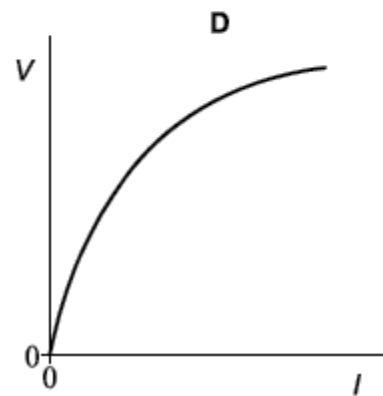
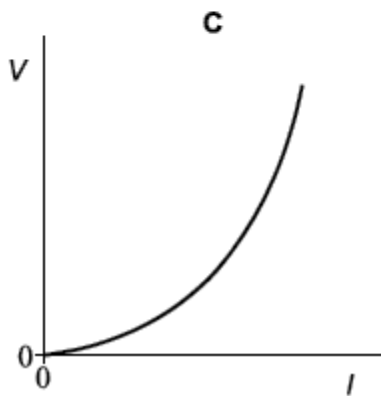
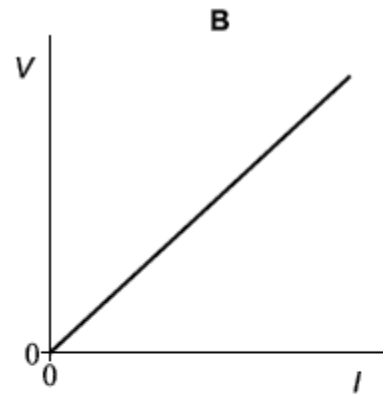
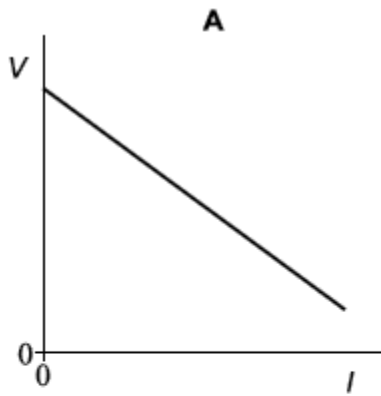


1

A student investigates how the potential difference V across the terminals of a cell varies with the current I in the cell.



Which graph correctly shows how V varies with I ?

A

B

C

D

(Total 1 mark)

- 2** The circuit in **Figure 1** is used to investigate how the potential difference V between the terminals of a cell varies as the current I in the circuit changes. **Figure 2** shows the graph of the results.

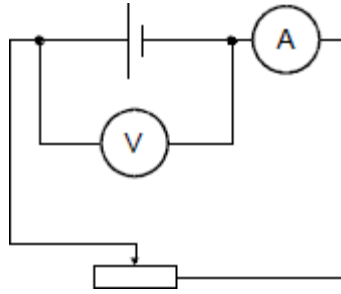


Figure 1

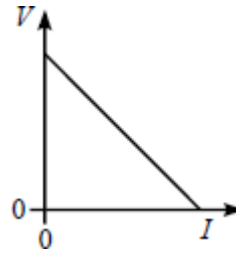


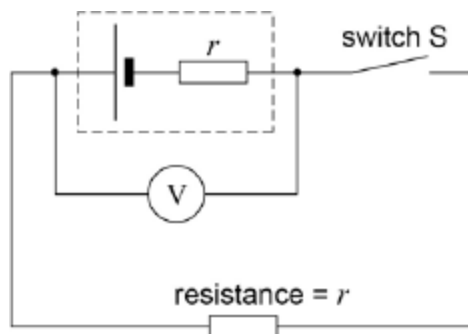
Figure 2

Which one of the following can be deduced from the gradient of the graph?

- A** The internal resistance of the cell
- B** The e.m.f. of the cell
- C** The power dissipated by the cell
- D** The resistance of the variable resistor

(Total 1 mark)

- 3** In the circuit shown, V is a voltmeter with a very high resistance. The internal resistance of the cell, r , is equal to the external resistance in the circuit.



external resistance

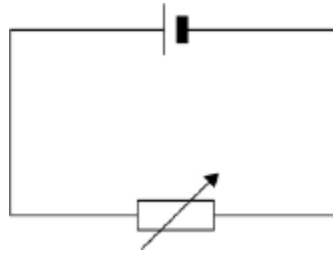
Which of the following is not equal to the emf of the cell?

- A** the reading of the voltmeter when the Switch S is open
- B** the chemical energy changed to electrical energy when unit charge passes through the cell
- C** twice the reading of the voltmeter when the switch S is closed
- D** the electrical energy produced when unit current passes through the cell

(Total 1 mark)

4

The cell in the circuit has an emf of 2.0 V. When the variable resistor has a resistance of 4.0 Ω , the potential difference (pd) across the terminals of the cell is 1.0 V.



What is the pd across the terminals of the cell when the resistance of the variable resistor is 12 Ω ?

- A 0.25 V
- B 0.75 V
- C 1.33 V
- D 1.50 V

(Total 1 mark)

5

A battery is connected to a 10 Ω resistor and a switch in series. A voltmeter is connected across the battery. When the switch is open (off) the voltmeter reads 1.45 V. When the switch is closed the reading is 1.26 V.

What is the internal resistance of the battery?

- A 0.66 Ω
- B 0.76 Ω
- C 1.3 Ω
- D 1.5 Ω

(Total 1 mark)

6

(a) Define the *electromotive force (emf)* of an electrical power supply.

.....

.....

.....

.....

(2)

- (b) Explain why, when a battery is supplying a current to a circuit, the voltage measured between its terminals is less than its emf.

.....

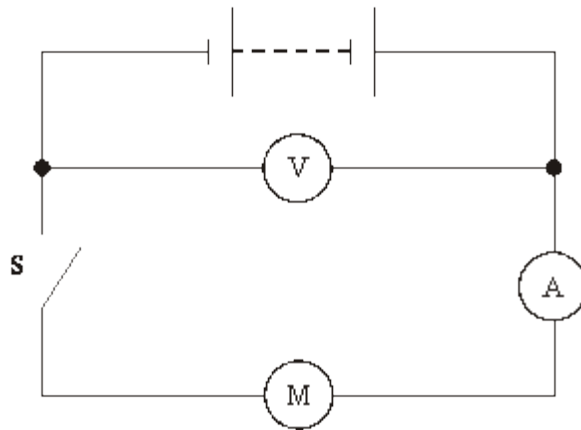
.....

.....

.....

(2)

- (c) In the circuit shown in the figure below the voltmeter has a very high resistance and the resistance of the ammeter is negligible. The motor M is being tested using a battery with an emf of 9.00 V.



- (i) State the reading on the voltmeter when the switch S is open.

voltmeter reading

- (ii) When S is closed and the motor is allowed to run freely the voltmeter reading is 8.41 V and the ammeter reads 0.82 A. Calculate the internal resistance of the battery.

internal resistance

- (iii) Explain why the ammeter reading is greater than 0.82 A when the motor does work by lifting a load.

.....

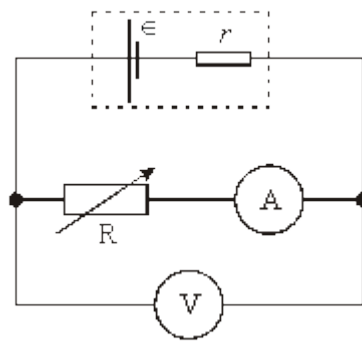
.....

.....

(5)
(Total 9 marks)

7

In the circuit shown, a battery of emf ϵ 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

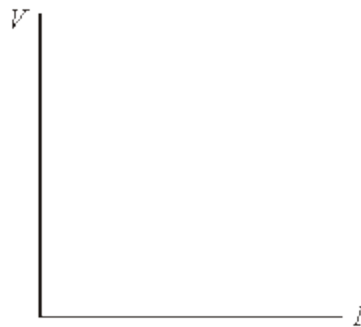
$$\epsilon = V + Ir$$

Rearrange the equation to give V in terms of ϵ , 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 ϵ and r may be obtained from the graph.

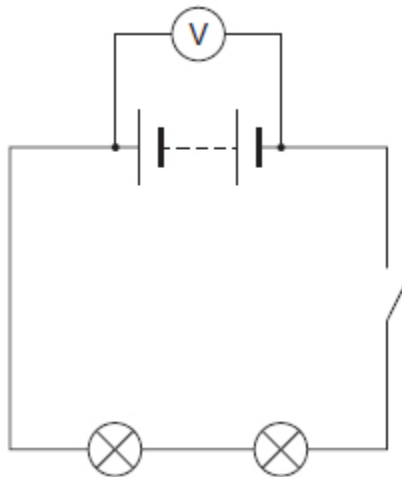
ϵ

r

(2)
(Total 5 marks)

8

The diagram shows an electrical circuit in a car. A voltmeter of very high resistance is used to measure the potential difference across the terminals of the battery.



(a) Define potential difference.

.....
.....

(1)

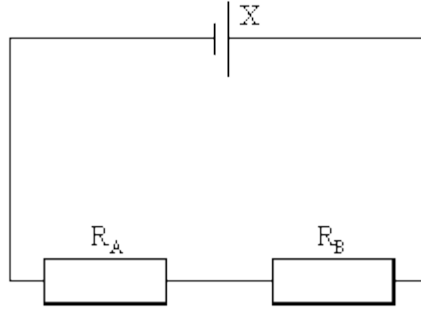
(b) Explain how and why the voltmeter reading changes when the switch is closed.

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

(3)
(Total 4 marks)

9

In the circuit shown in the diagram below cell **X** has an emf of 12 V and a negligible internal resistance. The resistances of R_A and R_B are $10\ \Omega$ and $15\ \Omega$ respectively.



- (a) Calculate the potential difference across R_B .

Potential difference

(2)

- (b) Cell **X** is replaced by cell **Y** that has an emf of 12 V and an internal resistance of 7.5 Ω. Calculate the terminal potential difference across cell **Y**.

Potential difference

(3)
(Total 5 marks)

10

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)

11

Figure 1 shows a circuit that includes an oscilloscope used to find the internal resistance r of a battery.

Figure 1

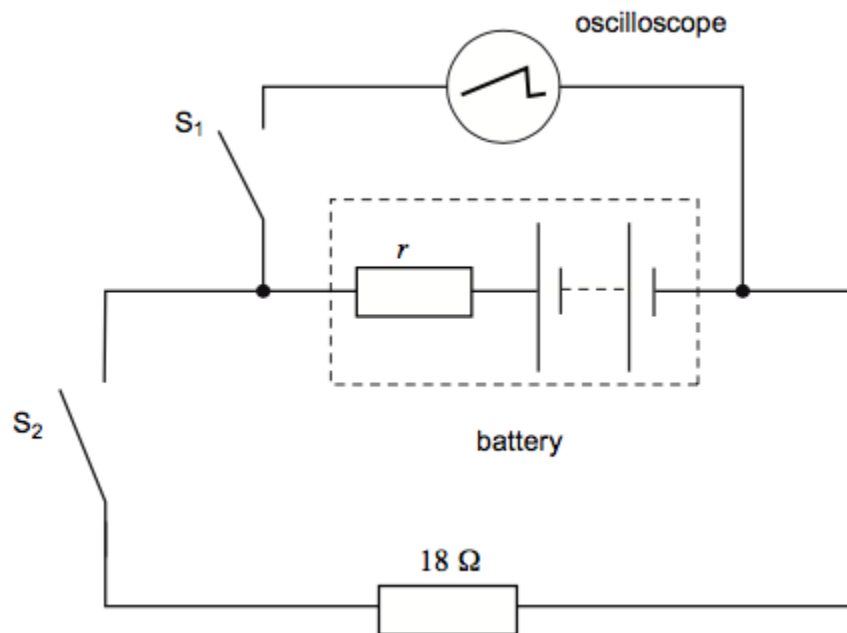
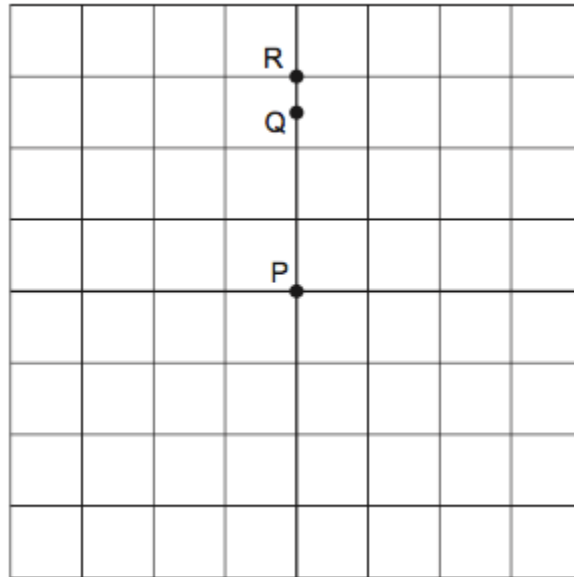


Figure 2 represents the screen of the oscilloscope. With switches S_1 and S_2 open, a bright spot is seen on the screen at P.

Figure 2



The vertical sensitivity of the oscilloscope is set at 2.0 V per division.

- (a) Explain why the oscilloscope shows a bright spot rather than a horizontal line.

.....

(1)

- (b) When switch S_1 is closed, the spot moves to R.

- (i) State the electrical property of the battery represented by the deflection PR.

.....

(1)

- (ii) Determine the value of the electrical quantity represented by the deflection PR.

electrical quantity =

(1)

- (c) With switch S_1 kept closed, switch S_2 is also closed. The spot moves to Q.

Explain why the spot moves from R to Q.

.....

.....

.....

.....

.....

(3)

- (d) Calculate the current in the battery when both switches are closed.

current = A

(2)

- (e) Calculate the internal resistance of the battery.

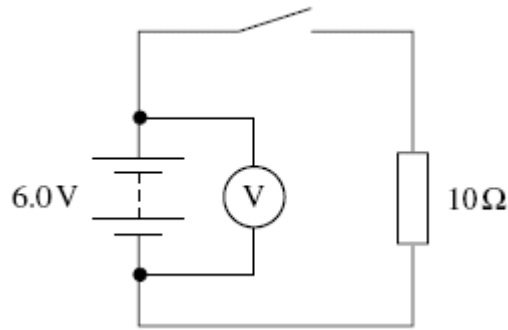
internal resistance = Ω

(2)

(Total 10 marks)

12

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 = Ω

(3)

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

.....

.....

.....

.....

.....

.....

(2)
(Total 8 marks)

13

A cordless phone handset contains two rechargeable cells connected in series. Each cell has an emf of 2.0 V and, when fully charged, the combination stores energy sufficient to provide 850 mA for 1 hour.

(a) Calculate the total energy stored by the two cells when fully charged.

energy stored J

(3)

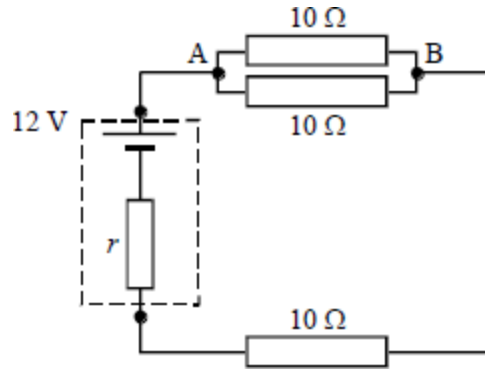
(b) The internal resistance of each cell is 0.60 Ω.
Calculate the potential difference across the two cells when they are connected in series across a 20.0 Ω load.

potential difference V

(3)
(Total 6 marks)

14

A battery of e.m.f. 12 V and internal resistance r is connected in a circuit with three resistors each having a resistance of $10\ \Omega$ as shown. A current of 0.50 A flows through the battery.



Calculate

- (a) the potential difference between the points A and B in the circuit,

.....

- (b) the internal resistance of the battery,

.....

- (c) the total energy supplied by the battery in 2.0 s,

.....

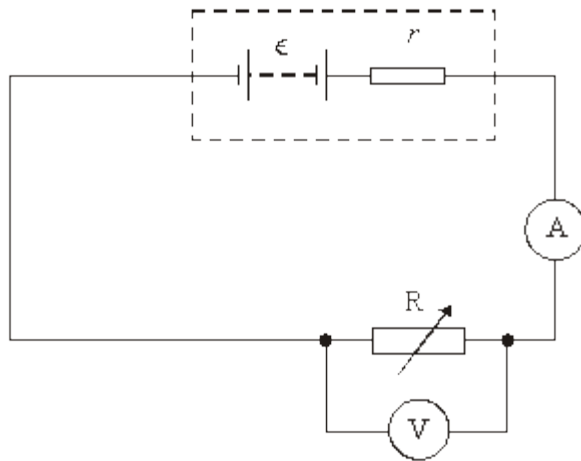
- (d) the fraction of the energy supplied by the battery that is dissipated within the battery.

.....

(Total 7 marks)

15

A battery of emf ϵ 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 ϵ 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 , ϵ 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 ϵ and r from the graph, explaining your method.

ϵ :

.....

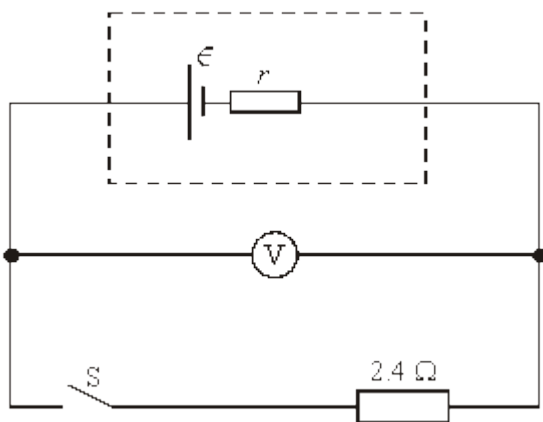
r :

.....

(8)
(Total 10 marks)

16

In the circuit shown the battery has emf ϵ 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 2.4Ω resistor,

.....

(ii) the total power dissipated in the circuit,

.....

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

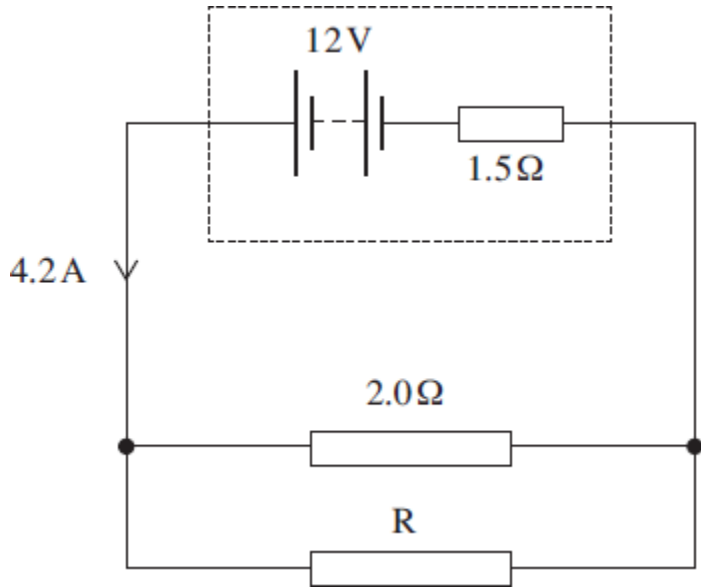
.....

(4)

(Total 8 marks)

17

The circuit diagram below shows a battery of electromotive force (emf) 12 V and internal resistance 1.5 Ω connected to a 2.0 Ω resistor in parallel with an unknown resistor, R. The battery supplies a current of 4.2 A.



(a) (i) Show that the potential difference (pd) across the internal resistance is 6.3 V.

(1)

(ii) Calculate the pd across the 2.0 Ω resistor.

pdV

(1)

(iii) Calculate the current in the 2.0 Ω resistor.

currentA

(1)

(iv) Determine the current in R.

current A

(1)

(v) Calculate the resistance of R.

R Ω

(1)

(vi) Calculate the total resistance of the circuit.

circuit resistance Ω

(2)

(b) The battery converts chemical energy into electrical energy that is then dissipated in the internal resistance and the two external resistors.

(i) Using appropriate data values that you have calculated, complete the following table by calculating the rate of energy dissipation in each resistor.

resistor	rate of energy dissipation / W
internal resistance	
2.0 Ω	
R	

(3)

(ii) Hence show that energy is conserved in the circuit.

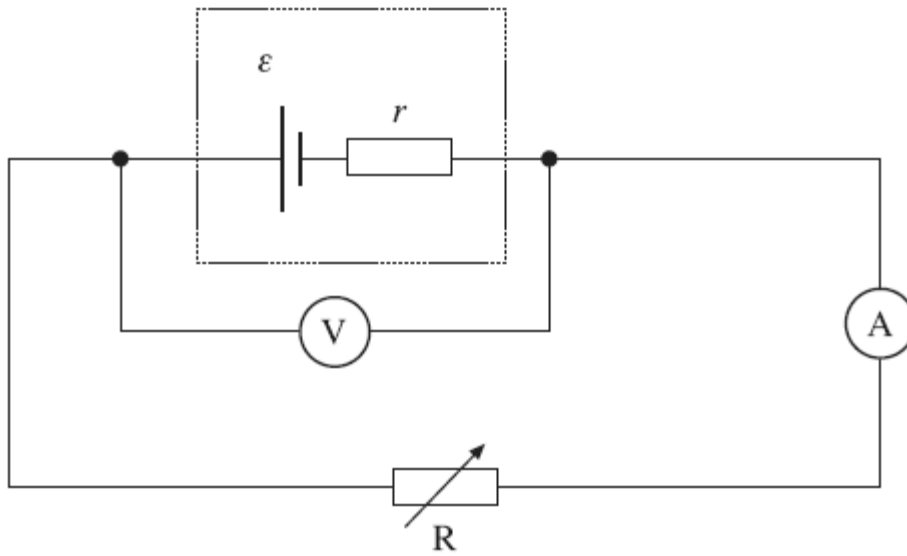
.....

(2)

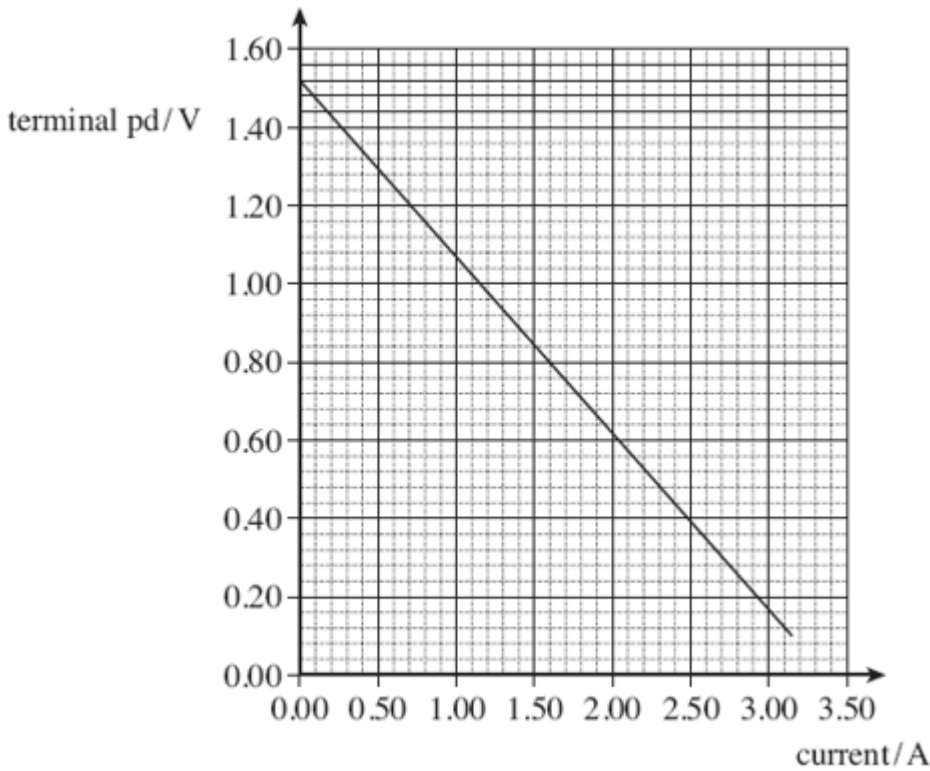
(Total 12 marks)

18

A cell of emf, ϵ , 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, ϵ , of the cell.

answer = V

(1)

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

answer = Ω

(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)

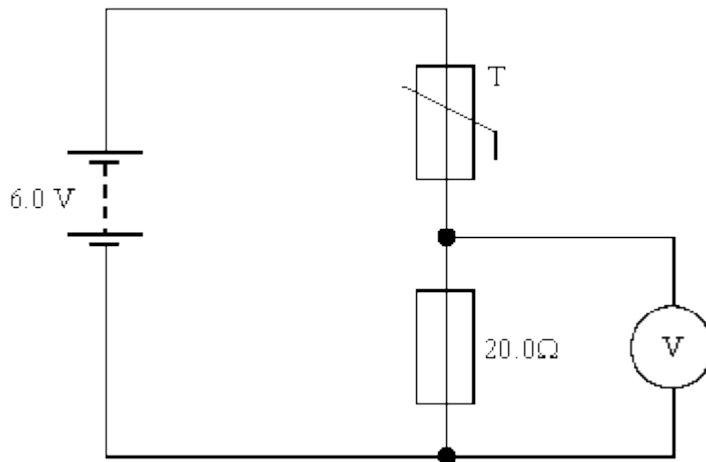
(ii) Calculate the energy dissipated in the internal resistance of the cell per second.

answer = W

(2)
(Total 13 marks)

19

The circuit shown in the diagram below can be used as an electronic thermometer. The battery has negligible internal resistance.



The reading on the digital voltmeter can be converted to give the temperature of the thermistor T which is used as a temperature sensor.

(a) Explain why the reading on the voltmeter increases as the temperature of the thermistor increases.

.....

.....

.....

.....

.....

.....

(2)

- (b) When the thermistor is at 80.0 °C the voltmeter reading is 5.0 V. Show that the resistance of the thermistor at this temperature is 4.0 Ω.

(1)

- (c) When the thermistor is at 20.0 °C its resistance is 24.5 Ω. Calculate the reading on the voltmeter.

Voltmeter reading

(2)

- (d) The battery is replaced with another having the same emf but an internal resistance of 3.0 Ω.

- (i) Calculate the new voltmeter reading when the thermistor temperature is 80.0 °C.

Voltmeter reading

(2)

- (ii) State and explain the effect, if any, on the measured temperature when the thermistor is at 20.0 °C.

.....

.....

.....

.....

.....

.....

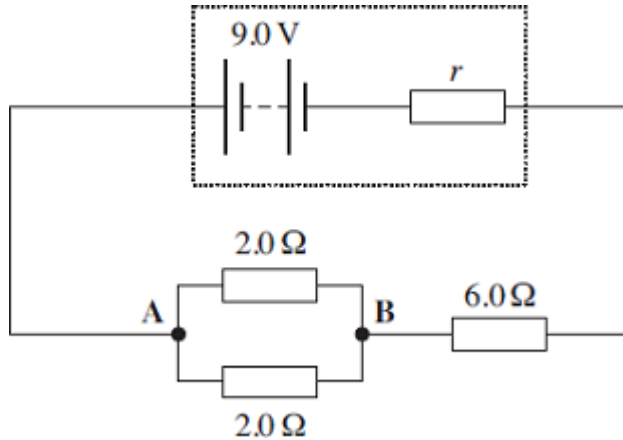
.....

(1)

(Total 8 marks)

20

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 = Ω

(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.

.....

.....

.....

.....

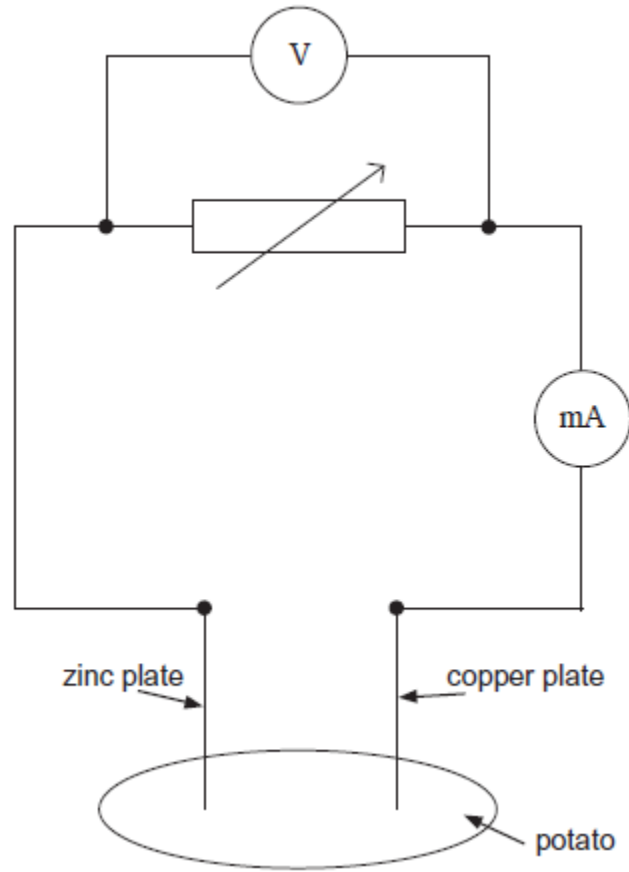
(2)

(Total 10 marks)

21

A 'potato cell' is formed by inserting a copper plate and a zinc plate into a potato. The circuit shown in **Figure 1** is used in an investigation to determine the electromotive force and internal resistance of the potato cell.

Figure 1



(a) State what is meant by electromotive force.

.....

.....

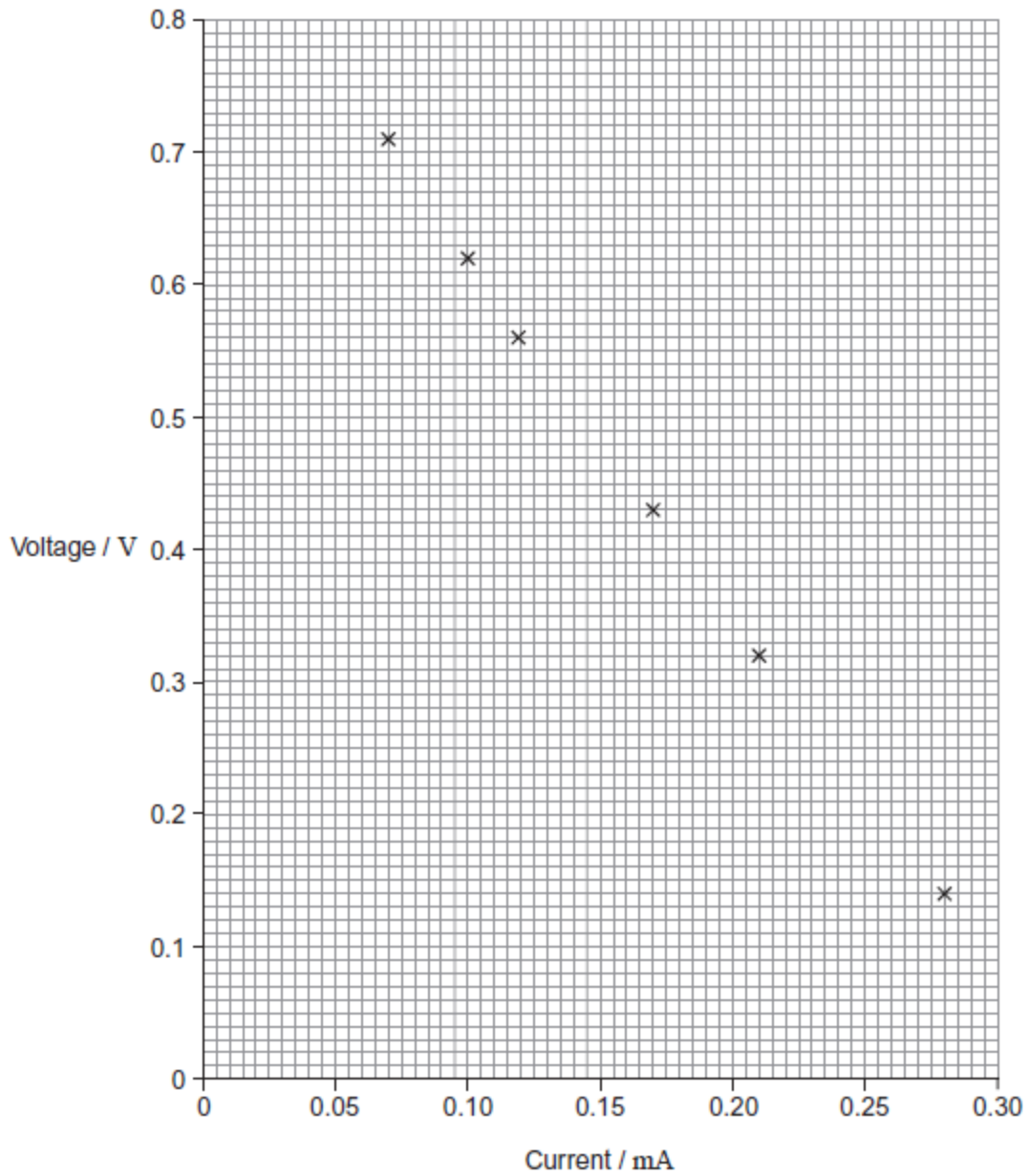
.....

.....

(2)

- (b) The plotted points on **Figure 2** show the data for current and voltage that were obtained in the investigation.

Figure 2



- (i) Suggest what was done to obtain the data for the plotted points.

.....

.....

.....

.....

(1)

- (ii) The electromotive force (emf) of the potato cell is 0.89 V. Explain why the voltages plotted on **Figure 2** are always less than this and why the difference between the emf and the plotted voltage becomes larger with increasing current.

.....

.....

.....

.....

.....

.....

.....

.....

(3)

- (iii) Use **Figure 2** to determine the internal resistance of the potato cell.

internal resistance = Ω

(3)

- (c) A student decides to use two potato cells in series as a power supply for a light emitting diode (LED). In order for the LED to work as required, it needs a voltage of at least 1.6 V and a current of 20 mA.

Explain whether the LED will work as required.

.....

.....

.....

.....

.....

.....

(2)

(Total 11 marks)

22

A student investigates how the power dissipated in a variable resistor, Y , varies as the resistance is altered.

Figure 1 shows the circuit the student uses. Y is connected to a battery of emf \mathcal{E} and internal resistance r .

Figure 1

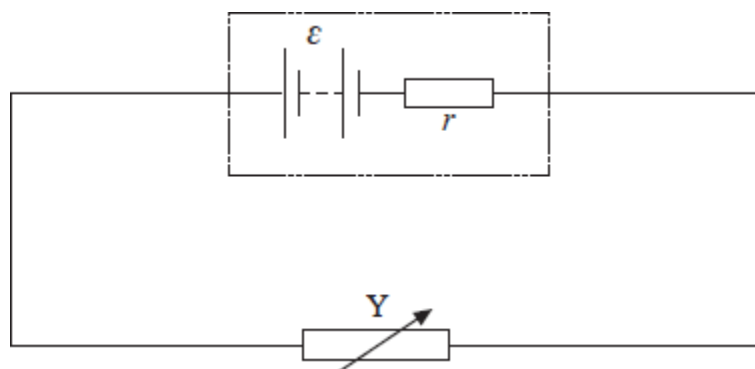
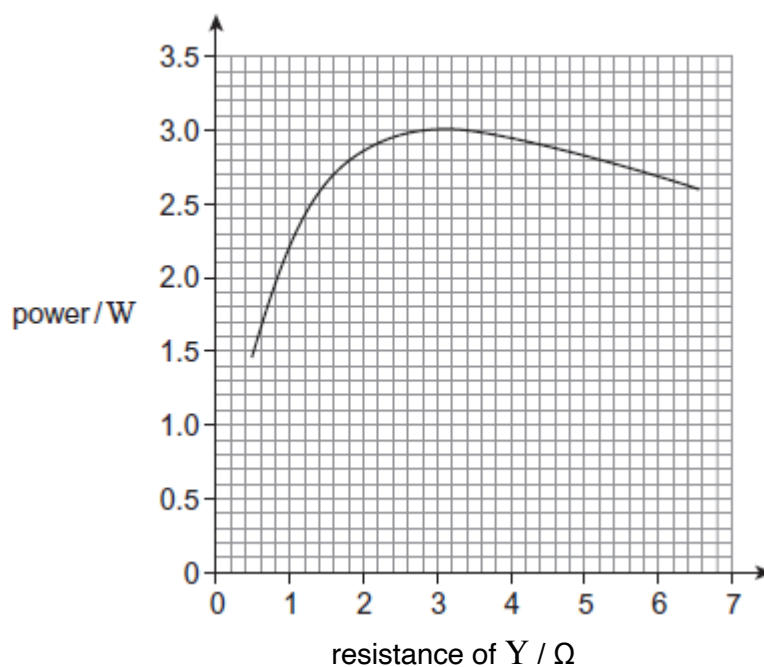


Figure 2 shows the results obtained by the student as the resistance of Y is varied from 0.5Ω to 6.5Ω .

Figure 2



- (a) Describe how the power dissipated in Y varies as its resistance is increased from 0.5Ω to 6.5Ω .

.....

.....

.....

.....

.....

(2)

- (b) The emf of the battery is 6.0 V and the resistance of Y is set at 0.80Ω .

- (i) Use data from **Figure 2** to calculate the current through the battery.

current A

(3)

- (ii) Calculate the voltage across Y .

voltage V

(2)

- (iii) Calculate the internal resistance of the battery.

internal resistance Ω

(2)

- (c) The student repeats the experiment with a battery of the same emf but negligible internal resistance. State and explain how you would now expect the power dissipated in Y to vary as the resistance of Y is increased from 0.5Ω to 6.5Ω .

.....

.....

.....

.....

.....

(3)
(Total 12 marks)

23

- (a) (i) Describe how you would make a direct measurement of the emf \mathcal{E} of a cell, stating the type of meter you would use.

.....

.....

(1)

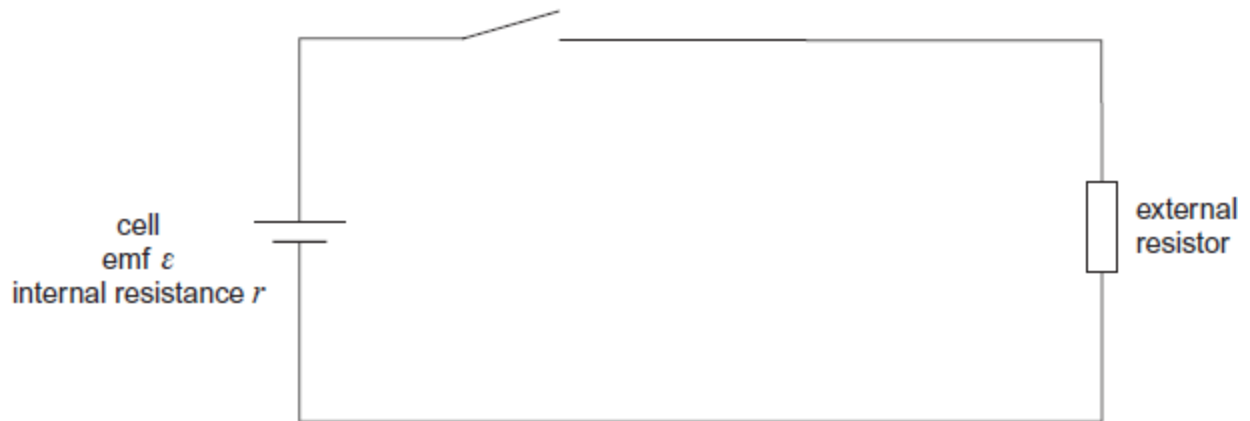
- (ii) Explain why this meter must have a very high resistance.

.....

.....

(1)

- (b) A student is provided with the circuit shown in the diagram below.



The student wishes to determine the efficiency of this circuit.

In this circuit, useful power is dissipated in the external resistor. The total power input is the power produced by the battery.

$$\text{Efficiency} = \frac{\text{useful power output}}{\text{total power input}}$$

The efficiency can be determined using two readings from a voltmeter.

- (i) Show that the efficiency = $\frac{V}{\mathcal{E}}$ where \mathcal{E} is the emf of the cell
and V is the potential difference across the external resistor.

(1)

- (ii) Add a voltmeter to the diagram and explain how you would use this new circuit to take readings of \mathcal{E} and V .

.....

(2)

- (c) Describe how you would obtain a set of readings to investigate the relationship between efficiency and the resistance of the external resistor. State any precautions you would take to ensure your readings were reliable.

.....

(2)

- (d) State and explain how you would expect the efficiency to vary as the value of R is increased.

.....

.....

.....

.....

.....

.....

(2)
(Total 9 marks)