2.2 Circuits and resistance

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

Objective

Build the skills to answer exam questions on **energy and voltage in circuits** : series and parallel circuits, current–voltage graphs, LDRs and thermistors, $V = IR$, $Q = It$ and $E = QV$.

You must be able to:

- use the rules for current and voltage in series and parallel circuits
- use $V = IR$, $Q = It$ and $E = QV$
- describe the current–voltage graphs of a resistor, a filament lamp and a diode
- plan an investigation of current and voltage for a component

1 Key knowledge and worked examples

Circuit rules

idea	equation or rule
resistance	$V = I \times R$
charge	$Q = I \times t$ (unit C)
energy	$E = Q \times V$ (unit J)
series	same current everywhere; the voltages add up to the supply voltage; $R_{total} = R_1 + R_2$
parallel	same voltage across each branch; the branch currents add up to the total current

Worked example 1: resistance. A component has 6.0 V across it and 0.50 A through it. Find its resistance.

1. Known: $V = 6.0$ V; $I = 0.50$ A.
2. Rule: $R = V \div I$.
3. Numbers: $6.0 \div 0.50$.
4. Result: 12 Ω.

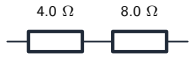
Worked example 2: charge and energy. A current of 0.20 A flows for 60 s through a 9.0 V battery. Find the charge and the energy.

1. Known: $I = 0.20$ A; $t = 60$ s; $V = 9.0$ V.
2. Rule: $Q = It$, then $E = QV$.
3. Numbers: $Q = 12$ C; $E = 12 \times 9.0$.
4. Result: 12 **C and** 108 **J**.

Answer shapes: the ammeter goes in series with the component; the voltmeter goes in parallel across it.

2 Practice

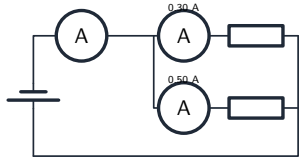
2.1 Calculate the total resistance of a 4.0 Ω resistor and an 8.0 Ω resistor in series. [2]



2.2 Describe how the resistance of a light-dependent resistor (LDR) changes as the light gets brighter, and give a use. [2]



2.3 In a parallel circuit the branch ammeters read 0.30 A and 0.50 A. State the reading on the main ammeter, and explain why. [2]



2.4 Describe the shape of the current–voltage graph for a diode. [2]



3 Exam-style questions

3.1 A current of 2.0 A flows through a 12 V heater for 5.0 minutes. Calculate the charge that flows and the energy transferred. [3]

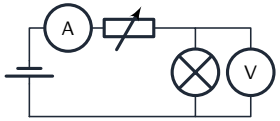


3.2 Explain why the resistance of a filament lamp increases as the current through it increases. [3]



3.3 A student measures the current through a fixed resistor and through a filament lamp at different voltages. The results are shown.

(a) Calculate the resistance of the fixed resistor. [3]



V / V	0	1	2	3	4	5	6
resistor I / A	0	0.10	0.20	0.30	0.40	0.50	0.60
lamp I / A	0	0.18	0.30	0.38	0.44	0.49	0.52

(b) Calculate the resistance of the lamp at 2.0 V and at 6.0 V, and explain the difference. [4]

(c) The resistor and the lamp are connected in parallel to a 4.0 V supply. Calculate the total current and the total power. [3]

(d) Describe how the student should obtain the results for the lamp. [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

- $4.0 + 8.0$
- **12** Ω

2.2

- its resistance decreases as the light intensity increases
- e.g. a light sensor for street lights

2.3

- **0.80** A
- the current splits between the branches and the branch currents add up

2.4

- no current in the reverse direction
- in the forward direction, current flows only above about 0.6 V and then rises steeply

3.1

- $Q = 2.0 \times 300 = 600$ C
- $E = 600 \times 12 =$ **7200** J

3.2

- a larger current makes the filament hotter
- the metal ions vibrate more
- electrons collide with the ions more often, so the resistance is higher

3.3

(a) any pair, e.g. $6.0 \div 0.60 =$ **10** Ω

(b) $2.0 \div 0.30 =$ **6.7** Ω; $6.0 \div 0.52 =$ **11.5** Ω; at higher voltage the current is larger, so the filament is hotter; its ions vibrate more, so its resistance is higher

(c) $0.40 + 0.44 = 0.84$ A; $P = 0.84 \times 4.0 =$ **3.4** W

(d) points to include:

- connect the lamp in series with an ammeter, a variable resistor and the supply (K)
- connect a voltmeter in parallel across the lamp (K)
- change the variable resistor (or supply) to set the voltage in steps, e.g. 1.0 V (K)
- record the current at each voltage (K)
- reverse the connections to take readings for negative voltages (App)
- switch off between readings so the lamp's temperature is not changed by the test itself; repeat and plot I against V (An)

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.