Unit 23 · DC Circuits

HARDER PRACTICE QUESTIONS · ANSWER KEY

Full marks 28

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

1 Spot the error

ANSWER U · 3

He stopped at 1/R. $1/R = 0.5\ \Omega^{-1}$, so $R = 1 \div 0.5 = \mathbf{2.0}\ \Omega$. (Check: it must be less than the smaller resistor, 3.0 Ω, and more than zero; product over sum, $18 \div 9 = 2.0\ \Omega$.)

MARKING SCHEME

- ✓ The error: 0.5 is 1/R, not R.
- ✓ $R = 1/0.5$.
- ✓ $R = 2.0\ \Omega$.

2 Check the readings

ANSWER HA · 3

From the first two: a drop of 0.10 V for 0.20 A, so $r = \mathbf{0.50}\ \Omega$, and $E = 1.40 + 0.20 \times 0.50 = \mathbf{1.50\ V}$. Check: $V = 1.50 - 0.50I$ gives 1.20, 1.10, 1.00 at 0.60, 0.80, 1.00 A; the last two fit. The reading at **0.60 A** (1.05 V) is wrong; it should be 1.20 V.

MARKING SCHEME

- ✓ $r = 0.50\ \Omega$ from the gradient.
- ✓ $E = 1.50$ V from the intercept.
- ✓ The 0.60 A reading is wrong (should be 1.20 V).

3 Estimate it

ANSWER A · 3

i. $v = I/(nAe) = 3.0 \div (8.5 \times 10^{28} \times 1.0 \times 10^{-6} \times 1.6 \times 10^{-19}) = \mathbf{2.2 \times 10^{-4}\ m/s}$, about a fifth of a millimeter per second.

ii. $t = 10 \div 2.2 \times 10^{-4} \approx 4.5 \times 10^{4}$ s, about **13 hours**: yet the lamp lights at once, since the electrons everywhere start moving together.

MARKING SCHEME

- ✓ $v = I/(nAe)$.
- ✓ $v = 2.2 \times 10^{-4}$ m/s.
- ✓ About 13 hours (4.5×10^{4} s).

4 Least and most

ANSWER HA · 4

i. $I = E/(R + r)$; $P = I^2R$. R = 1.0: I = 4.0 A, P = **16 W**. R = 2.0: I = 3.0 A, P = **18 W**. R = 4.0: I = 2.0 A, P = **16 W**.

ii. **R = 2.0** Ω: the load takes the most power when its resistance equals the internal resistance.

iii. The same current through equal resistances: **half** the power is wasted in the battery.

MARKING SCHEME

- ✓ $I = E/(R + r)$ and $P = I^2R$ used.
- ✓ 16 W, 18 W, 16 W.
- ✓ Most power when R = r.
- ✓ Half is wasted inside the battery.

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5 A real setting

ANSWER A · 3

i. Each wire: $R = \rho l/A = 1.68 \times 10^{-8} \times 25 \div 0.75 \times 10^{-6} = 0.56\ \Omega$; both: **1.12 Ω**.

ii. $I \approx 2000 \div 230 = 8.7$ A; $P = I^2R = 8.7^2 \times 1.12 \approx$ **85 W**, heating the cable. A thinner cable has more resistance, so it heats more: coiled up, it can melt its insulation and start a fire.

MARKING SCHEME

- ✓ $R = \rho l/A$ for 50 m of wire: 1.12 Ω.
- ✓ $I \approx 8.7$ A, $P = I^2R \approx 85$ W.
- ✓ More resistance in a thin cable means more heating: a fire risk.

6 Predict, then explain

ANSWER HA · 3

A is brightest: the whole current passes through it, and splits equally between B and C. When C breaks, the parallel part's resistance rises from R/2 to R, so the total resistance rises (1.5R to 2R) and the total current falls: **A gets dimmer**. B's share of the p.d. rises from 1/3 to 1/2 of the battery's, so **B gets brighter**.

MARKING SCHEME

- ✓ A brightest: it carries the whole current, which splits between B and C.
- ✓ After C breaks, total resistance rises, the current falls: A dimmer.
- ✓ B's share of the p.d. rises (1/3 → 1/2): B brighter.

7 Show that

MARKING SCHEME A · 2

- ✓ $P = QV/t = VI$.
- ✓ Substituting $V = IR$ and $I = V/R$ gives I^2R and V^2/R.

8 Correct the misconceptions

ANSWER U · 3

1. Current is **not used up**: the same current flows back to the battery (charge is conserved); it is the **energy** that is transferred in the lamps.
2. A filament lamp **doesn't** obey Ohm's law: its resistance rises as it heats up, so I isn't proportional to V.
3. **Resistance** depends on length and thickness; **resistivity** is a property of the material alone (and its temperature).

MARKING SCHEME

- ✓ Current isn't used up; energy is transferred.
- ✓ A filament lamp is non-ohmic.
- ✓ Resistivity depends only on the material (and temperature), not on the wire's size.

9 Design it

MARKING SCHEME A · 2

- ✓ LDR and fixed resistor in series across the supply, output across the LDR.
- ✓ In the dark the LDR's resistance rises, so its share of the p.d. (the output) rises.

10 Make your own

ANSWER HA · 2

For example 4 Ω in series with 12 Ω ∥ 12 Ω: 4 + 6 = 10 Ω. Any combination worked to 10 Ω with the series and parallel rules is right.

MARKING SCHEME

- ✓ Three resistors drawn in a combination.
- ✓ Worked to 10 Ω with the series and parallel rules.

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See it at Science Playground

Exhibits and plants at the center, Bhaktapur, that go with this unit. Book a class visit at science-playground.com/booking.

- **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	0	6	10	12	**28**

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