Year 12 Science: DC circuits: series, parallel and combined

Name: _____ Date: _____

Try these without your notes first, then check the answer key.

Practice

1. Find the total resistance of a 4.0 Ω and a 12 Ω resistor in parallel.

2. A 9.0 V battery drives 0.30 A round a circuit. How much charge flows in 2.0 minutes?

3. A lamp has 6.0 V across it and a resistance of 4.0 Ω. What is its power?

4. A 5.0 Ω resistor in series with two 10 Ω resistors in parallel is connected to 20 V. What is the total current?

5. In question 4, what is the current in each 10 Ω resistor?

Exam-style question: a campervan's lights

A campervan's 12 V battery runs two lamps in parallel: a reading lamp of 12 Ω and a ceiling lamp of 4.0 Ω. A dimmer, a rheostat set to 1.0 Ω, is in series with the battery.

6. Show that the two lamps together have a resistance of 3.0 Ω.

7. Calculate the current in the ceiling lamp.

8. Explain why the reading lamp carries a third of the ceiling lamp's current.

9. Calculate the energy the reading lamp transfers in 2.0 hours.

10. The ceiling lamp burns out. Discuss what happens to the brightness of the reading lamp.

Fix the mistake

11. Correct this statement: "Current gets used up as it goes through each lamp, so less comes back to the battery."

12. Correct this statement: "$1/R_t = 1/6.0 + 1/12 = 0.25$, so $R_t = 0.25$ Ω."

13. Correct this statement: "When one branch breaks, the other lamp keeps the same voltage, so nothing else changes."

14. Correct this statement: "The current splits in parallel, so each branch gets half."

Answer key (for parents and tutors)

1. Find the total resistance of a 4.0 Ω and a 12 Ω resistor in parallel.
   $1/R_t = 1/4.0 + 1/12 = 4/12$, so $R_t = 12 \div 4 = 3.0\ \Omega$.

2. A 9.0 V battery drives 0.30 A round a circuit. How much charge flows in 2.0 minutes?
   $q = It = 0.30 \times 120 = 36$ C (2.0 minutes = 120 s).

3. A lamp has 6.0 V across it and a resistance of 4.0 Ω. What is its power?
   $P = V^2 \div R = 6.0^2 \div 4.0 = 9.0$ W.

4. A 5.0 Ω resistor in series with two 10 Ω resistors in parallel is connected to 20 V. What is the total current?
   The pair is $10 \div 2 = 5.0\ \Omega$; $R_t = 5.0 + 5.0 = 10\ \Omega$; $I = V \div R = 20 \div 10 = 2.0$ A.

5. In question 4, what is the current in each 10 Ω resistor?
   The 5.0 Ω resistor takes $2.0 \times 5.0 = 10$ V, leaving $20 - 10 = 10$ V across the pair; $I = 10 \div 10 = 1.0$ A in each, half of 2.0 A.

6. Show that the two lamps together have a resistance of 3.0 Ω.
   $1/R_t = 1/12 + 1/4.0 = 1/12 + 3/12 = 4/12$, so $R_t = 12 \div 4 = 3.0\ \Omega$ (Achieved).

7. Calculate the current in the ceiling lamp.
   $R_t = 1.0 + 3.0 = 4.0\ \Omega$; $I_t = 12 \div 4.0 = 3.0$ A; the rheostat takes $3.0 \times 1.0 = 3.0$ V, leaving $12 - 3.0 = 9.0$ V across the lamps; $I = 9.0 \div 4.0 = 2.25$ A, about 2.3 A (Merit: a chain of steps).

8. Explain why the reading lamp carries a third of the ceiling lamp's current.
   The lamps are in parallel, so both have the same 9.0 V; the reading lamp has three times the resistance, so by $I = V/R$ it has a third of the current: 0.75 A against 2.25 A (Merit for the reason with the formula).

9. Calculate the energy the reading lamp transfers in 2.0 hours.
   $P = VI = 9.0 \times 0.75 = 6.75$ W; $t = 2.0 \times 3600 = 7200$ s; $E = Pt = 6.75 \times 7200 = 48\,600$ J, about 4.9×10^4 J (Merit).

10. The ceiling lamp burns out. Discuss what happens to the brightness of the reading lamp.
    Achieved: there is one fewer path, so the total resistance goes up and the current falls. Merit: with the supply fixed at 12 V, R_t rises to $1.0 + 12 = 13\ \Omega$ and I_t falls to 0.92 A, so the rheostat's voltage falls ($V = IR$) to 0.92 V. Excellence: that leaves 11.1 V across the reading lamp, up from 9.0 V, and its current rises from 0.75 A to 0.92 A, so its power $P = VI$ rises from 6.75 W to about 10.2 W and it glows brighter.

11. Correct this statement: "Current gets used up as it goes through each lamp, so less comes back to the battery."
    The current returning to the battery equals the current leaving it; the lamps transfer energy, not charge.

12. Correct this statement: "$1/R_t = 1/6.0 + 1/12 = 0.25$, so $R_t = 0.25\ \Omega$."
    0.25 is $1/R_t$; turn it over to get $R_t = 4.0\ \Omega$, which must be smaller than the smallest branch.

13. Correct this statement: "When one branch breaks, the other lamp keeps the same voltage, so nothing else changes."
    The total current changes, so the voltage across the series resistor changes, and so does the voltage across the parallel part.

14. Correct this statement: "The current splits in parallel, so each branch gets half."
    Both branches have the same voltage, so the current splits by $I = V/R$: a branch with twice the resistance takes half the current.