11.5 Compound DC Circuits

Name: _____ Class: _____ Date: _____ **Total: 11 marks**

KEY WORDS parallel • series • internal resistance • resistance

Objective

Build the skills to answer exam questions on **compound DC circuits**.

You must be able to:

- combine resistors in **series** ($R_s = R_1 + R_2 + \dots$) and in **parallel** ($\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \dots$)
- account for the **internal resistance** of a real battery and its terminal voltage
- analyse a circuit with mixed series and parallel sections

1 Key knowledge and worked examples

Study these first. Each one shows the method for a question type used later.

Series and parallel

- **Series:** same current, $R_s = R_1 + R_2 + \dots$ (resistance adds up).
- **Parallel:** same voltage, $\dfrac{1}{R_p} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + \dots$ (total is **less** than the smallest).

Internal resistance

A real cell has internal resistance r, so the terminal voltage is $V = \varepsilon - Ir$.

Example

Two 4.0 Ω resistors in parallel: $\dfrac{1}{R_p} = \dfrac{1}{4} + \dfrac{1}{4} \Rightarrow R_p = 2.0\ \Omega$.

2 Practice

2.1 Two 6.0 Ω resistors are connected in series. Find the total resistance. [1]

2.2 The same two 6.0 Ω resistors are connected in parallel. Find the total resistance. [2]

2.3 A battery of emf 12 V and internal resistance 0.50 Ω drives a current of 2.0 A. Find the terminal voltage. [2]

3 Exam-style questions

3.1 Resistors in series have a total resistance equal to [1]

- ☐ **A** less than the smallest
- **B** the sum of the individual resistances
- **C** their average
- **D** their product

3.2 Adding another resistor in parallel makes the total resistance [1]

- ☐ **A** larger
- **B** smaller
- **C** unchanged
- **D** infinite

3.3 A 3.0 Ω and a 6.0 Ω resistor are in parallel across a 12 V supply.

(a) Find the combined resistance. [2]

(b) Find the total current drawn from the supply. [2]

Solutions

Each answer shows the steps, then the **result**.

2.1

- $R_s = 6.0 + 6.0 = 12\ \Omega$

2.2

- $\dfrac{1}{R_p} = \dfrac{1}{6.0} + \dfrac{1}{6.0} = \dfrac{2}{6.0} \Rightarrow R_p = 3.0\ \Omega$

2.3

- $V = \varepsilon - Ir = 12 - 2.0(0.50) = 11\ \text{V}$

3.1 B

- the sum of the individual resistances.

3.2 B

- smaller.

3.3

(a)

- $\dfrac{1}{R_p} = \dfrac{1}{3.0} + \dfrac{1}{6.0} = \dfrac{3}{6.0} \Rightarrow R_p = 2.0\ \Omega$

(b)

- $I = \dfrac{V}{R_p} = \dfrac{12}{2.0} = 6.0\ \text{A}$