5.1 Electrical circuits

Name: _____ Class: _____ Date: _____ **Total: 30 marks**

KEY WORDS potential difference • thermistor

Objective

Build the skills to answer exam questions on **electric circuits** : current and charge, potential difference, resistance, I–V graphs of components, sensors, and series and parallel circuits.

You must be able to:

- use $I = \frac{Q}{t}$, $V = \frac{E}{Q}$ and $V = IR$
- recognise circuit symbols and describe the I–V graphs of a resistor, a lamp and a diode
- explain how thermistors and LDRs work in circuits
- use the rules for current, potential difference and resistance in series and parallel circuits

1 Key knowledge and worked examples

Circuits

idea	equation or rule
current and charge	$I = \frac{Q}{t}$ (A); in a series circuit the current is the same everywhere
potential difference	$V = \frac{E}{Q}$ (V), the energy transferred per coulomb; $V = IR$ (resistance in Ω)
I–V graphs	resistor: straight line through the origin; filament lamp: curve, resistance rises as it gets hot; diode: current flows one way only
sensors	thermistor: resistance falls as temperature rises; LDR: resistance falls as light gets brighter
series	$R_{\text{total}} = R_1 + R_2$; the p.d. of the supply is shared
parallel	each branch has the full p.d.; branch currents add up; adding a branch lowers the total resistance

Worked example 1: charge. A current of 0.50 A flows for 2.0 minutes. Find the charge that flows.

1. Known: $I = 0.50$ A, $t = 120$ s.
2. Rule: $Q = It$.
3. Numbers: 0.50×120.
4. Result: $Q = 60$ **C**.

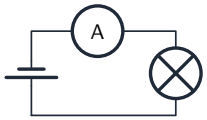
Worked example 2: a series circuit. A 6.0 V battery is connected to a 4.0 Ω and an 8.0 Ω resistor in series. Find the current and the p.d. across the 8.0 Ω resistor.

1. Known: $R_{\text{total}} = 12\,\Omega$, $V = 6.0$ V.
2. Rule: $I = \frac{V}{R}$, then $V = IR$ for one resistor.
3. Numbers: $I = \frac{6.0}{12} = 0.50$ A; 0.50×8.0.
4. Result: 0.50 **A and** 4.0 **V**.

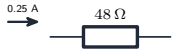
Answer shapes: change minutes to seconds and mA to A; a voltmeter goes across a component, an ammeter in series.

2 Practice

2.1 A charge of 30 C flows through a lamp in 15 s. Calculate the current. [2]



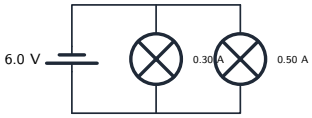
2.2 A current of 0.25 A flows through a 48 Ω resistor. Calculate the potential difference across it. [2]



2.3 Name the components with symbols A and B. [2]

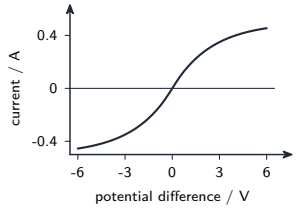


2.4 A 6.0 V battery is connected to two lamps in parallel. The currents in the branches are 0.30 A and 0.50 A. Write down the current from the battery and the p.d. across each lamp. [2]

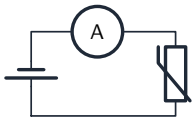


3 Exam-style questions

3.1 The graph shows the I–V graph of a filament lamp. Describe the shape of the graph and explain it. [3]



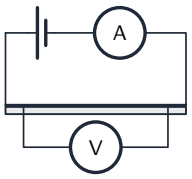
3.2 A thermistor is connected in series with a battery and an ammeter. The temperature of the room rises. Explain what happens to the ammeter reading. [3]



3.3 A student investigates how the resistance of a wire depends on its length. She keeps the current at 0.50 A and measures the p.d. across different lengths of wire.

length / cm	**20**	**40**	**60**	**80**	**100**
V / V	0.40	0.82	1.18	1.62	2.00

(a) Calculate the resistance of the 60 cm and the 100 cm lengths. [3]



(b) Describe the relationship between length and resistance. Predict the resistance of 150 cm of the same wire. [4]

(c) The current flows through the 100 cm wire for 2.0 minutes. Calculate the energy transferred in the wire. [3]

(d) Describe how the student did this investigation and how she made the results accurate. [6]

Solutions

Marking: **M1** a correct method, **A1** the correct answer, **B1** an independent mark.

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

2.1

- $I = Q \div t = 30 \div 15 = \mathbf{2.0}$ A

2.2

- $V = IR = 0.25 \times 48 = \mathbf{12}$ V

2.3

- A: **diode**; B: **light-dependent resistor** (LDR)

2.4

- $0.30 + 0.50 = \mathbf{0.80}$ A; **6.0** V across each lamp

3.1

- at low p.d. the graph is almost straight; then it curves and gets less steep
- so the resistance of the lamp increases as the current increases
- the filament gets hotter, its ions vibrate more and the electrons collide with them more

3.2

- the resistance of the thermistor falls as the temperature rises
- the p.d. of the battery stays the same, so $I = \frac{V}{R}$
- the current increases, so the ammeter reading **goes up**

3.3

(a) $R = \frac{V}{I}$; 60 cm: $1.18 \div 0.50 = \mathbf{2.36}\,\Omega$; 100 cm: $2.00 \div 0.50 = \mathbf{4.0}\,\Omega$

(b) resistance increases as length increases; they are directly proportional: double the length, double the resistance; $R = \frac{4.0}{100} \times 150 = \mathbf{6.0}\,\Omega$

(c) $Q = It = 0.50 \times 120 = 60$ C; $E = QV = 60 \times 2.00 = \mathbf{120}$ J

(d) points to include:

- tape the wire to a metre rule; connect it in series with a battery, ammeter and switch
- connect a voltmeter across the length of wire between two crocodile clips
- move one clip to set lengths of 20, 40, 60, 80, 100 cm; record V and I
- switch off between readings so the wire does not get hot (temperature changes resistance)
- repeat, find means, calculate $R = \frac{V}{I}$ and plot R against length

Levels: **5–6** a full, logical answer with correct physics and correct terms; **3–4** several correct points, partly linked; **1–2** one or two relevant points.