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EMF, internal resistance and practical analysis worksheet

AQA AS 7407 and first-year A Level 7408 | OCR A AS H156 and A Level H556

35–40 minutes independent practice + 15–20 minutes review | 39 marks

Specification points covered

AQA 7407 / 7408: 3.5.1.6 emf and internal resistance; 3.5.1.4 selected source combinations and energy; 3.1.2 selected uncertainty and experimental analysis. Required practical 6 preparation.
OCR A H156 / H556: 4.3.1(f), 4.3.2(a), (b), (c)(i)–(ii); 1.1.3(d)(i)–(ii), 1.1.4(d)–(e), selected practical analysis and improvement.

Asteria checks whether a research balloon battery can keep its instrument controller running during launch and high-altitude operation. Follow the explicitly separate ideal-source checks, real-battery operating tests and laboratory measurements to evaluate the supply model.

1. Energy supplied by a real source [4 marks]

Asteria develops a battery system for a high-altitude research balloon. In an initial test, the source transfers 25.2 J to each 2.10 C passing through it.

(a) Calculate the emf of this source. [1 mark]

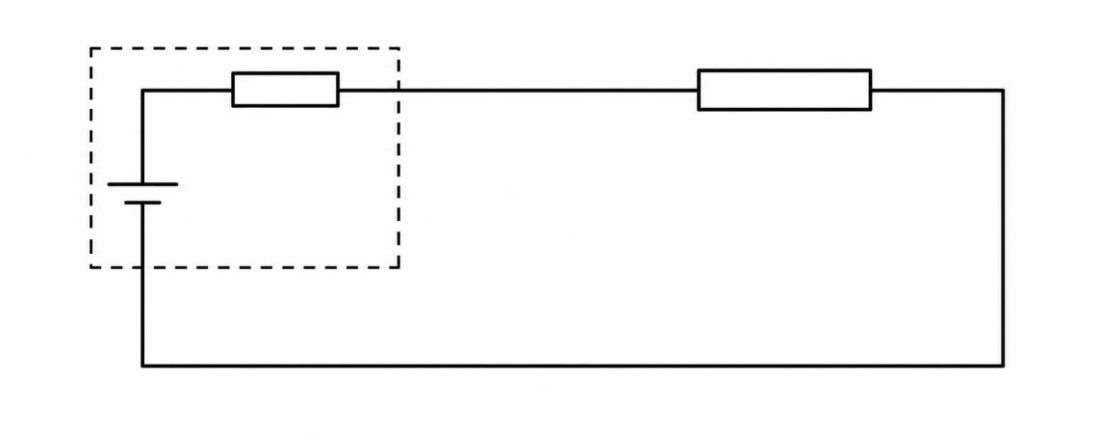
(b) Define terminal potential difference and lost volts for a source supplying a current. [2 marks]

(c) A high-resistance voltmeter reads 12.6 V across an otherwise disconnected battery. Explain why this is a good estimate of its emf. [1 mark]

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2. The launch-day operating tests [7 marks]

For these tests the battery is modelled by emf E = 12.6 V and internal resistance r = 0.600 Ω. The initial external resistance is 5.70 Ω. The diagram distinguishes the internal and external parts.



(a) Calculate the current in the complete circuit. [1 mark]

(b) Calculate the lost volts and terminal p.d. Check the terminal p.d. using the external resistance. [2 marks]

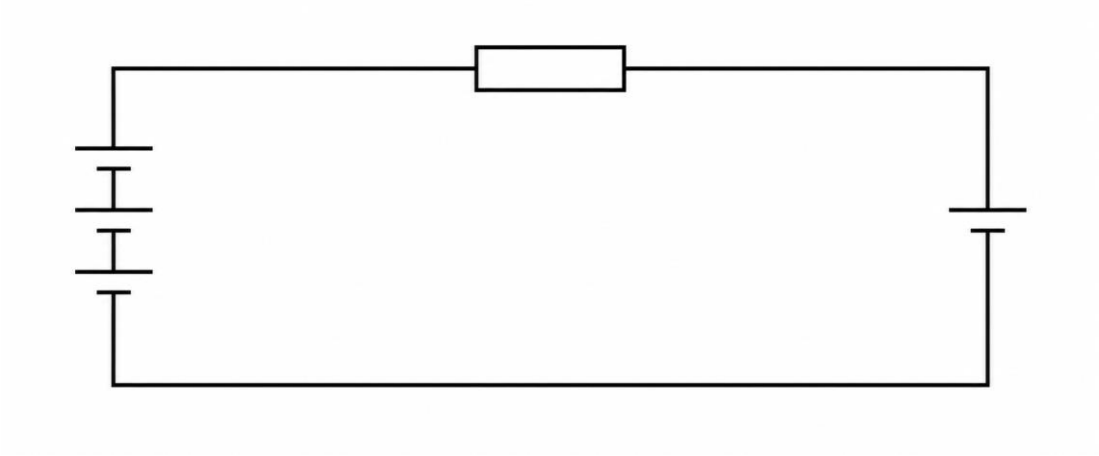
(c) The external resistance is changed to 1.50 Ω. Calculate the new current and terminal p.d. [2 marks]

(d) For the 6.00 A test, calculate the power dissipated inside the battery and the percentage of the source power transferred to the external circuit. [2 marks]

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3. An opposing backup source [4 marks]

In a separate idealised check, the main source has emf 12.0 V and the backup source has emf 3.00 V. Their internal resistances are negligible. They are connected as shown, with an 18.0 Ω external resistor.



(a) Determine the resultant emf and the current through the resistor. [2 marks]

(b) Describe the energy balance for each coulomb passing around this circuit. [1 mark]

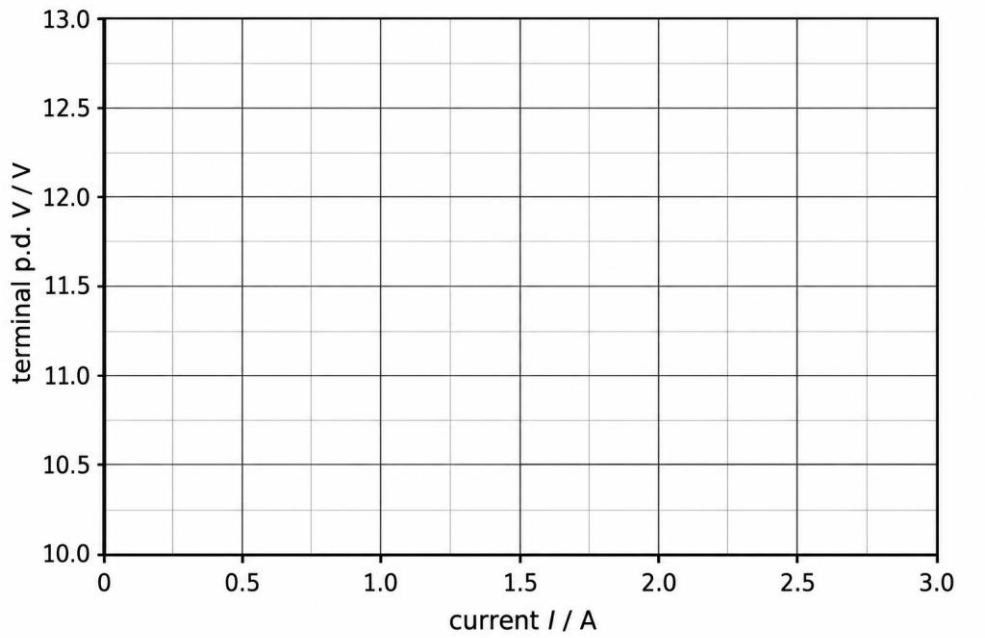
(c) The backup source is reversed so that the two emfs aid. Calculate the new current. [1 mark]

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4. Load-test graph and data checks [9 marks]

A laboratory test uses a different battery. At 1.50 A an initial reading of 10.70 V is questioned. Repeat readings are 11.54 V and 11.56 V; the table uses their mean, 11.55 V. Treat this test as having constant emf and internal resistance.

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



(a) Write an equation relating terminal p.d. V to current I, emf E and internal resistance r. State what the intercept and gradient of a V–I graph represent. [2 marks]

(b) Plot the five table readings and draw a straight line of best fit over the measured trend. [3 marks]

(c) Explain why the initial 10.70 V reading should be investigated and repeated rather than simply deleted because it does not fit the line. [1 mark]

(d) Use a large gradient triangle to determine the internal resistance. [2 marks]

(e) Determine the emf from the graph. [1 mark]

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5. Uncertainty and the reset limit [6 marks]

The laboratory graph gives E = (12.60 ± 0.04) V. Its best gradient is −0.700 V A^{-1}, with limiting gradients −0.660 and −0.740 V A^{-1}. Use half their range as the absolute gradient uncertainty. The controller resets if its terminal supply falls below 8.00 V.

(a) Give r with its absolute uncertainty and calculate its percentage uncertainty. [2 marks]

(b) In a separate regulated-current check the controller draws exactly 6.00 A. Use the lowest E and largest r in the stated intervals to calculate the lowest predicted terminal p.d. and decide whether a reset is predicted. [2 marks]

(c) At altitude another test has E = 12.6 V, r = 1.50 Ω and a fixed external resistance of 1.50 Ω. Calculate the terminal p.d. and decide whether the controller resets. [2 marks]

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6. A scaffolded six-mark practical plan [6 marks]

A school team investigates the emf and internal resistance of a low-voltage cell. Plan the experiment using the three prompts. The complete method is worth six marks.

(a) Draw a circuit using the cell, switch, ammeter, variable resistor and voltmeter. Use standard circuit symbols. [2 marks]

(b) Describe how to collect a suitable set of paired current and terminal-p.d. readings reliably. [2 marks]

(c) Describe how to use a graph to obtain both E and r. [2 marks]

7. Validity of one straight-line model [3 marks]

During a long sequence the cell warms and its state of charge changes.

(a) Explain why fitting one straight line may no longer give a valid single E and r. [1 mark]

(b) Suggest two checks or improvements linked to this drift. [2 marks]

Review: identify the correct operating test, distinguish emf from terminal p.d., obtain r from the negative gradient, and qualify supply decisions using the stated model and uncertainties.

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