Smarter practice. Stronger understanding

WORKSHEETS

ATTEMPT | CHECK | CORRECT | IMPROVE

OCR A AS EMF and Internal Resistance worksheet

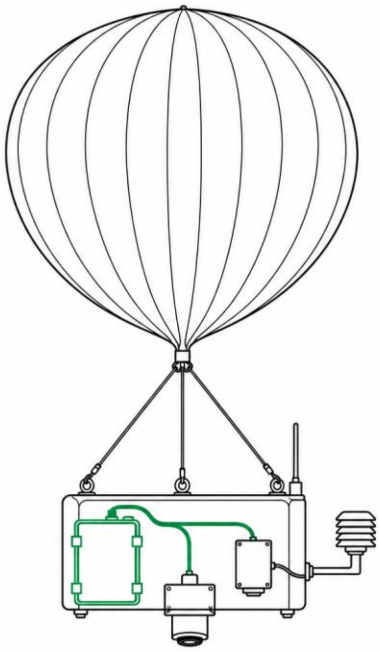
35–40 minutes independent practice + 15–20 minutes review | 40 marks

Specification points covered

- 4.3.1(f) Analyse circuits with more than one source of e.m.f.
- 4.3.2(a) Define a source of e.m.f. and internal resistance.
- 4.3.2(b) Define terminal potential difference and lost volts.
- 4.3.2(c)(i) Use and apply $E = I(R + r)$ and $E = V + Ir$.
- 4.3.2(c)(ii) Use techniques and procedures to determine the internal resistance of a cell or power supply.

Asteria high altitude balloon

Asteria carries cameras, heaters, weather sensors and communications equipment beneath a high-altitude research balloon.
Analyse how its sources share energy, why the terminal p.d. falls under load and how engineers measure the battery's internal resistance before launch.



Context diagram: the Asteria balloon and its battery-powered instrument gondola.

1 Energy and source language

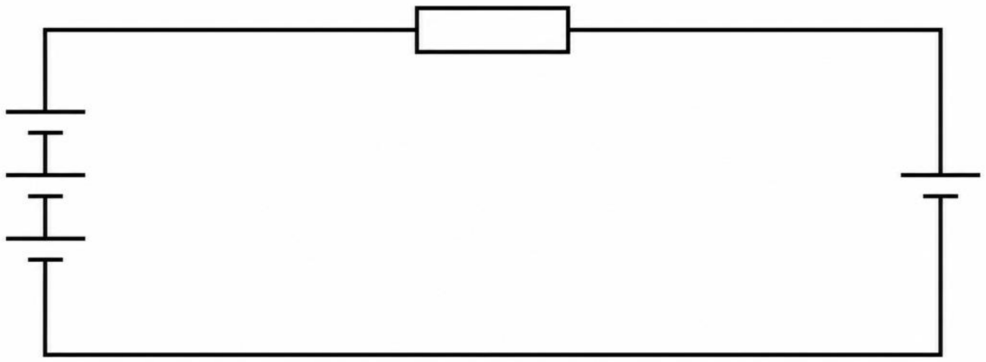
1. The Asteria balloon battery transfers 25.2 J from chemical energy to electrical energy when 2.10 C of charge passes through it. Calculate the e.m.f. of the battery. [1 mark]

2. State what is meant by the internal resistance of a source. Define terminal potential difference and explain the term lost volts. [3 marks]

3. A high-resistance voltmeter connected across the battery reads 12.6 V when the external circuit is open. Explain why this reading equals the e.m.f. of the battery. [1 mark]

2 Opposing and aiding sources

4. The diagram shows the main pack of e.m.f. 12.0 V and a backup source of e.m.f. 3.0 V connected in opposition. Their internal resistances are negligible. Determine the resultant e.m.f. and the direction of conventional current. [2 marks]



Opposing sources: the three-cell main pack is on the left and the single-cell backup pack is on the right.

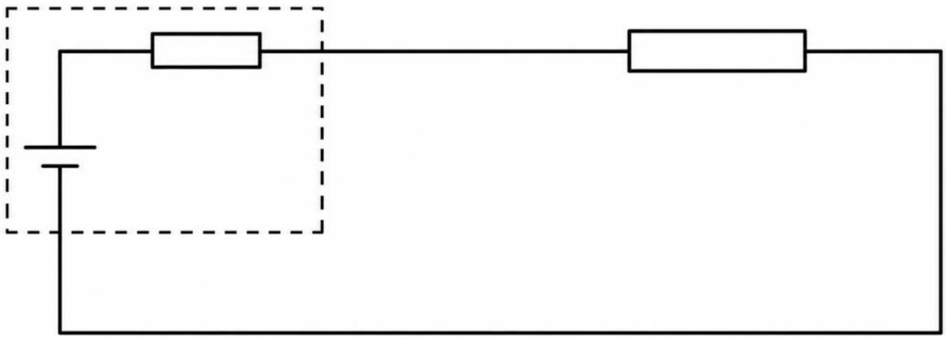
5. The external resistor in the circuit in Question 4 has resistance 18.0 Ω. Calculate the current in the resistor. [1 mark]

6. For each coulomb that passes around the circuit, state the energy supplied by the main pack, the energy transferred to the backup source and the energy dissipated in the resistor. Show that energy is conserved. [2 marks]

7. The backup source is reversed so that the two e.m.f.s act in the same direction. Calculate the new current. Determine the factor by which the power dissipated in the 18.0 Ω resistor increases. [3 marks]

3 A real source under load

8. The diagram models the Asteria battery as an ideal source of e.m.f. 12.6 V in series with internal resistance 0.600 Ω. The external instrument load has resistance 5.70 Ω. Calculate the current using $E = I(R + r)$. [1 mark]



Real-source model: the dashed boundary contains the ideal cell and its internal resistance.

9. Calculate the lost volts and the terminal p.d. of the battery. Verify the terminal p.d. using the external load resistance. [2 marks]

10. Account for the 12.6 J transferred by the source for each coulomb of charge by stating the energy per coulomb transferred inside the battery and in the external load. [2 marks]

4 High current operation

11. When the camera and heater operate together, the external load resistance falls to 1.50 Ω. The battery e.m.f. and internal resistance remain 12.6 V and 0.600 Ω. Calculate the current and terminal p.d. [2 marks]

12. For the operating condition in Question 11, calculate the power dissipated by the internal resistance and the percentage of the source power delivered to the external load. [2 marks]

13. At high altitude the internal resistance increases to 1.50 Ω while the external load remains 1.50 Ω. Calculate the new terminal p.d. and decide whether an instrument that resets below 8.0 V will continue to operate. [3 marks]

5 Load test data

14. Rearrange E = V + Ir into the straight-line form for a graph of terminal p.d. V against current I. State what the y-intercept and gradient represent. [3 marks]

15. The table shows readings from a load test on the balloon battery. Use two widely separated points to calculate the gradient of the V against I graph and hence determine the internal resistance. [2 marks]

Current I / A	Terminal p.d. V / V
0.50	12.25
1.00	11.90
1.50	11.55
2.00	11.20
2.50	10.85

16. Use one row of the table and your value of internal resistance to determine the e.m.f. of the battery. [1 mark]

6 Measuring internal resistance

17. A pupil has a cell, an ammeter, a voltmeter, a variable resistor, a switch and connecting wires. Describe an experiment to determine the e.m.f. and internal resistance of the cell. Include a circuit diagram, the measurements, how readings are varied, the graph and how both quantities are obtained. [6 marks]

18. The pupil leaves the circuit connected while changing the variable resistor and the cell becomes warm. Explain why this can reduce the validity of the straight-line analysis. State two improvements to the procedure. [3 marks]

Review and improve

- □ I subtract opposing e.m.f.s and add sources that act in the same direction.
- □ I distinguish e.m.f., terminal p.d. and lost volts using energy per unit charge.
- □ I can obtain E and r from the intercept and gradient of a V against I graph.