

ELECTRIC CIRCUITS

Checklist

Make sure you can

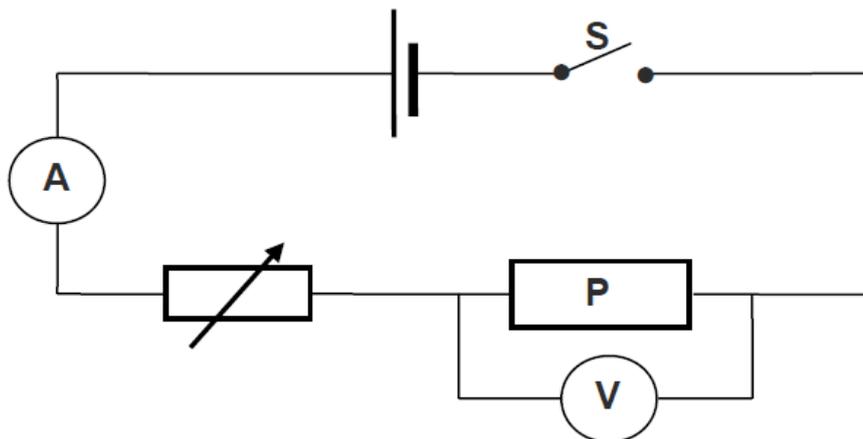
- State Ohm's law in words.
- Determine relationship between current, potential difference and resistance at constant temperature using a simple circuit
- Draw, sketch and interpret the current vs potential difference graphs at constant temperature
- Identify ohmic conductors and non-ohmic conductors
- Solve problems involving current, voltage and resistance for circuits containing arrangements of resistors in series and in parallel.
- Explain the term internal resistance.
- Solve circuit problems using $\epsilon = V_{\text{load}} + V_{\text{internal}}$ resistance and circuit problems, with internal resistance, involving series-parallel networks of resistors.
- Define power
- Solve circuit problems involving the concepts of power and electrical energy.
- Deduce that the kilowatt hour (kWh) meaning.
- Calculate the cost of electricity usage given the power specifications of the appliances used, the duration and the cost of 1 kWh.

Exam Questions

Question 1

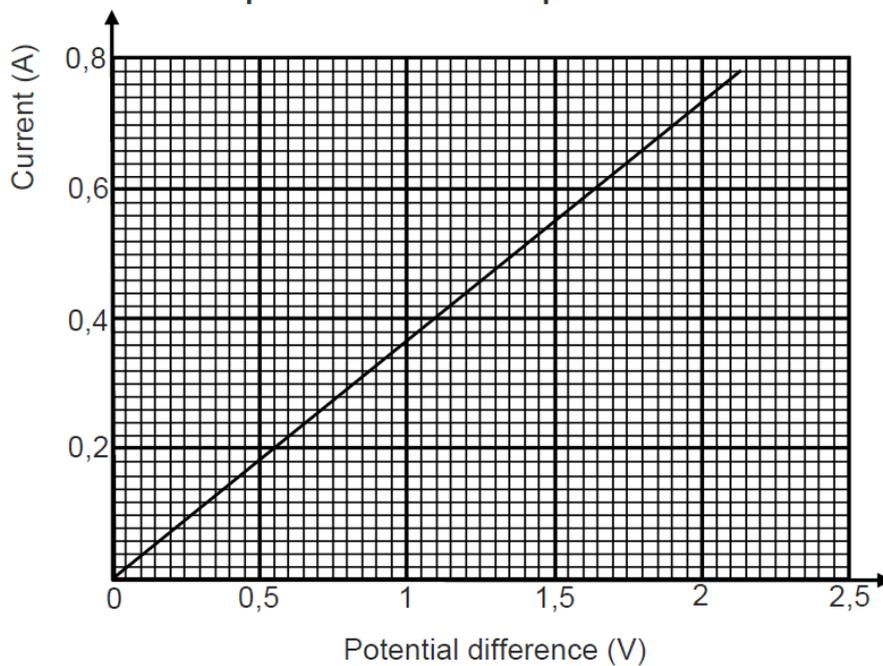
(Adapted from DBE Feb 2012, Paper 1, Question 9)

The circuit represented below is used to investigate the relationship between the current passing through and the potential difference across resistor **P**.



The results obtained are used to draw the graph below

Graph of current versus potential difference

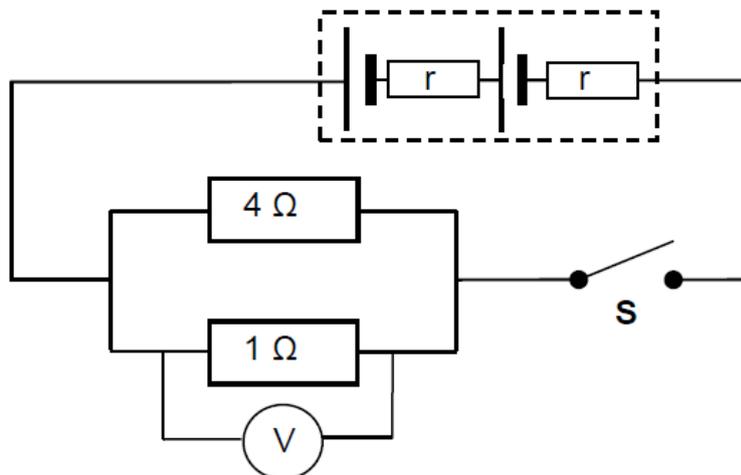


- 1.1. Write down the independent variable. (1)
 - 1.2. Write down the variable that must be controlled. (1)
 - 1.3. Write down the conclusion that can be obtained from the graph (2)
 - 1.4. Using the gradient of the graph, calculate the resistance of resistor P (4)
- [8]**

Question 2

(Adapted from February/March 2014, Paper 1, Question 9)

Two identical cells, EACH with an emf of 1,5 V and an internal resistance r , are connected in series with each other and to the resistors as shown below.



- 2.1. Define, in words, the term *electromotive force* (emf). (2)
- 2.2. Write down the total emf of the circuit. (1)

When switch **S** is closed, the potential difference across the $4\ \Omega$ resistor is $2,8\ \text{V}$.

2.3. Calculate the total current in the circuit. (5)

2.4. Calculate the internal resistance r of EACH cell (5)

2.5. An unknown resistor is now connected in parallel with the $4\ \Omega$ and $1\ \Omega$ resistors. How will this change affect the magnitude of :

2.5.1. The internal resistance of the battery, Write down only INCREASES, DECREASES or REMAINS THE SAME. (1)

2.5.2. The reading on the voltmeter, Write down INCREASES, DECREASES or REMAINS THE SAME. Explain the answer by referring to resistance, current and 'lost volts'. (4)

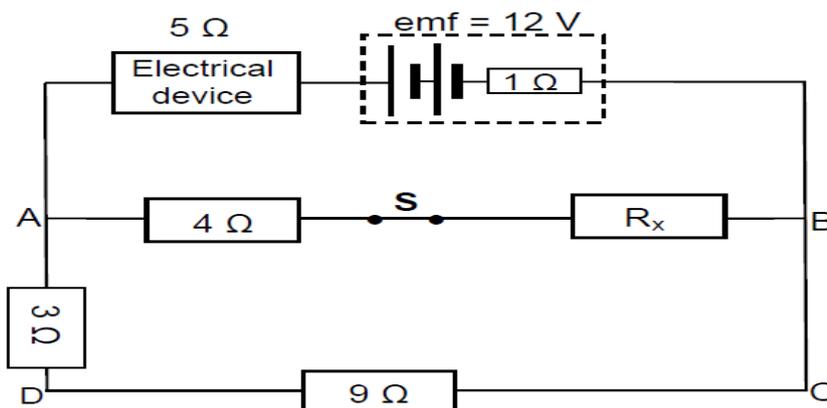
[18]

Question 3

(Adapted from November 2013, Paper 1, Question 9)

A learner wants to use a $12\ \text{V}$ battery with an internal resistance of $1\ \Omega$ to operate an electrical device. He uses the circuit below to obtain the desired potential difference for the device to function. The resistance of the device is $5\ \Omega$.

When switch **S** is **closed** as shown, the device functions at its maximum power of $5\ \text{W}$.



2.1. Explain, in words, the meaning of an emf of $12\ \text{V}$. (2)

2.2. Calculate the current that passes through the electrical device. (3)

2.3. Calculate the resistance of resistor R_x . (7)

2.4. Switch **S** is now **opened**. Will the device still function at maximum power? Write down YES or NO. Explain the answer without doing any calculations. (4)

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Question 4

A top loader washing machine operates at a potential difference of $240\ \text{V}$ and a current of $9,5\ \text{A}$. It takes a learner $1,5\ \text{hrs}$ to wash completely was a $6\ \text{kg}$ load of heavily soiled laundry. Eskom charges energy usage at $\text{R}1,65$ per $\text{kW}\cdot\text{h}$.

3.1. What does $\text{kW}\cdot\text{h}$ represents (1)

3.2. Calculate the cost of operating the hairdryer for the $1,5\ \text{hrs}$. ($1\ \text{unit} = 1\ \text{kW}\cdot\text{h}$) (6)

[7]



SOLUTIONS TO ELECTRIC CIRCUITS

Question 1

- 1.1 Potential difference
1.2 Temperature
1.3 The potential difference is directly proportional to the current
1.4 Gradient = $(\Delta I / \Delta V)^{-1}$
 $= (0.36 - 0.18 / 1 - 0.5)^{-1}$
 $= 2.77 \Omega$

Question 2

- 2.1 Emf is the amount of energy given to each coulomb of charge passing through the battery or the maximum ability of a cell to do work

2.2 3 V

2.3 $\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2}$

$$\frac{1}{R_p} = \frac{1}{4} + \frac{1}{1}$$

$$R_p = 0,8 \Omega$$

$$V = IR$$

$$2,8 = I(0,8)$$

$$I = 3,5 \text{ A}$$

2.4. Emf = $I(R + r)$

$$3 = 3,5(0,8 + 2r)$$

$$2r = 0,06 \Omega (0,057 \Omega)$$

$$r = 0,03 \Omega$$

2.5.1. Remains the same

2.5.2. Decreases, Total resistance decreases, Current (through battery) increases hence 'Lost volts' increases



Question 3.

3.1 12 J of energy are transferred to / work done on each coulomb (of charge) / per C passing through the battery

3.2. $P = I^2 R$

$$5 = I^2(5)$$

$$I = 1 \text{ A}$$

3.3 $\text{Emf} = I(R + r)$

$$12 = (1)(R_p + 5 + 1)$$

$$\therefore R_p = 6 \Omega$$

$$\frac{1}{R_p} = \frac{1}{R_{12}} + \frac{1}{R}$$

$$\frac{1}{6} = \frac{1}{12} + \frac{1}{4+R_x}$$

$$R_x = 8\Omega$$

3.4 No, Total resistance (R) increases, for a constant R, power ($P = I^2 R$) decreases

Question 4.

4.1. kW.h → to the use of 1 kilowatt of electricity for 1 hour

4.2 $W = VIt$

$$= 240 \times 9.5 \times 5400$$

$$= 12312000 \text{ J}$$

$$\text{Cost} = (12312000 \text{ J} / 3.6 \times 10^6) \times 1.65$$

$$= 5.643 \text{ thus R}5.64\text{c}$$