Unit 23 · DC Circuits

ANSWER KEY · FOR TEACHERS

Full marks 37

Give the marks for the points in the marking scheme; an answer in other words that says the same is right.

1 Key words

1. current
2. drift velocity
3. electromotive force
4. Ohm's law
5. thermistor
6. resistivity
7. divider
8. internal resistance

Each carries 0.5 mark. **K · 4**

2 Label the diagram

1. stretch
2. pads
3. plastic backing
4. fine wire

Each carries 0.5 mark. **K · 2**

3 Multiple choice

i. **c.** 1.08×10^4 C **A · 1**

$Q = It = 1.5 \times 7200 = 10{,}800$ C.

ii. **b.** the filament's resistance rises as it gets hotter **U · 1**

The metal's ions vibrate more as it heats up, so its resistance rises: equal steps of V give smaller steps of I.

iii. **b.** 1.0 Ω **A · 1**

$I = V/R = 1.2 \div 4.0 = 0.30$ A; the lost volts are 0.30 V, so $r = 0.30 \div 0.30 = 1.0\ \Omega$.

iv. **c.** half as large **U · 1**

$R = \rho l/A$: twice the length doubles R; twice the diameter makes A four times larger, quartering R. Overall $\times 2/4 = \frac{1}{2}$.

v. **a.** rises **U · 1**

In the dark the LDR's resistance rises, so it takes a larger share of the supply's p.d.

4 Very short answers

a. **MARKING SCHEME** **K · 1**

✓ $I \propto V$ at constant temperature (physical conditions).

b. **MARKING SCHEME** **K · 1**

✓ Ω m.

c. **MARKING SCHEME** **U · 1**

✓ The lost volts Ir across the internal resistance: $V = E - Ir$.

5 Short answers

a. **MARKING SCHEME** **U · 2**

✓ E.m.f.: the energy converted into electrical energy per unit charge by a source (a cell).

✓ P.d.: the electrical energy converted into other forms per unit charge between two points (in a component).

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b. MARKING SCHEME U · 2

- ✓ When the material stretches, the gauge's fine wire gets longer (and slightly thinner).
- ✓ Its resistance $R = \rho l/A$ rises in proportion to the strain, so measuring ΔR measures the stretch.

c. MARKING SCHEME A · 2

- ✓ In parallel each lamp gets the full mains p.d., so each works at its rated power.
- ✓ Each can be switched on and off on its own; if one fails, the others stay lit.

6 Long answer

ANSWER U · 4

In a time t each carrier moves a distance vt, so all the carriers in a length vt of the wire, volume Avt, pass a cross-section. Their number is nAvt and their charge nAvtq. The current is the charge passing per unit time: $I = nAvtq/t = nAvq$. In a series circuit the current is the same through every part of the wire. Where the wire is thinner (smaller A), with the same n and q, the drift velocity $v = I/(nAq)$ must be larger.

MARKING SCHEME

- ✓ Carriers in a length vt (volume Avt) pass in time t.
- ✓ Charge passing = nAvtq.
- ✓ $I = Q/t = nAvq$.
- ✓ Same I, smaller A: larger v in the thin part.

7 Numerical problems

a. ANSWER A · 3

$A = \pi(0.20 \times 10^{-3})^2 = 1.26 \times 10^{-7}\ m^2$.
$l = RA/\rho = 50 \times 1.26 \times 10^{-7} \div 1.1 \times 10^{-6} =$ **5.7 m**.

MARKING SCHEME

- ✓ $A = \pi r^2 = 1.26 \times 10^{-7}\ m^2$.
- ✓ $l = RA/\rho$.
- ✓ $l = 5.7$ m.

b. ANSWER A · 3

$V(out) = V \times R(T)/(R_1 + R(T)) = 9.0 \times 5.0 \div (10 + 5.0) =$ **3.0 V**.
As it warms, its resistance falls, so its share of the p.d. **falls**.

MARKING SCHEME

- ✓ $V(out) = V\ R(T)/(R_1 + R(T))$.
- ✓ 3.0 V.
- ✓ The output falls as it warms.

c. ANSWER A · 4

i. $I = P/V = 1500 \div 230 =$ **6.5 A**; $R = V^2/P = 230^2 \div 1500 =$ **35 Ω**.
ii. Energy = 1.5 kW × 0.25 h × 30 = 11.25 kWh; cost = 11.25 × 12 = **Rs 135**.

MARKING SCHEME

- ✓ I = 6.5 A.
- ✓ R = 35 Ω.
- ✓ Energy 11.25 kWh in 30 days.
- ✓ Cost Rs 135.

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8 Think

ANSWER HA · 3

The wire is full of free electrons all along it. When the switch closes, the electric field set up by the cell spreads along the whole circuit at nearly the speed of light, and the electrons everywhere, including those already in the lamp's filament, start drifting at once. No electron has to travel from the switch to the lamp.

MARKING SCHEME

- ✓ The wire is already full of free electrons, including those in the lamp.
- ✓ The field (the push) spreads round the circuit almost at the speed of light.
- ✓ All the electrons start drifting together, so the lamp lights at once.

9 Activity: The I–V characteristic of a filament lamp

(not marked)

WHAT STUDENTS SHOULD FIND

The graph starts straight but bends over towards the V axis: equal steps of voltage give smaller and smaller steps of current. V/I rises steadily, several times larger when the filament glows than when it is cold, because the hot metal's ions vibrate more. The lamp doesn't obey Ohm's law: its temperature doesn't stay the same.

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- **The Fun Circuit** (exhibit): The lamp lights only while the loop is closed: a current is charge flowing round a complete circuit, and opening the loop anywhere stops it.

Marks by level	Knowledge	Understanding	Application	Higher ability	Total
Marks	8	12	14	3	**37**

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