11.5 Compound Direct Current Circuits

Name: ____________ Class: ________ Date: __________ **Total: 11 marks**

KEY WORDS internal resistance 内阻 • terminal voltage 端电压 • ideal emf 电动势 • equivalent resistance 等效电阻 • series 串联

Objective

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

You must be able to:

- reduce a network of **series and parallel** resistors to one equivalent resistance
- model a real battery as an **ideal emf 电动势** in series with an **internal resistance 内阻**
- distinguish a battery's **emf** from its **terminal voltage 端电压** under load
- find the current and voltage for each element

1 Worked examples

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

Reducing a network

Combine resistors step by step: series add, parallel combine by $\frac{1}{R} = \sum \frac{1}{R_i}$, until one equivalent resistance remains.

Real battery

A real battery is an ideal emf ε in series with an internal resistance r, so the **terminal voltage** under load is

$$V = \varepsilon - Ir.$$

emf vs terminal voltage

The emf is the full "push"; the terminal voltage is what is left across the external circuit once Ir is lost inside.

2 Practice

2.1 A battery of emf 9.0 V and internal resistance 1.0 Ω drives 2.0 A. Find the terminal voltage. [2]

2.2 Two 8.0 Ω resistors in parallel are in series with a 4.0 Ω resistor. Find the total resistance. [2]

2.3 State the difference between the emf and the terminal voltage of a battery. [1]

3 Exam-style questions

3.1 A real battery is modelled as an ideal emf in series with [1]

- **A** a capacitor
- **B** an internal resistance
- **C** an inductor
- **D** nothing

3.2 The terminal voltage of a battery under load is [1]

- **A** greater than the emf
- **B** less than the emf
- **C** equal to zero
- **D** infinite

3.3 A 12 V battery of internal resistance 0.50 Ω is connected to a 5.5 Ω resistor.

(a) Find the current. [2]

(b) Find the terminal voltage. [2]

Solutions

2.1 $V = \varepsilon - Ir = 9.0 - 2.0(1.0) = 7.0$ V.

2.2 parallel pair: $\dfrac{8.0}{2} = 4.0\ \Omega$; then $4.0 + 4.0 = 8.0\ \Omega$.

2.3 the emf is the total energy per charge supplied; the terminal voltage is the smaller potential difference across the external circuit once Ir is lost internally.

3.1 **B**.

3.2 **B**.

3.3 (a) $I = \dfrac{\varepsilon}{R + r} = \dfrac{12}{5.5 + 0.50} = 2.0$ A. (b) $V = \varepsilon - Ir = 12 - 2.0(0.50) = 11$ V.