INTERNATIONAL BACCALAUREATE · IB DIPLOMA · PHYSICS · HL • EXERCISE SHEET

10.2 Current and circuits (full B.5)

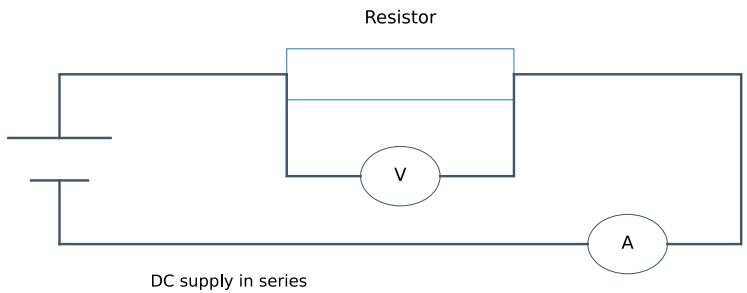
Name: _____ Class: _____ Date: _____ **Total: 28 marks**

KEY WORDS electromotive force (emf) • internal resistance • resistivity • Ohm's law • thermistor

Objective

Practise the full guide B.5 toolkit: current as charge flow $I = \Delta q/\Delta t$, potential difference $V = W/q$, resistance and resistivity $\rho = RA/L$, Ohm's law and non-ohmic behaviour, the three power forms, series and parallel combinations, and cells with internal resistance $\varepsilon = I(R + r)$. Original practice; not an official IB paper.

1 Key knowledge and worked examples



Ammeter in series; voltmeter across resistor

■ The B.5 equation set

$$I = \frac{\Delta q}{\Delta t} \qquad V = \frac{W}{q} \qquad R = \frac{V}{I} \qquad \rho = \frac{RA}{L}$$

$$P = IV = I^2R = \frac{V^2}{R} \qquad \varepsilon = I(R + r)$$

Series: one current, pds add, $R_s = R_1 + R_2$. Parallel: one pd, currents add, $1/R_p = 1/R_1 + 1/R_2$. Terminal pd $V = \varepsilon - Ir$.

■ Worked example: a real cell under load

A cell of emf 6.0 V and internal resistance 0.50 Ω drives a 5.5 Ω resistor. Current $I = 6.0/(5.5 + 0.50) = 1.0$ A; terminal pd $= 6.0 - 1.0 \times 0.50 = 5.5$ V; power wasted inside the cell $= I^2r = 0.50$ W. Two habits: include r in the loop resistance before any other step, and check the terminal pd against IR as you go.

2 Practice

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

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 Exam-style questions

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]

3.2 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]

Solutions

Original-task marking: M1 method, A1 accuracy, B1 reasoning.

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

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

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

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

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

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.

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

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 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.