A-LEVEL PHYSICS • EXERCISE SHEET

9.3 Resistance and resistivity

Name: _____ Class: _____ Date: _____ **Total: 17 marks**

KEY WORDS thermistor 热敏电阻 • diode 二极管 • filament lamp 灯丝灯泡 • resistance and resistivity 电阻率 • resistance 电阻

Objective

Build the skills to answer exam questions on **resistance and resistivity** 电阻率 — Ohm's law, I–V characteristics, and **measuring** resistivity.

You must be able to:

- define **resistance** and state **Ohm's law**
- sketch the I–V graphs of a **metal wire**, a **filament lamp** and a **diode**
- use $R = \rho L/A$, getting A from a **diameter** ($A = \pi d^2/4$)
- describe the **circuit and steps** to measure the resistivity of a wire

1 Worked examples

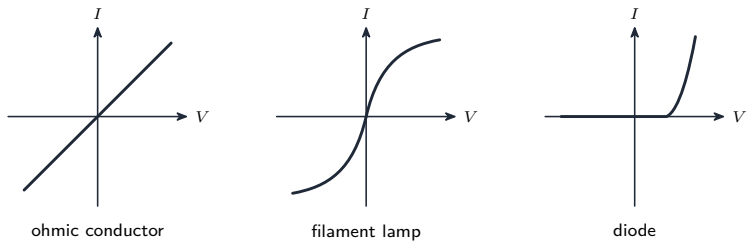
Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

■ **Resistance and Ohm's law**

$$R = \frac{V}{I}\ (\Omega).$$

Ohm's law: for a metal at constant temperature, $I \propto V$, so R is constant (a straight-line I–V graph).

■ **I–V characteristics**



A **filament lamp**'s resistance **rises** as current increases: more current heats the filament, raising its temperature and resistance, so the graph flattens.

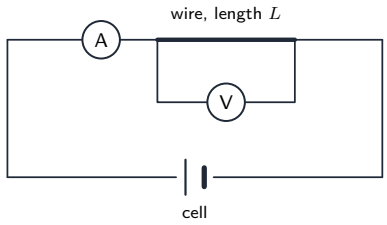
■ **Resistivity, LDR, thermistor**

$$R = \frac{\rho L}{A}.$$

An **LDR**'s resistance **falls** as light gets brighter; a **thermistor**'s resistance **falls** as temperature rises.

■ **Measuring resistivity**

A very common experiment: find ρ for a wire. Connect an **ammeter in series** with the wire and a **voltmeter across** it:



1. Read V and $I \rightarrow$ resistance $R = V/I$.
2. Measure the **diameter** $d \rightarrow$ area $A = \pi d^2/4$ (use the radius $d/2$).
3. Measure the length $L \rightarrow \rho = \dfrac{RA}{L}$.

Worked example. $V = 1.5$ V, $I = 0.45$ A $\rightarrow R = 3.33\ \Omega$. Diameter $d = 0.40$ mm $\rightarrow A = \pi(0.20 \times 10^{-3})^2 = 1.26 \times 10^{-7}$ m^2. Length $L = 0.80$ m: $\rho = \dfrac{RA}{L} = \dfrac{(3.33)(1.26 \times 10^{-7})}{0.80} = 5.2 \times 10^{-7}\ \Omega\,\text{m}$.

2 Practice

Now apply the methods above.

2.1 Define **resistance**. [1]

2.2 State **Ohm's law**. [1]

2.3 A component has 6.0 V across it and 0.30 A through it. Find its **resistance**. [2]

2.4 A wire has diameter 0.50 mm. Calculate its cross-sectional **area** in m^2. [2]

2.5 State what happens to a **thermistor's** resistance as its temperature **rises**. [1]

3 Exam-style questions

3.1 Which component has a **straight-line** I–V graph through the origin? [1]

- **A** a filament lamp
- **B** a diode
- **C** a metal wire at constant temperature
- **D** a thermistor

3.2 Explain why the **resistance** of a filament lamp **increases** as the current increases. [2]

3.3 A student measures the resistivity of a metal wire.

(a) Draw a circuit, using an ammeter and a voltmeter, to measure the **resistance** of the wire. [2]

(b) The readings are $V = 1.5$ V and $I = 0.45$ A; the wire has length 0.80 m and diameter 0.40 mm. Calculate the **resistivity** of the metal. [4]

3.4 State what happens to the resistance of an **LDR** as the light intensity **increases**. [1]

Solutions

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

2.1

- resistance = p.d./current ($R = V/I$)

2.2

- the current is **proportional** to the p.d. (at constant temperature)

2.3

- $V = 6.0$ V, $I = 0.30$ A
- $R = V/I$

$$R = \frac{6.0\ \text{V}}{0.30\ \text{A}} = \mathbf{20}$$

2.4

- $d = 0.50\ \text{mm} = 5.0 \times 10^{-4}\ \text{m}$
- $A = \pi d^2/4$

$$A = \frac{\pi(5.0 \times 10^{-4}\ \text{m})^2}{4} = \mathbf{2.0 \times 10^{-7}\ m^2}$$

2.5

- it **decreases**

3.1 C

- a straight line through the origin means $I \propto V$, so R is constant — Ohm's law, which holds for a **metal wire at constant temperature**
- **A** a filament heats and R rises, so the graph bends; **B** a diode conducts one way only; **D** a thermistor's R falls as it warms

3.2

- a larger current **heats** the filament, raising its temperature
- a hotter metal has a **higher resistance** (ions vibrate more and impede the electrons)

3.3

(a) ammeter in **series** with the wire

- voltmeter connected **across** (in parallel with) the wire; a cell drives the current

(b) $V = 1.5$ V, $I = 0.45$ A

- $R = V/I$

$$R = \frac{1.5\ \text{V}}{0.45\ \text{A}} = 3.33\ \Omega$$

- $d = 0.40\ \text{mm} = 4.0 \times 10^{-4}$ m; $A = \pi d^2/4$

$$A = \frac{\pi(4.0 \times 10^{-4}\ \text{m})^2}{4} = 1.26 \times 10^{-7}\ \text{m}^2$$

- $\rho = RA/L$

$$\rho = \frac{(3.33\ \Omega)(1.26 \times 10^{-7}\ \text{m}^2)}{0.80\ \text{m}} = \mathbf{5.2 \times 10^{-7}}\ \text{m}$$

3.4

- it **decreases**