W

(C) 9.8 W

(D) 5.4 W

$$P_1 = \frac{\mathcal{E}^2}{R}\left(\frac{R}{r+R}\right)^2$$

$$5.6 = \frac{3^2}{R}\left(\frac{R}{0.1+R}\right)^2 \qquad R = 1.4\ \Omega$$

$$P_2 = \frac{2\mathcal{E}^2}{R}\left(\frac{R}{2r+R}\right)^2 \approx 9.8\ W$$

(C)