Exercise walk-through

7.2
Current and circuits (full B.5)

International Baccalaureate · IB Diploma · Physics · SL

Circuits · 3.1

Reasoning

Current is the same through components in series. Potential differences add around the series path. In parallel, branches share the same potential difference, while branch currents sum at a junction. Place an ammeter in series and a voltmeter in parallel. For an I-V investigation, change voltage in steps, reverse polarity when appropriate and limit current to reduce heating.

The cell loses terminal voltage

1. **Set the model** A cell has emf $1.5\,\mathrm{V}$, internal resistance $0.50\,\Omega$ and external resistance $7.5\,\Omega$.
2. **Calculate** $I = 1.5/(7.5 + 0.50) = 0.1875\,\mathrm{A}$. Terminal pd $V = IR = 1.406\,\mathrm{V}$, also $\varepsilon - Ir$.

Decision

Emf is energy supplied per charge. Some energy heats the internal resistance, so terminal pd is lower when the cell supplies current.

Exercises 2.1·2.3

2.1 State Ohm's law, and state the condition a metal conductor must meet for it to hold. [2]

2.2 Calculate the charge that passes a point when a current of 0.50 A flows for 2.0 minutes. [2]

2.3 A nichrome wire ($\rho = 1.1 \times 10^{-6}\ \Omega\,\mathrm{m}$) has length 2.0 m and cross-sectional area 0.10 mm^2. Calculate its resistance. [3]

Exercises 2.1·2.3

2.1 State Ohm's law, and state the condition a metal conductor must meet for it to hold. [2]

2.1 Current is proportional to potential difference, $V = IR$; constant temperature – a metal at fixed temperature.

2.2 Calculate the charge that passes a point when a current of 0.50 A flows for 2.0 minutes. [2]

2.2 $\Delta q = I\Delta t = 0.50 \times 120 = 60$ C.

2.3 A nichrome wire ($\rho = 1.1 \times 10^{-6}\ \Omega\,\mathrm{m}$) has length 2.0 m and cross-sectional area 0.10 mm^2. Calculate its resistance. [3]

2.3 $A = 0.10\ \mathrm{mm}^2 = 1.0 \times 10^{-7}\ \mathrm{m}^2$; $R = \rho L/A = (1.1 \times 10^{-6} \times 2.0)/(1.0 \times 10^{-7}) = 22\ \Omega$.

Exercises 2.4·3.1

2.4 State how the resistance of a thermistor changes as temperature rises, and name one other component whose resistance changes with its environment. [2]

2.5 A 4.0 Ω resistor and a 12 Ω resistor are connected in parallel. Calculate the combined resistance. [2]

3.1 A cell of emf 6.0 V and internal resistance 0.50 Ω is connected to a 5.5 Ω resistor. Calculate the current, the terminal potential difference, and the power dissipated inside the cell. [4]

Exercises 2.4·3.1

2.4 State how the resistance of a thermistor changes as temperature rises, and name one other component whose resistance changes with its environment. [2]

2.4 Falls as temperature rises; LDR – falls as light intensity rises.

2.5 A 4.0 Ω resistor and a 12 Ω resistor are connected in parallel. Calculate the combined resistance. [2]

2.5 $1/R_p = 1/4.0 + 1/12 = 0.333$, so $R_p = 3.0\ \Omega$.

3.1 A cell of emf 6.0 V and internal resistance 0.50 Ω is connected to a 5.5 Ω resistor. Calculate the current, the terminal potential difference, and the power dissipated inside the cell. [4]

3.1 $I = 6.0/(5.5 + 0.50) = 1.0$ A; terminal pd $= \varepsilon - Ir = 6.0 - 0.50 = 5.5$ V; internal power $= I^2 r = 1.0^2 \times 0.50 = 0.50$ W.

Exercises 3.2·3.4

3.2 A lamp is rated 12 V, 36 W. Calculate the current it draws at normal operation and its resistance then, and verify the power with a second power formula. [4]

3.3 Compare solar cells with chemical cells as energy sources for a circuit: give two advantages and two disadvantages of solar cells. [4]

3.4 A 12 V battery of negligible internal resistance is connected to a 2.0 Ω resistor in series with a parallel pair of 6.0 Ω and 3.0 Ω. Calculate the total resistance, the battery current, and the potential difference across the parallel pair. [5]

Exercises 3.2·3.4

3.2 A lamp is rated 12 V, 36 W. Calculate the current it draws at normal operation and its resistance then, and verify the power with a second power formula. [4]

3.2 $I = P/V = 36/12 = 3.0$ A; $R = V/I = 12/3.0 = 4.0\ \Omega$; check $P = I^2R = 9.0 \times 4.0 =$ 36 W – matches the rating.

3.3 Compare solar cells with chemical cells as energy sources for a circuit: give two advantages and two disadvantages of solar cells. [4]

3.3 Advantages: renewable energy source, no fuel consumed in use; no emissions while generating. Disadvantages: no output in darkness or low light – output varies with weather and time of day; manufacture requires energy and materials – finite cell lifetime and replacement cost.

3.4 A 12 V battery of negligible internal resistance is connected to a 2.0 Ω resistor in series with a parallel pair of 6.0 Ω and 3.0 Ω. Calculate the total resistance, the battery current, and the potential difference across the parallel pair. [5]

3.4 Parallel pair: $1/R_p = 1/6.0 + 1/3.0 = 0.50$, so $R_p = 2.0\ \Omega$; total $R = 2.0 + 2.0 = 4.0\ \Omega$; $I = 12/4.0 = 3.0$ A; pd across the pair $= IR_p = 3.0 \times 2.0 = 6.0$ V.