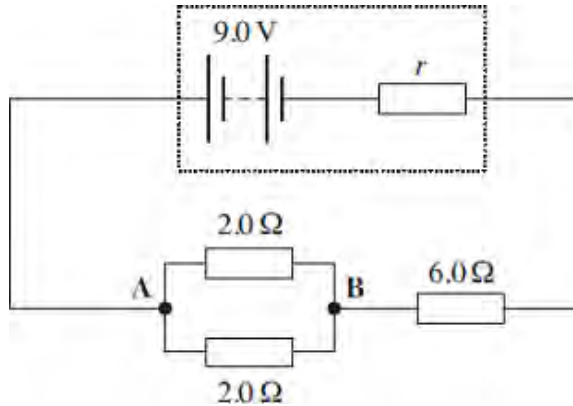


# Internal Resistance

- Q1.** A battery of emf 9.0 V and internal resistance,  $r$ , is connected in the circuit shown in the figure below.



- (a) The current in the battery is 1.0 A.
- (i) Calculate the pd between points **A** and **B** in the circuit.

answer = ..... V (2)

- (ii) Calculate the internal resistance,  $r$ .

answer = .....  $\Omega$  (2)

- (iii) Calculate the **total** energy transformed by the battery in 5.0 minutes.

answer = ..... J (2)

- (iv) Calculate the percentage of the energy calculated in part (iii) that is dissipated in the battery in 5.0 minutes.

answer = .....

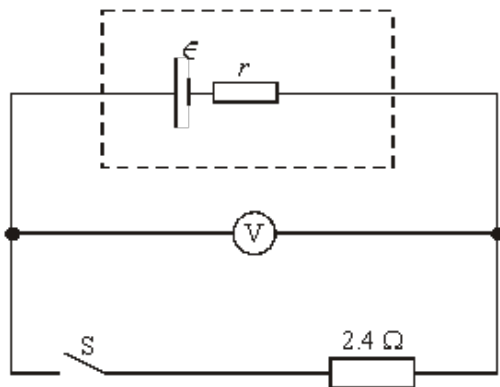
(2)

- (b) State and explain **one** reason why it is an advantage for a rechargeable battery to have a low internal resistance.

.....  
 .....  
 .....  
 .....

(2)  
 (Total 10 marks)

**Q2.** In the circuit shown the battery has emf  $\epsilon$  and internal resistance  $r$ .



- (a) (i) State what is meant by the emf of a battery.

.....  
 .....

- (ii) When the switch S is open, the voltmeter, which has infinite resistance, reads 8.0 V. When the switch is closed, the voltmeter reads 6.0 V. Determine the current in the circuit when the switch is closed.

.....  
 .....

(iii) Show that  $r = 0.80 \Omega$ .

.....  
.....

(4)

(b) The switch S remains closed. Calculate

(i) the power dissipated in the  $2.4 \Omega$  resistor,

.....

(ii) the total power dissipated in the circuit,

.....  
.....

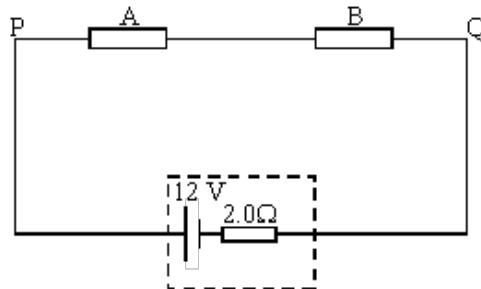
(iii) the energy wasted in the battery in 2 minutes.

.....

(4)

(Total 8 marks)

**Q3.** In the circuit shown, the battery has an emf of 12 V and an internal resistance of  $2.0 \Omega$ . The resistors A and B each have resistance of  $30 \Omega$ .



Calculate

(i) the total current in the circuit,

.....  
.....

(ii) the voltage between the points P and Q,

.....  
.....

(iii) the power dissipated in resistor A,

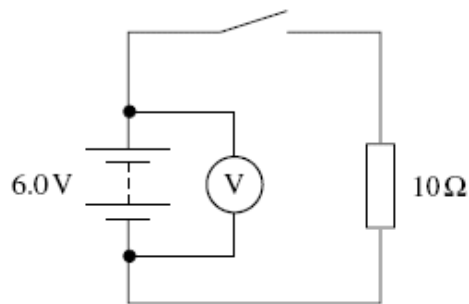
.....  
.....  
.....

(iv) the energy dissipated by resistor A in 20 s.

.....  
.....  
.....

**(Total 8 marks)**

**Q4.** A battery is connected to a  $10\ \Omega$  resistor as shown in the diagram below. The emf (electromotive force) of the battery is  $6.0\ \text{V}$ .



(a) (i) Define the emf of a battery.

.....  
.....

**(1)**

(ii) When the switch is open the voltmeter reads  $6.0\ \text{V}$  and when it is closed it reads  $5.8\ \text{V}$ . Explain why the readings are different.

.....  
.....  
.....  
.....  
.....

**(2)**

(b) Calculate the internal resistance of the battery.

answer = .....  $\Omega$

(3)

(c) State and explain why it is important for car batteries to have a very low internal resistance.

.....  
.....  
.....  
.....  
.....  
.....

(2)

(Total 8 marks)

**Q5.** A car battery has an emf of 12 V and an internal resistance of  $9.5 \times 10^{-3} \Omega$ . When the battery is used to start a car the current through the battery is 420 A.

(a) Calculate the voltage across the terminals of the battery, when the current through the battery is 420 A.

.....  
.....  
.....  
.....

answer ..... V

(2)

- (b) The copper cable connecting the starter motor to the battery has a length of 0.75 m and cross-sectional area of  $7.9 \times 10^{-5} \text{ m}^2$ . The resistance of the cable is  $1.6 \times 10^{-3} \Omega$ .

Calculate the resistivity of the copper giving an appropriate unit.

.....  
.....  
.....  
.....  
.....  
.....

answer .....

(3)  
(Total 5 marks)

**Q6.** A car battery has an *emf* of 12 V and an *internal resistance* of  $5.0 \times 10^{-3} \Omega$ .

- (a) (i) Explain what is meant by the emf of the battery.

.....  
.....

(1)

- (ii) Explain what is meant by the internal resistance of the battery.

.....  
.....

(1)

- (b) The battery is used to provide the starting motor of a car with a current of 800 A.

- (i) Calculate the potential difference across the terminals of the battery.

answer = ..... V

(2)

- (ii) Calculate the rate of dissipation of energy due to its internal resistance stating an appropriate unit.

answer = .....

(3)

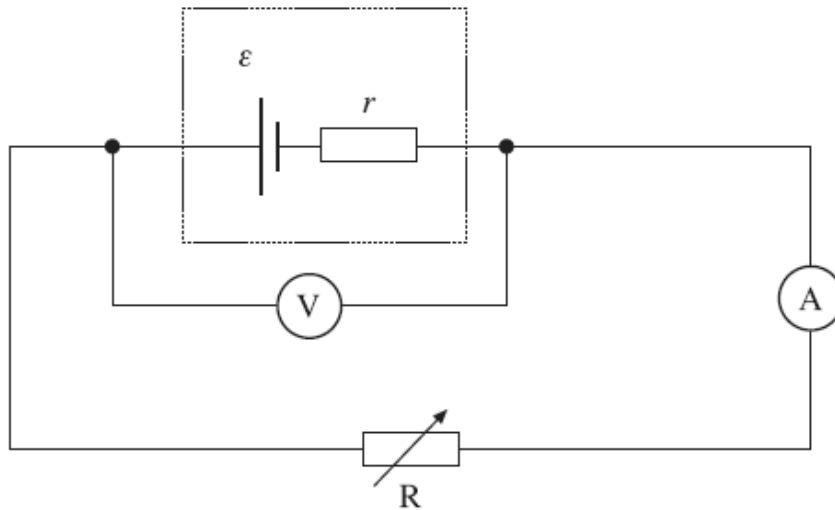
- (c) State and explain the effect of attempting to use a battery with a much higher internal resistance to start the car.

.....  
.....  
.....  
.....

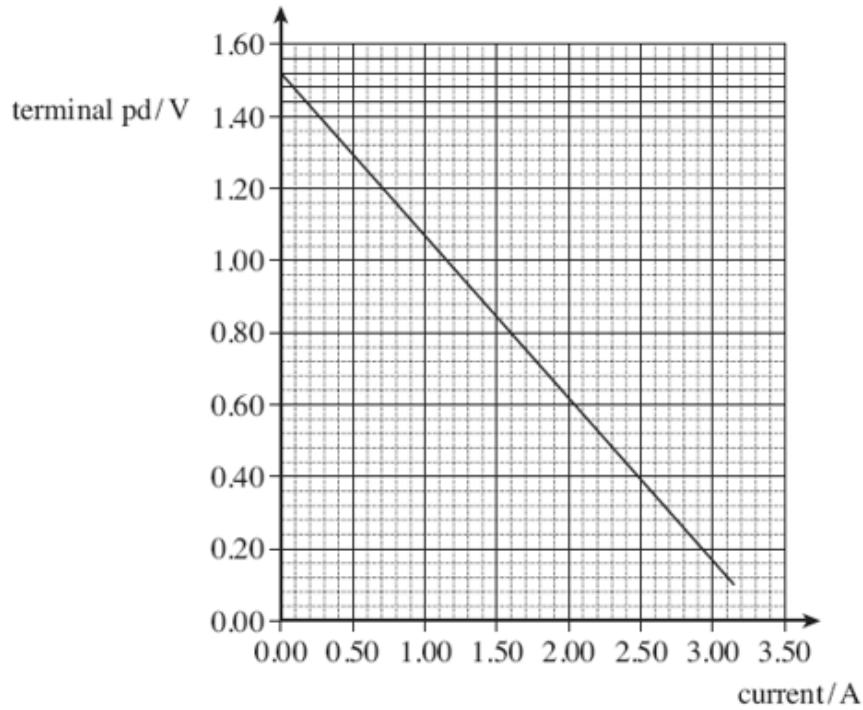
(2)

(Total 9 marks)

- Q7.** A cell of emf,  $\epsilon$ , and internal resistance,  $r$ , is connected to a variable resistor  $R$ . The current through the cell and the terminal pd of the cell are measured as  $R$  is decreased. The circuit is shown in the figure below.



The graph below shows the results from the experiment.



(a) Explain why the terminal pd decreases as the current increases.

.....  
.....  
.....  
.....

(2)

(b) (i) Use the graph to find the emf,  $\epsilon$ , of the cell.

answer = ..... V

(1)



- (ii) Use the graph above to find the internal resistance,  $r$ , of the cell.

answer = .....  $\Omega$  (3)

- (c) Draw a line on the graph above that shows the results obtained from a cell with

(i) the same emf but double the internal resistance of the first cell labelling your graph **A**. (2)

(ii) the same emf but negligible internal resistance labelling your graph **B**. (1)

- (d) In the original circuit shown in part (a), the variable resistor is set at a value such that the current through the cell is 0.89 A.

(i) Calculate the charge flowing through the cell in 15 s, stating an appropriate unit.

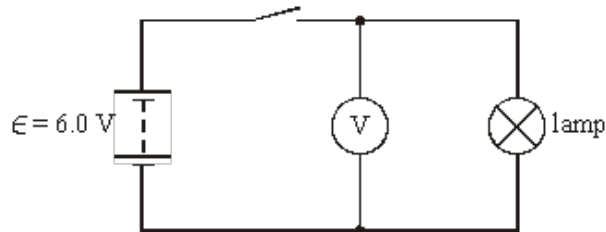
answer = ..... (2)

(ii) Calculate the energy dissipated in the internal resistance of the cell per second.

answer = ..... W

(2)  
(Total 13 marks)

**Q8.** (a) In the circuit shown in **Figure 1**, the battery has an emf of 6.0 V. With the switch closed and the lamp lit, the reading on the voltmeter is 5.4 V.



**Figure 1**

Explain without calculation, why the voltmeter reading is less than the emf of the battery.

You may be awarded marks for the quality of written communication in your answer.

.....  
.....  
.....  
.....

(3)

(b) A torch is powered by two identical cells each having an emf of 1.5 V and an internal resistance  $r$ . The cells are connected in series. The torch bulb is rated at 1.6 W and the voltage across it is 2.5 V.

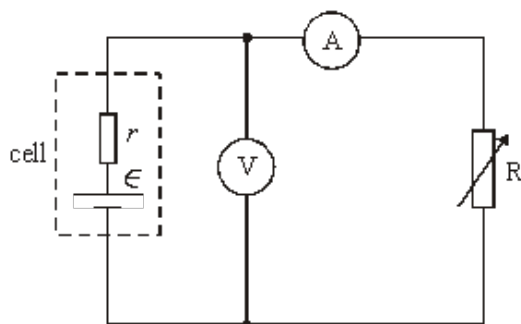
(i) Draw the circuit described.

(ii) Calculate the internal resistance of each cell.

.....  
.....  
.....  
.....

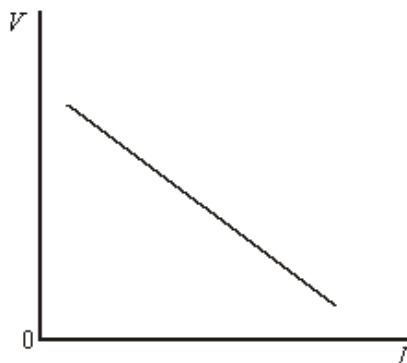
(5)

(c) In the circuit in **Figure 2** the cell has emf  $\epsilon$  and internal resistance  $r$ . The voltage  $V$  across the cell is read on the voltmeter which has infinite resistance, and the current  $I$  through the variable resistor  $R$  is read on the ammeter.



**Figure 2**

By altering the value of the variable resistor  $R$ , a set of values of  $V$  and  $I$  is obtained. These values, when plotted, give the graph shown in **Figure 3**.



**Figure 3**

Show how the values of  $\epsilon$  and  $r$  may be obtained from this graph. Explain your method.

.....

.....

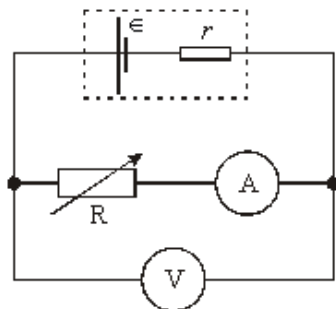
.....

.....

.....

(3)  
(Total 11 marks)

**Q9.** In the circuit shown, a battery of emf  $\epsilon$  and internal resistance  $r$  is connected to a variable resistor  $R$ . The current  $I$  and the voltage  $V$  are read by the ammeter and voltmeter respectively.



(a) The emf is related to  $V$ ,  $I$  and  $r$  by the equation

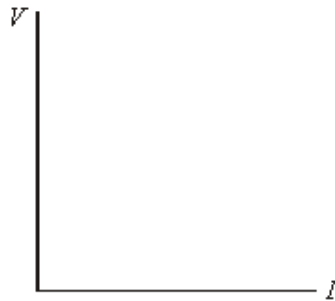
$$\epsilon = V + Ir$$

Rearrange the equation to give  $V$  in terms of  $\epsilon$ ,  $I$  and  $r$ .

.....

(1)

- (b) In an experiment, the value of  $R$  is altered so that a series of values of  $V$  and the corresponding values of  $I$  are obtained. Using the axes, sketch the graph you would expect to obtain as  $R$  is changed.



(2)

- (c) State how the values of  $\epsilon$  and  $r$  may be obtained from the graph.

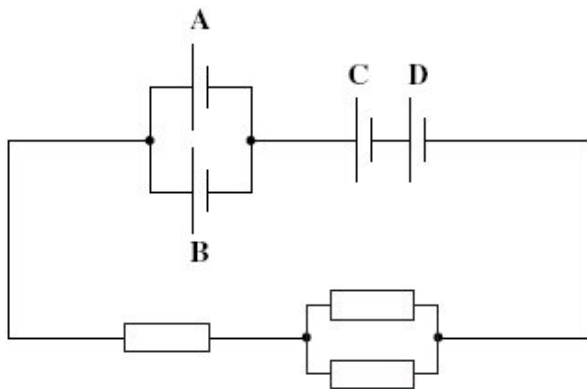
$\epsilon$  .....

$r$  .....

(2)

(Total 5 marks)

- Q10.** The circuit in the diagram below contains four identical new cells, **A**, **B**, **C** and **D**, each of emf 1.5V and negligible internal resistance.



- (a) The resistance of each resistor is  $4.0 \Omega$ .  
 (i) Calculate the total resistance of the circuit.

answer = .....  $\Omega$

(1)

(ii) Calculate the total emf of the combination of cells.

answer = ..... V (1)

(iii) Calculate the current passing through cell A.

answer = ..... A (2)

(iv) Calculate the charge passing through cell A in five minutes, stating an appropriate unit.

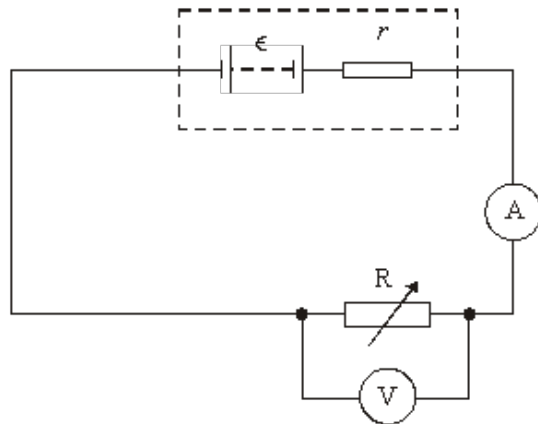
answer = ..... (2)

(b) Each of the cells can provide the same amount of electrical energy before going flat. State and explain which two cells in this circuit you would expect to go flat first.

.....  
.....  
.....  
.....  
.....  
.....

(3)  
(Total 9 marks)

**Q11.** A battery of emf  $\epsilon$  and internal resistance  $r$  is connected in series to a variable resistor  $R$  and an ammeter of negligible resistance. A voltmeter is connected across  $R$ , as shown in the figure below.



(a) (i) State what is meant by the emf of the battery.

.....  
 .....

(ii) The reading on the voltmeter is less than the emf. Explain why this is so.

.....  
 .....

(2)

(b) A student wishes to measure  $\epsilon$  and  $r$ . Using the circuit shown in the figure above the value of  $R$  is decreased in steps and at each step the readings  $V$  and  $I$  on the voltmeter and ammeter respectively are recorded. These are shown in the table.

reading on voltmeter/ $V$	reading on ammeter/ $A$
8.3	0.07
6.8	0.17
4.6	0.33
2.9	0.44
0.3	0.63

(i) Give an expression relating  $V$ ,  $I$ ,  $\epsilon$  and  $r$ .

.....

(ii) Draw a graph of  $V$  (on the  $y$ -axis) against  $I$  (on the  $x$ -axis) on graph paper.

(Allow one sheet of graph paper)

(iii) Determine the values of  $\epsilon$  and  $r$  from the graph, explaining your method.

$\epsilon$ : .....

.....

$r$ : .....

.....

(8)  
(Total 10 marks)