2019 Ph H2 Q12

Section: Electricity

Topic: Internal Resistance, Circuits and Power

(a) A cell has EMF E and internal resistance r. With switch open, voltmeter reads 1.5 V. With switch closed, voltmeter reads 1.3 V and ammeter 0.88 A. (i) State EMF. (ii) Calculate internal resistance. (iii) Explain drop in voltmeter reading. (b) Battery: EMF 9.0 V, internal resistance 1.2 Ω, lamp 2.4 Ω in series. (i) Find current. (ii) Calculate lamp power.

Worked solution

(a)(i) EMF of the cell is the open-circuit voltage (no current).
So E = 1.5 V.

Answer: 1.5 V

(a)(ii) r = (E − V_load)/I.
= (1.5 − 1.3)/0.88.
= 0.23 Ω.

Answer: 0.23 Ω

(a)(iii) When the switch is closed, current flows. Some energy is lost as heat in the internal resistance, so the terminal voltage falls. This explains why the voltmeter reading decreases.

(b)(i) Current $I = E / (R + r)$.
$= 9.0 / (2.4 + 1.2)$.
$= 2.50$ A.

Answer: 2.5 A

(b)(ii) Power dissipated in lamp: $P = I^2R$.
$= (2.50)^2 \times 2.4$.
$= 15.0$ W.

Answer: 15 W

Final answers

(a)(i) E = 1.5 V

(a)(ii) r ≈ 0.23 Ω

(a)(iii) Terminal p.d. drops due to energy loss in r

(b)(i) I ≈ 2.5 A

(b)(ii) P ≈ 15 W

Revision tips

- Open-circuit voltage = EMF of cell.
- Internal resistance causes lost volts: $V = E - Ir$.
- Greater current → greater voltage drop inside cell.
- In series: total resistance = R + r.
- Power in resistor: $P = I^2R$ or VI.