Solutions

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

2.1

- two resistors in series carry the **same current**, so the supply p.d. is shared between them in proportion to their **resistances**

$$V_{\text{out}} = V_{\text{in}} \times \frac{R_2}{R_1 + R_2}$$

2.2

- the 3.0 kΩ resistor takes its share of the supply

$$V = 12\text{ V} \times \frac{3.0\text{ k}\Omega}{3.0\text{ k}\Omega + 9.0\text{ k}\Omega} = \mathbf{3.0}\text{ V}$$

2.3

- for a uniform wire $R = \dfrac{\rho L}{A}$ with ρ and A constant, so resistance is proportional to **length**
- the whole wire carries the same current, so the p.d. across a part is IR, which is therefore proportional to that part's length

2.4

- a null method adjusts the circuit until an instrument reads **exactly zero**, and the measurement is taken at that setting
- the instrument is a **galvanometer**, which is a sensitive centre-zero ammeter

2.5

- at the balance point the galvanometer reads zero, so **no current flows** through the cell being measured
- with $I = 0$ there is no p.d. Ir across its internal resistance, so the p.d. being balanced is the full **e.m.f.**
- a voltmeter always draws **some** current, so there is always a small Ir inside the cell and it reads the **terminal p.d.**, which is slightly less than the e.m.f.

3.1 A

- a zero reading on the galvanometer means **no current** flows in that branch, which is the whole point of the method

3.2

(a)

- the e.m.f. is proportional to the balance length

$$E_2 = E_1 \times \frac{\ell_2}{\ell_1} = 1.018\text{ V} \times \frac{78.0\text{ cm}}{62.5\text{ cm}} = \mathbf{1.27}\text{ V}$$

(b)

- the p.d. available along the whole wire is set by the driver cell
- if the cell being measured had a larger e.m.f., no length of wire would have a p.d. big enough to balance it and there would be **no balance point**

(c)

- any **two** of: at balance **no current** is drawn from the cell, so the **e.m.f.** is measured rather than the terminal p.d.; the galvanometer only has to detect **zero**, so its calibration does not matter; the result depends on a **length**, which can be measured very precisely

3.3

(a)

- the LDR and the fixed resistor in **series** across the 6.0 V supply, drawn with correct symbols
- the output terminals shown **across the LDR**
- the circuit complete, with correct symbols for the supply and the LDR

(b)

- as the light level falls, the resistance of the **LDR rises**
- so the LDR takes a **larger share** of the supply p.d.
- the output is taken across the LDR, so V_{out} **rises** as it gets darker

(c)

- use the divider formula with the LDR as the output component
- in bright light

$$V_{\text{out}} = 6.0\text{ V} \times \frac{500\ \Omega}{500\ \Omega + 4700\ \Omega} = \mathbf{0.58}\text{ V}$$

- in darkness

$$V_{\text{out}} = 6.0\text{ V} \times \frac{20\,000\ \Omega}{20\,000\ \Omega + 4700\ \Omega} = \mathbf{4.9}\text{ V}$$