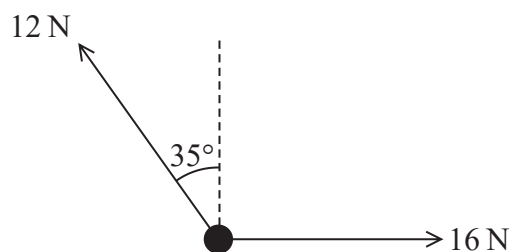
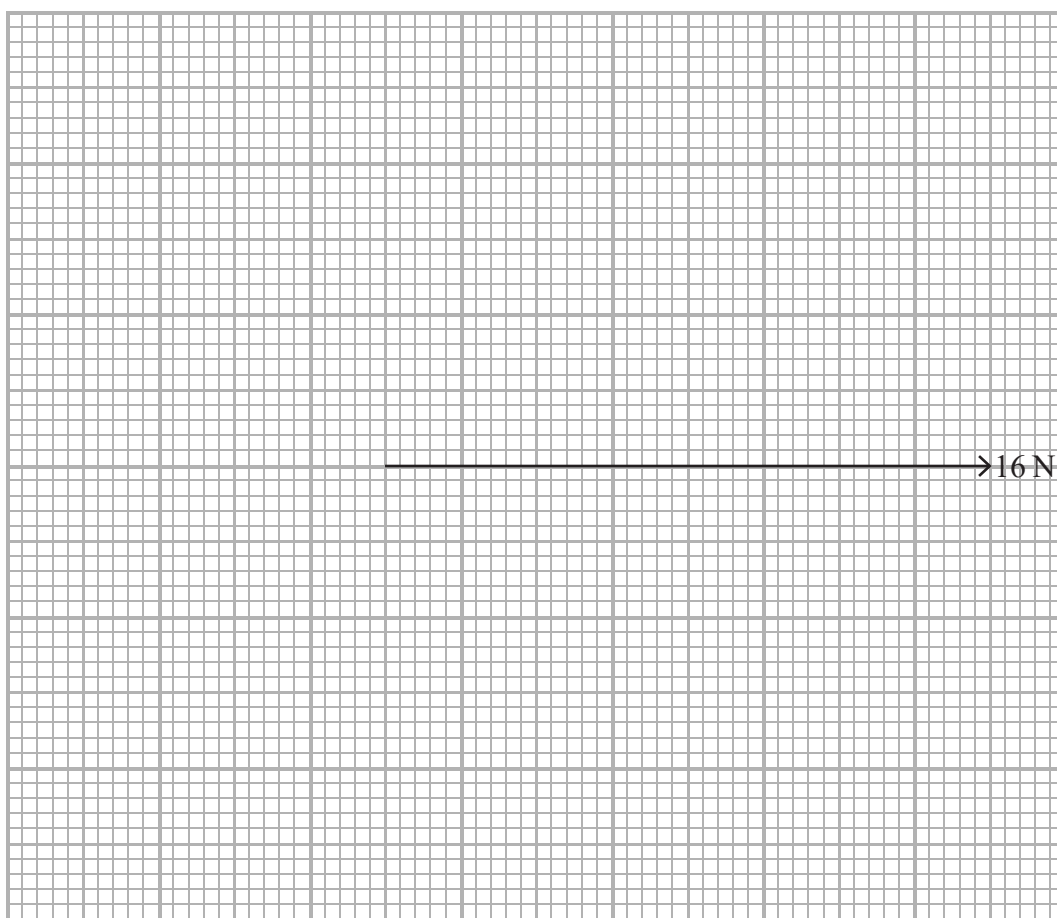


- 1 (a) Two forces act on a body. The free-body force diagram is shown.



On the grid below, complete the scale diagram to determine the resultant force acting on the body.

(3)



Magnitude of resultant force =

Angle of resultant force to 16 N force =

(b) Force is a vector quantity.

(i) State what is meant by vector quantity.

(1)

(ii) Give **two** further examples of vector quantities.

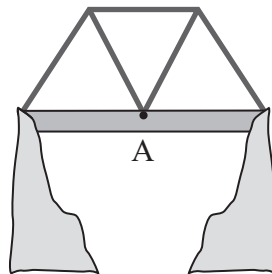
(1)

**(Total for Question = 5 marks)**

- 2 To increase the load that a bridge can withstand, some bridges have beams in a triangular design. These beams are called trusses.



A simple truss bridge is shown.



- (a) A lorry stops at point A.

Draw a free-body force diagram for the forces acting on the bridge at point A.

(3)

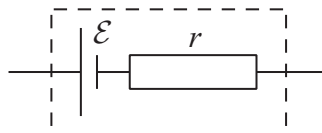


- (b) Explain why the structure of the bridge allows it to withstand greater loads.

(2)

**(Total for Question = 5 marks)**

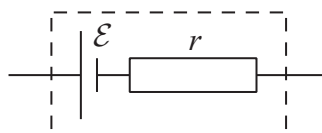
3 A cell may be represented as an e.m.f.  $\mathcal{E}$  in series with an internal resistance  $r$ .



A student used the relationship  $V = \mathcal{E} - Ir$  and a graphical method to determine  $\mathcal{E}$  and  $r$ . She connected a cell in a circuit and took a series of measurements of the current  $I$  in the cell and the potential difference  $V$  across the terminals of the cell.

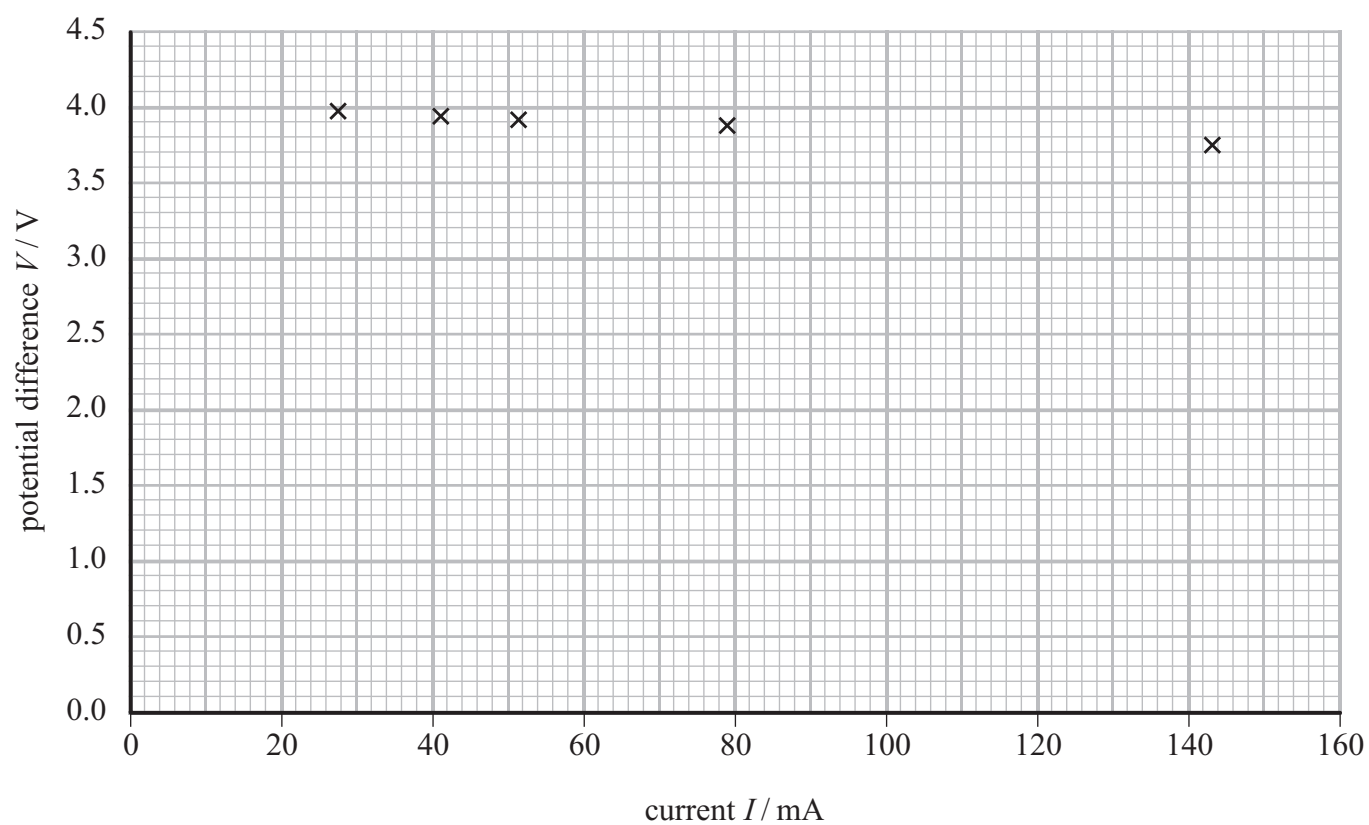
(a) Complete a circuit diagram of a circuit she could have used.

(2)



(b) The student's measurements are shown in the table and plotted on the graph.

$I / \text{mA}$	$V / \text{V}$
27.5	3.97
41.0	3.94
51.6	3.90
78.6	3.88
143.0	3.75



Determine values for  $\mathcal{E}$  and  $r$  from the graph and show how you obtained your answers.

(4)

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$\mathcal{E}$  .....

$r$  .....

(c) Explain how the graph could be constructed to obtain better values for  $\mathcal{E}$  and  $r$ .

(2)

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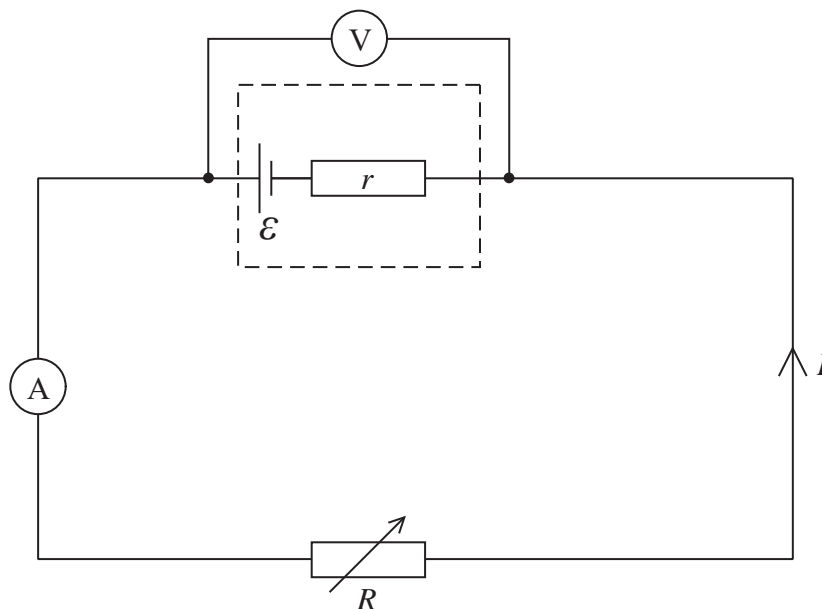
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**(Total for Question 8 marks)**

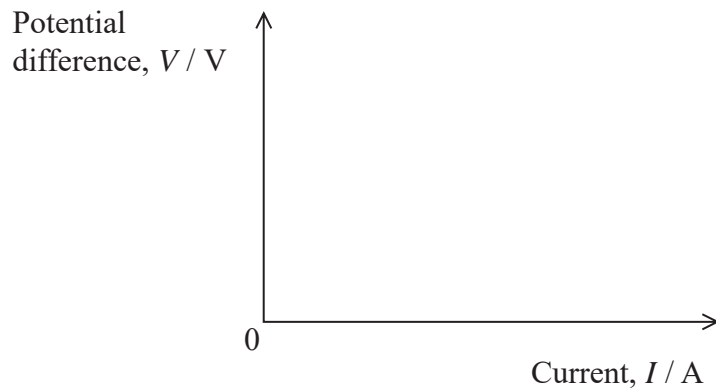
- 4 The diagram shows a circuit which may be used to find the emf  $\mathcal{E}$  and internal resistance  $r$  of a cell.



- (a) As the resistance  $R$  of the variable resistor is varied, values of the current  $I$  in the circuit and the terminal potential difference  $V$  across the cell are recorded.

Sketch the graph of  $V$  against  $I$  and explain how it may be used to determine  $\mathcal{E}$  and  $r$ .

(5)





\*(b) We usually assume that ammeters have negligible resistance and voltmeters have infinite resistance.

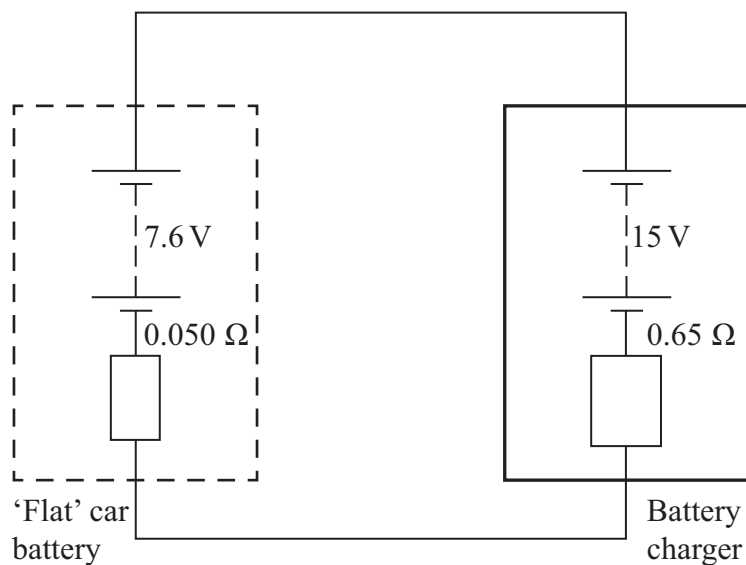
The determination of  $\mathcal{E}$  and  $r$  is not affected by using an ammeter with non-negligible resistance but is affected by using a voltmeter with a low resistance.

Explain why.

(4)

**(Total for Question = 9 marks)**

- 5 A 'flat' car battery of internal resistance  $0.050\ \Omega$  is charged with a battery charger. The battery charger consists of a power supply (with negligible internal resistance) of e.m.f.  $15\text{ V}$  in series with a resistor of resistance  $0.65\ \Omega$ .



The positive terminal of the car battery is connected to the positive terminal of the battery charger.

- (a) (i) Determine the resultant e.m.f. of the circuit.

(1)

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Resultant e.m.f. = .....

- (ii) Determine the total resistance of the circuit.

(1)

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Total resistance = .....

- (iii) Calculate the initial charging current.

(2)

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Charging current = .....

(b) The e.m.f. of the car battery quickly increases to 12.0 V and the charging current becomes 4.30 A.

- (i) Show that the terminal potential difference across the battery charger is now about 12 V.

(3)

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- (ii) Calculate the rate at which electrical energy is now being supplied by the 15 V power supply.

(2)

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Rate of energy supply = .....

- (iii) The wasted energy in this process is the energy dissipated in the internal resistance of the car battery and the series resistor in the battery charger.

Calculate the efficiency of the charging process when the current is 4.30 A.

(3)

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Efficiency = .....

**(Total for Question = 12 marks)**

6 A cell of e.m.f. 1.5 V is connected to a lamp of resistance  $80\ \Omega$ . The current in the circuit is 17 mA.

Calculate the internal resistance of this cell.

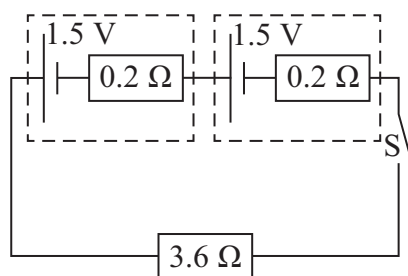
Internal resistance =

**(Total for Question = 3 marks)**

- 7 Electrically heated gloves are used by skiers and climbers to provide extra warmth for their hands.



Each glove has a heating element of resistance  $3.6 \, \Omega$ . Two cells each of e.m.f.  $1.5 \, \text{V}$  and internal resistance  $0.2 \, \Omega$  are used to operate each heating element.



(a) When the switch is closed:

- (i) Calculate the total resistance in the circuit

(1)

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Total resistance = .....

- (ii) Calculate the current in the heating element

(2)

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Current = .....

- (iii) Calculate the power output from the heating element.

(2)

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Power output = .....

(b) When in use the internal resistance of each cell gradually increases.

State and explain the effect this will have on the power output of the heating element.

(3)

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**(Total for Question = 8 marks)**

**8** A car battery has an e.m.f. of 12 V and an internal resistance of  $3.0 \times 10^{-3} \Omega$ . For the starter motor to turn the engine, the battery must provide a current of 400 A.

- (a) Calculate the terminal potential difference across the terminals of the battery when the current through the battery is 400 A.

(3)

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Terminal potential difference .....

- (b) The copper wires between the battery and the motor have a diameter of 1 cm.

Explain why such a thick wire is needed.

(3)

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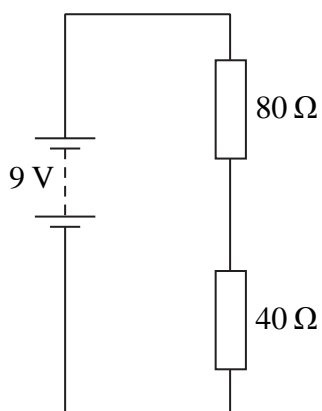
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**(Total for Question 6 marks)**

\*9 A circuit is set up as shown in the diagram. The battery has negligible internal resistance.



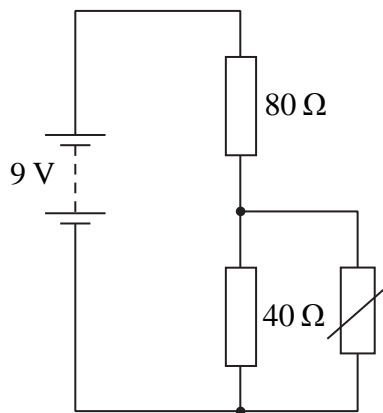
(a) Calculate the potential difference across the  $40\ \Omega$  resistor.

(2)

Potential difference =



(b) A thermistor is connected in parallel with the  $40\ \Omega$  resistor as shown.



The thermistor is initially at a temperature of  $100\ ^\circ\text{C}$  and its resistance is  $20\ \Omega$ . As the thermistor cools down, its resistance increases.

Explain what happens to the current through the battery as the temperature of the thermistor decreases.

(3)

**(Total for Question = 5 marks)**

- 10** Explain, in terms of energy, the difference between potential difference (p.d.) and electromotive force (e.m.f.).

(2)

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**(Total for Question = 2 marks)**