2022 Ph H2 Q12

Section: Electricity

Topic: Sources & Internal Resistance

Student investigates EMF and internal resistance from V–I graph. (a) Define EMF. (b) Use graph to find EMF and r. (c) How to measure EMF directly. (d) Explain why terminal PD decreases as R decreases. (e) Sketch line for smaller EMF, same r.

Worked solution

(a) EMF is the energy supplied by a source to each coulomb of charge, when no current is drawn (open circuit).

(b)

(i) From graph, intercept at I=0 gives E ≈ 6.0 V.

(ii) Slope = −r, using ΔV/ΔI:
(6.0 − 2.0) / (0.0 − 0.40) = −10 Ω.

Answer: E = 6.0 V, r = 10 Ω

(c) To measure EMF directly, open the switch so no current flows. Measure the potential difference across the battery with a voltmeter.

(d) Decreasing R increases current. Voltage lost across internal resistance (Ir) increases, so terminal PD (V = E − Ir) decreases.

(e) A smaller EMF but same r gives a straight line with:
• Same gradient (−r)
• Lower intercept on V axis.

Graph shifts downward, parallel to original line.

Final answers

(a) EMF = energy per coulomb, no current

(b)(i) E = 6.0 V

(b)(ii) r = 10 Ω

(c) Open circuit voltmeter reading

(d) Increased current ⇒ larger Ir ⇒ smaller V

(e) Line parallel, lower intercept

Revision tips

- V–I graph: intercept = EMF, slope = −r.
- Internal resistance causes lost volts Ir inside battery.
- Open circuit voltmeter reading gives EMF directly.
- Reducing load resistance increases current, increasing lost volts.
- For smaller EMF, line is parallel but lower intercept.