DC Circuits, Ohm's Law & Kirchhoff's Rules

Circuits · 8 questions · step-by-step answers at the end

Name: Date: Score: / 8

USEFUL EQUATIONS

$V = IR \quad R = \rho L/A \quad R_{ser} = \Sigma R \quad 1/R_{par} = \Sigma 1/R \quad P = IV = I^2R = V^2/R$

Questions

Show your working in the space under each question.

1. Find the equivalent resistance of 30 Ω, 60 Ω and 20 Ω in parallel.

2. A 28 V battery drives 4 Ω in series with (6 Ω ∥ 3 Ω) and then 8 Ω. Find R_{eq}, the total current, and the current through the 6 Ω and 3 Ω resistors.

3. A wire is stretched to 3 times its length, keeping its volume. By what factor does R change?

4. Find the resistance of 10 m of copper wire ($\rho = 1.7 \times 10^{-8}$ Ω·m) with cross-section 1.0 mm².

5. A third identical bulb is added in parallel to two parallel bulbs on an ideal battery. What happens to the brightness of the first two, and to the battery current?

6. A battery has $\varepsilon = 12$ V and $r = 2\ \Omega$. What load resistance draws the maximum power, and how much?

7. Why must a voltmeter have a very large resistance?

8. A voltmeter reads the terminal voltage of a battery as 1.5 V with nothing else connected. Why might it read less when a bulb is connected?

Step-by-step answers

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1. $1/R = 1/30 + 1/60 + 1/20 = 6/60 \rightarrow R =$ **10 Ω**.

2. 1. Parallel pair first: $6 \times 3/(6 + 3) = 2\ \Omega$.
2. Series: $R_{eq} = 4 + 2 + 8 =$ **14 Ω**.
3. Total current: $I = V/R_{eq} = 28/14 =$ **2.0 A**, through the 4 Ω, the pair, and the 8 Ω.
4. Voltage across the pair: $V = IR = (2.0)(2) = 4.0$ V.
5. $I_6 = 4.0/6 =$ **0.67 A**, $I_3 = 4.0/3 =$ **1.33 A**. Check: 0.67 + 1.33 = 2.0 ✓

Answer: R_{eq} = 14 Ω, I = 2.0 A, I_6 = 0.67 A, I_3 = 1.33 A

3. L ×3 and A ÷3, so **R ×9**.

4. $R = \rho L/A = (1.7 \times 10^{-8})(10)/(1.0 \times 10^{-6}) =$ **0.17 Ω**.

5. The brightness is **unchanged** (same V), and the battery current **rises** by half.

6. R = r = **2 Ω**; I = 3 A, so $P = 9 \times 2 =$ **18 W**.

7. So it draws **almost no current** and doesn't change the circuit it's measuring.

8. Current now flows through the internal resistance, so $V = \varepsilon - Ir$ **drops**.