Training and Consultancy

The path to enlightened education

PHYSICAL SCIENCE

GRADE 12

AUTUMN CLASSES 2026

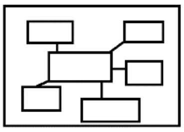
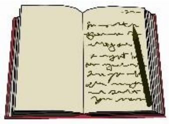
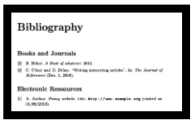
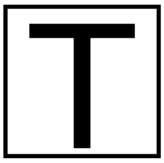
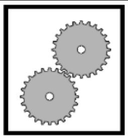
TEACHER AND LEARNER CONTENT MANUAL

Topics

Topic 1: Electrostatics

Topic 2: Electric circuits

ICON DESCRIPTION

 MIND MAP	 EXAMINATION GUIDELINE	 CONTENTS	 ACTIVITIES
 BIBLIOGRAPHY	 TERMINOLOGY	 WORKED EXAMPLES	 STEPS

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TOPIC 1: ELECTROSTATICS

EXAMINATION GUIDELINES

Electrostatics
(This section must be read in conjunction with the CAPS, p. 84–85.)

Coulomb's law

- State Coulomb's law: The magnitude of the electrostatic force exerted by one point charge (Q_1) on another point charge (Q_2) is directly proportional to the product of the magnitudes of the charges and inversely proportional to the square of the distance (r) between them:
- Solve problems using the equation $F = \frac{kQ_1Q_2}{r^2}$ for charges in one dimension (1D) (restrict to three charges).
- Solve problems using the equation $F = \frac{kQ_1Q_2}{r^2}$ for charges in two dimensions (2D) – for three charges in a right-angled formation (limit to charges at the 'vertices of a right-angled triangle').

Electric field

- Describe an *electric field* as a region of space in which an electric charge experiences a force. The direction of the electric field at a point is the direction that a positive test charge would move if placed at that point.
- Draw electric field lines for the following configurations:
    - o A single point charge
    - o Two point charges (one negative, one positive OR both positive OR both negative)
    - o A charged sphere

  NOTE: Restrict to situations in which the charges are identical in magnitude.
- Define *electric field at a point*: The electric field at a point is the electrostatic force experienced per unit positive charge placed at that point. In symbols: $E = \frac{F}{q}$
- Solve problems using the equation $E = \frac{F}{q}$.
- Calculate the electric field at a point due to a number of point charges, using the equation $E = \frac{kQ}{r^2}$ to determine the contribution to the field due to each charge. Restrict to three charges in a straight line.

TERMS AND DEFINITIONS

T

1. Coulomb's law: states that the magnitude of the electrostatic force exerted by one point charge (Q1) on another point charge (Q2) is directly proportional to the product of the magnitudes of the charges and inversely proportional to the square of the distance (r) between them.

2. Electric field: is a region of space in which an electric charge experiences a force.

The direction of the electric field at a point is the direction that a positive test charge would move if placed at that point.

3. **Electric field at a point**: is the electrostatic force experienced per unit positive charge placed at that point.

IMPORTANT CONCEPTS

1. THE NATURE OF CHARGES:

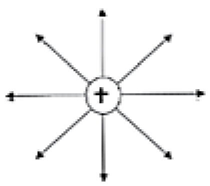
- There are two types of charges, the **positive charge** and the **negative charge**.
- Charges are measured in Coulombs (C);
- Other units used are :
  - micro-Coulombs:1μC = 1 x 10^{-6}C;
  - nano-Coulombs: 1nc = 1 x 10^{-9}C;
  - pico-Coulombs: 1pc = 1 x 10^{-12}C.

2. ELECTRIC FIELD PATTERNS AROUND CHARGES

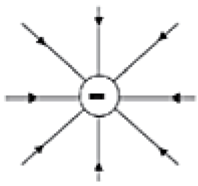
- Electric fields are represented by field lines as illustrated in the diagrams below.
- Electric field is a vector quantity.
- An electric field line indicates the direction in which a positive test charge would move if placed at a point in the electric field.

  PROPERTIES OF ELECTRIC FIELD LINES: electric field lines**:**
  - start and end perpendicular to the surface of a charged object;
  - never cross each other;
  - are closer where the electric field is stronger;
  - are directed from positive to negative.

Around a positive charge

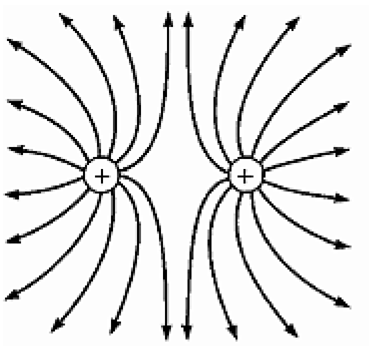


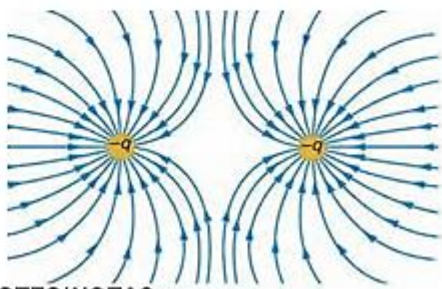
Around a negative charge



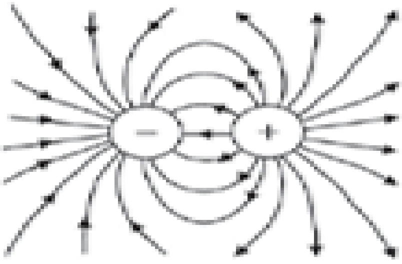
Around two positive charges

Around two negative charges





Between two unlike (opposite) point charges: one positive and the other negative)



3. QUANTISATION OF CHARGE:

The **principle of conservation of charge** states that charge can neither be created nor be destroyed but can be transferred from one object to another. When two spheres are brought into contact, electrons are transferred from the more negative sphere to the less negative sphere.

CLASS ACTIVITY 1

consider two spheres, **A** and **B**, of charges +5µC and -11µC respectively,

are brought into contact and then separated.

1.1 Will electrons be transferred from **A** to **B** or from **B** to **A**? (1)

1.2 Calculate the:

  1.2.1 the net charge (Q_{net}) after separation of the spheres. (2)

  1.2.2 the number of electrons transferred. (3)

CLASS ACTIVITY 2

Sphere P has a charge of -7.5nc. Electrons are added or removed from sphere P to give it a final charge of +4.3nC.

2.1 Were electrons added or removed from sphere **P**? Explain your answer. (2)

2.2 Calculate the number of electrons added or removed from sphere **P**. (3)

3. ELECTROSTATIC FORCE (F/F_e):

Coulomb's law: states that the electrostatic force that one point charge exerts on another point charge is directly proportional to the product of the magnitude of the charges and inversely proportional to the square of the distance between them.

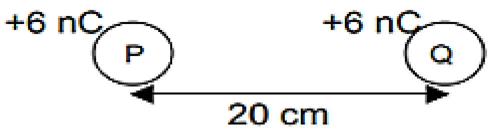
According to Coulomb's law:

$$F = \frac{kQ_1 \; Q_2}{r^2}$$

Where: Q_1 and Q_2 = magnitudes of charges in Coulombs (C);
k = Coulomb's constant ($k = 9 \times 10^9$);
r = distance between the two charges in metres (m).

CLASS ACTIVITY 3

The diagram below shows two identical insulated metal spheres. Spheres **P** and **Q** each carry a charge of 6 nC**.**



3.1 Define Coulomb's Law in words. (2)

3.2 Draw the electric field pattern due to the two spheres **P** and **Q**. (3)

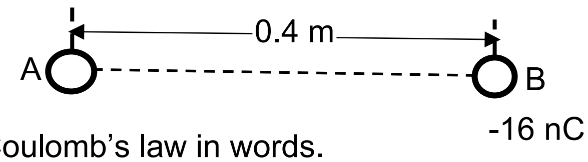
3.3 Calculate the magnitude of the electrostatic force between spheres **P** and **Q**. (4)

NOTE:

- Sphere P exerts an electrostatic force of 8.1×10^{-6}N on sphere Q;
- Sphere **Q** exerts an electrostatic force of same magnitude (8.1×10^{-6}N) on sphere **P**;
- This is according to Newton's Third Law of motion.

CLASS ACTIVITY 4

Two identical spheres, **A** and **B**, both negatively charged, are placed 0.4m apart in a vacuum. The charge on sphere **B** is -16nC. The magnitude of the electrostatic force that one sphere exerts on the other is 7.2×10^{-6}N**.**



4.1 State Coulomb's law in words. (2)

4.2 Calculate the charge on sphere **A**. (3)

4. NET FORCE (F_{net}): is the sum of all the forces acting on an object.

If there are more than two charges involved, a free-body diagram has to be drawn in order to calculate the net force or net electric field.

TIPS ON DRAWING OF FREE-BODY DIAGRAMS: [For electrostatic forces

and electric field]

Rule 1: Identify the object and represent it as a dot in the diagram. Only the object can move.

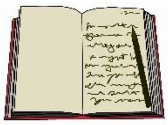
Rule 2: Consider the object and one other sphere.

Remember: (1) objects with unlike charges attract each other and the identified object will move towards the sphere. This movement toward the sphere represents a force or electric field.

(2) objects with like charges will repel each other and the identified object will move away from the sphere. This movement away from the sphere represents a force or electric field.

Rule 3: Consider the object and the second sphere and repeat rule 2.

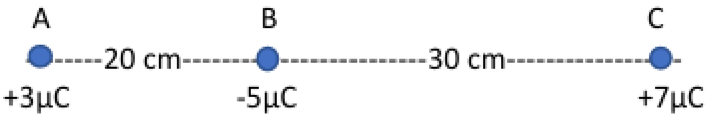
NOTE: Forces and electric fields will go in the same direction.



CLASS ACTIVITY 5

Spheres **A**, **B** and **C**, with magnitudes +3µC, -5µC and +7µC, are placed along

a straight line as shown in the diagram below.



5.1 Draw a labelled free body diagram showing ALL the forces acting on sphere **B** due to the presence of spheres **A** and **C**. (2)

5.2 Calculate the net electrostatic force experienced by sphere B due to the presence of spheres **A** and **C**. (5)

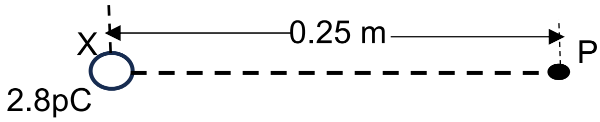
5. ELECTRIC FIELD AT A POINT: is the electrostatic force experienced per unit positive charge placed at that point.

Thus: $E = \frac{kQ}{r^2}$ and $E = \frac{F}{q}$

CLASS ACTIVITY 6

P is a point that is 0.25 m from a point charge X with a magnitude of -2.8pC

as shown in the diagram below.



Calculate the electric field at point P. (3)

7. NET ELECTRIC FIELD (E_{net}): is the sum of all the electric fields acting at a point or on a charge.

- To calculate the net electric field at a point, a free-body has to be drawn.
- The free-body diagram is drawn the same way a free-body is drawn for the net electrostatic force.

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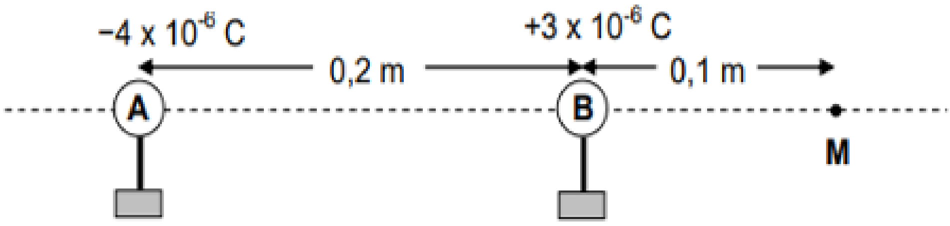
CLASS ACTIVITY 7

Two small charged spheres, **A** and **B**, are placed on insulated stands, 0,2 m

apart, as shown in the diagram below. They carry charges of -4×10^{-6} C and $+3 \times 10^{-6}$ C respectively.



M is a point that is a distance of 0,1 m to the right of sphere **B**.

7.1 Calculate the number of electrons in excess on sphere **A**. (3)

7.2 Calculate the magnitude of the electrostatic force exerted by sphere **A** on sphere **B**. (3)

7.3 Describe the term electric field. (2)

7.4 Calculate the magnitude of the net electric field at point **M**. (5)

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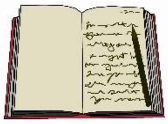
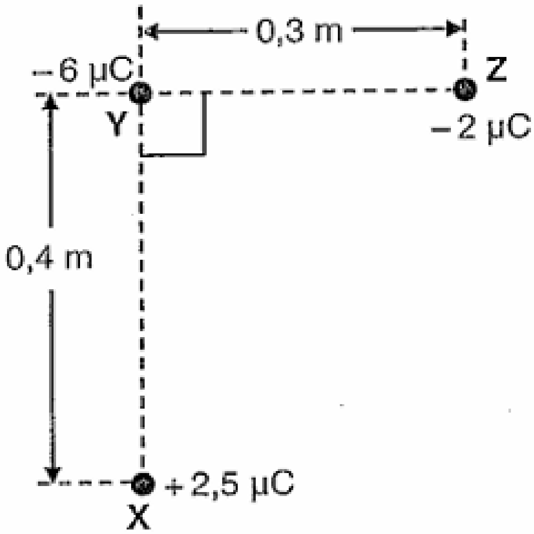
PROBLEMS IN TWO DIMENSIONS

CLASS ACTIVITY 8



Three charged spheres **X**, **Y** and **Z** are placed perpendicular to each other, as

shown in the diagram below.



8.1 State Coulomb's law in words. (2)

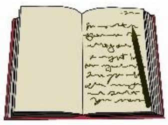
8.2 Draw a labelled free-body diagram showing all the forces acting on sphere **Y** due to the presence of spheres **X** and **Z**. And show the direction of the net force. (3)

8.3 Calculate the net force experienced by sphere **Y** due to the presence of spheres **X** and **Z**. (5)

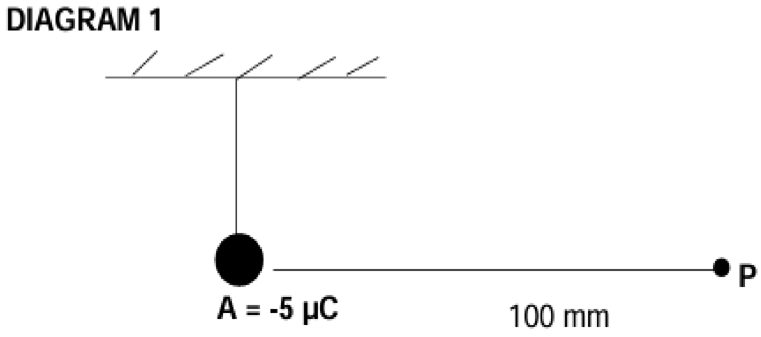
[10]

PROBLEMS INVOLVING TENSION

CLASS ACTIVITY 9



9.1 A small sphere **A** carrying a charge of -5 μC hangs vertically from a ceiling by means of an inextensible string. Point **P** is 100 mm to the right of sphere **A** as shown on the Diagram 1 below.

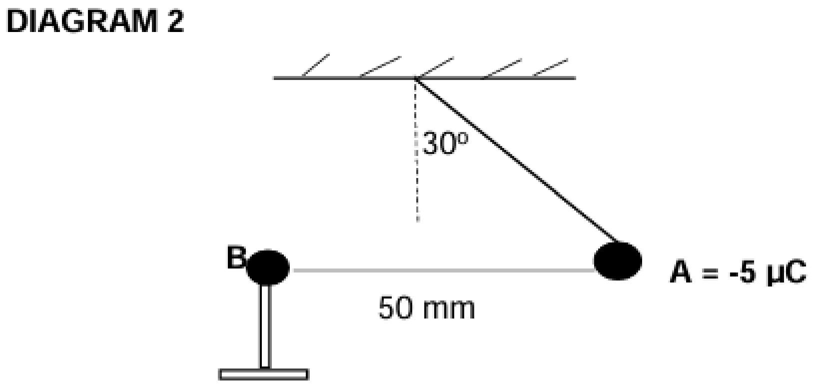


9.1.1 Did charged sphere **A** LOSE or GAIN electrons to acquire a charge of -5 μC? (1)

9.1.2 Calculate the number of electrons lost or gained by charged sphere **A**, to acquire a charge of -5 μC. (3)

9.1.3 Calculate the electric field at point **P**, due to charged sphere **A**. (5)

9.2 An identical sphere **B** carrying an unknown charge placed on an insulated stand is brought closer to sphere **A**. Charged sphere A swings to the right and comes to rest so that the string makes an angle of 30° with the vertical and the tension in the string is 25 N. The distance between the two charged spheres is 50 mm as shown on **Diagram 2** below.



9.2.1 Is the charge on sphere B POSITIVE or NEGATIVE? Give a reason for your answer. (2)

9.2.2 Calculate the magnitude of the charge on sphere **B**. (6)

[17]

STRUCTURED EXAM QUESTIONS

QUESTION 1

1.1 A small neutral sphere acquires a charge of -1,95 x 10^{-6} C.

1.1.1 Were electrons ADDED TO or REMOVED FROM the sphere? (1)

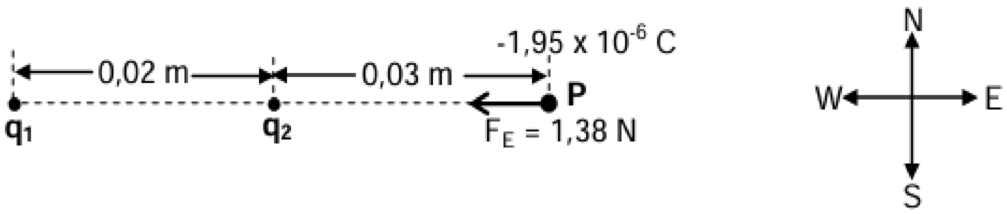
1.1.2 Calculate the number of electrons which were added or removed. (3)

1.1.3 Define the term electric field at a point. (2)

1.1.4 Calculate the magnitude of the electric field at a point 0,5 m from the centre of the charged sphere. (3)

1.3 Two point charges, $\mathbf{q_1}$ and $\mathbf{q_2}$, are fixed 0,02 m apart. The magnitude of charges $\mathbf{q_1}$ and $\mathbf{q_2}$ is the same and $\mathbf{q_1}$ is NEGATIVELY charged.

The small charged sphere with the charge of -1,95 x 10^{-6} C is placed at point **P**, 0,03 m east of charge $\mathbf{q_2}$, as shown in the diagram below. The sphere at point **P** experiences a net electrostatic force of 1,38 N west.

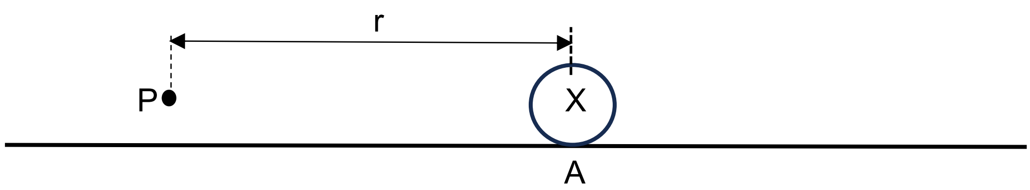


Calculate the magnitude of the charge on $\mathbf{q_2}$. (5)

[14]

QUESTION 2

A sphere **X** is placed at a point **A** on a horizontal surface. **X** carries a charge of +3x10^{-7} C. Point **P** is **r** metres to the left of point **A**.



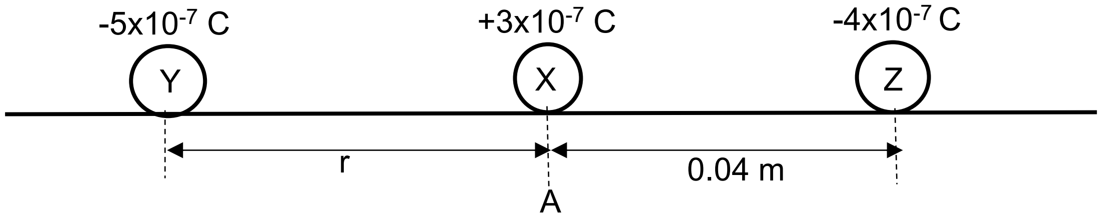
The magnitude of the electric field at point P is 1.08x10^{6} N.C^{-1}.

2.1 Describe an electric field. (2)

2.2 Draw the electric field pattern due to the charge on sphere **X**. (2)

2.3 Show, by means of a calculation, that r = 0.05 m. (3)

Sphere **Y**, carrying a charge of -5×10^{-7} C, is now fixed at point P and sphere **Z**, carrying a charge of -4×10^{-7} C, is fixed 0.04 m to the right of sphere **X**.



2.4 The NET FORCE acting on sphere X is 0.0427 N at point A.

Is the surface frictionless? Choose from YES or NO. Explain the answer by means of a calculation. (6)

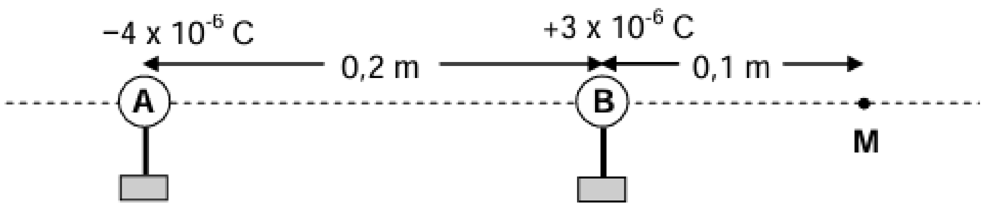
2.5 Sphere Y is brought into contact with sphere **X**, and is placed back in its original position.

How will the magnitude of the force that sphere **X** now exerts on sphere **Y** be affected? Choose from INCREASES, DECREASES or REMAINS THE SAME. (2)

[15]

QUESTION 3

Two small, charged spheres, **A** and **B**, are placed on insulated stands, 0,2 m apart, as shown in the diagram below. They carry charges of -4×10^{-6} C and $+3 \times 10^{-6}$ C respectively.



M is a point that is a distance of 0,1 m to the right of sphere **B**.

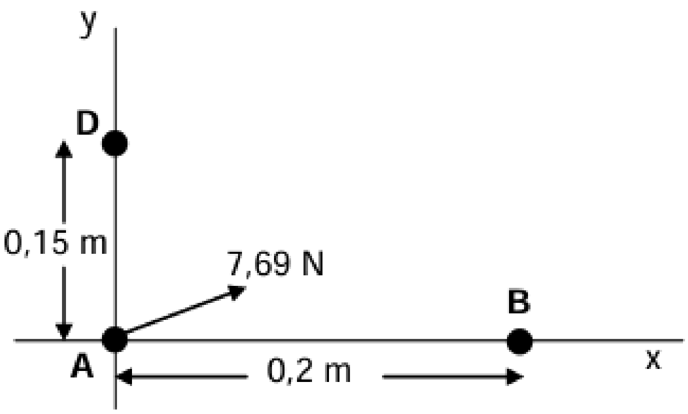
3.1 Calculate the number of electrons in excess on sphere **A**. (3)

3.2 Calculate the magnitude of the electrostatic force exerted by sphere **A** on sphere **B**. (3)

3.3 Describe the term electric field. (2)

3.4 Calculate the magnitude of the net electric field at point **M**. (5)

Charged spheres **A** and **B** and another charged sphere **D** are now arranged along a rectangular system of axes, as shown in the diagram below.



The net electrostatic force experienced by sphere **A** is 7,69 N in the direction as shown in the diagram above.

3.5 Is the charge on sphere **D** POSITIVE or NEGATIVE? (1)

3.6 Calculate the magnitude of the charge on sphere **D**. (3)

[17]

QUESTION 4

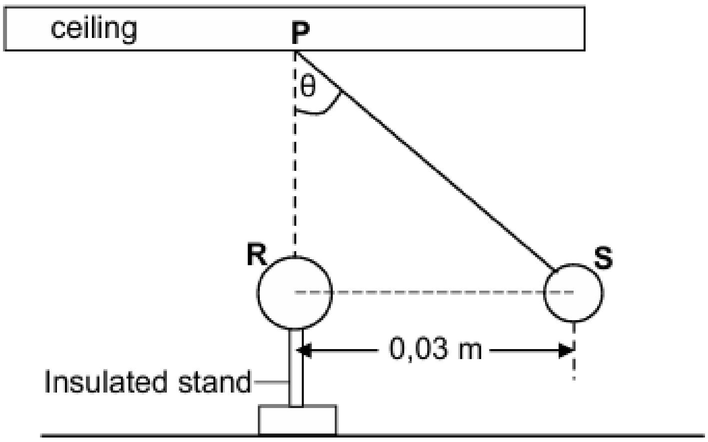
4.1 A small negative charge q placed at a fixed distance from charged sphere **Q**, experiences a force **F**, as shown in the diagram below.

The charge q is now removed.

Draw the electric field pattern for the charged sphere **Q**. (3)

4.2 Sphere **S** is attached to the ceiling at point **P** by a light inextensible string. When sphere **R**, on an insulated stand, is brought close to sphere S they repel and sphere **S** comes to rest with the horizontal distance between the centres of the spheres equal to 0,03 m.

Sphere **R** is directly below point **P**. The string makes an angle θ with the vertical, as shown in the diagram below.



4.2.1 State Coulomb's law in words. (2)

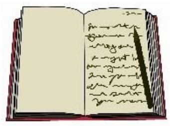
4.2.2 Draw a labelled free-body diagram showing ALL the forces acting on sphere **S** when it is at rest. (3)

Sphere **R** has a charge of +6 nC. Sphere S has a charge +3 nC and a mass of 0,15 g.

4.2.3 Calculate angle θ. (5)

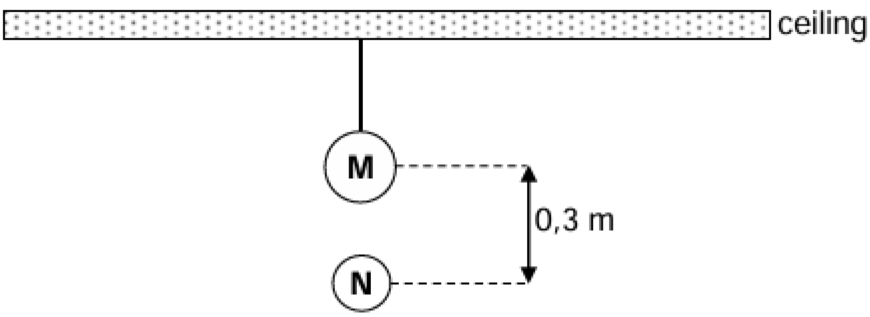
[13]

QUESTION 5



A charged sphere **M** is suspended from a ceiling by a light inextensible, insulated string.

Another charged sphere **N**, of mass $2,04 \times 10^{-3}$ kg and carrying a charge of + $8,6 \times 10^{-8}$ C, hangs STATIONARY vertically below sphere M. The centres of the spheres are 0,3 m apart, as shown in the diagram below.



5.1 State Coulomb's law in words.
(2)

5.2 State whether the charge on sphere **M** is POSITIVE or NEGATIVE. (1)

5.3 Draw a labelled free-body diagram for sphere **N**. (2)

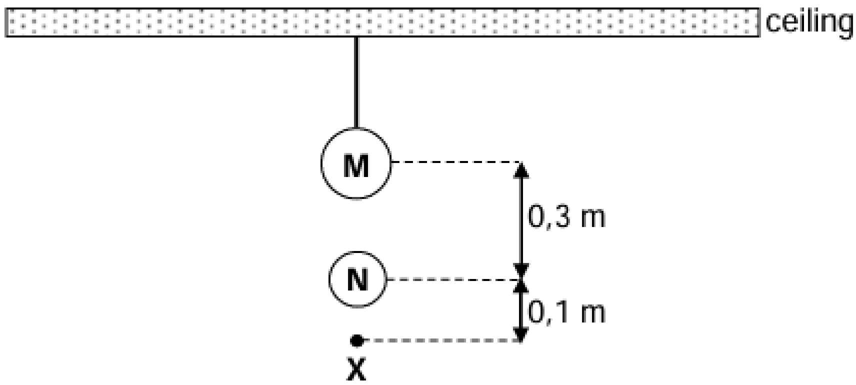
5.4 Calculate the magnitude of the charge on sphere **M**. (5)

5.5 How does the electrostatic force that sphere **M** exerts on sphere **N** compare to that exerted by sphere **N** on sphere **M** with respect to:

5.5.1 Magnitude. (1)

5.5.2 Direction. (1)

Point **X** is 0,1 m vertically below the centre of sphere **N**, as shown below.



5.6 Calculate the net electric field at point **X**. (5)

[17]

TOPIC 2: ELECTRIC CIRCUITS

EXAMINATION GUIDELINES

Electric Circuits (This section must be read in conjunction with the CAPS, p. 88–89 & 121.)

Ohm's law

- State Ohm's law in words: The potential difference across a conductor is directly proportional to the current in the conductor at constant temperature.
- Determine the relationship between current, potential difference and resistance at constant temperature using a simple circuit.
- State the difference between ohmic conductors and non-ohmic conductors and give an example of each.
- Solve problems using $R = \frac{V}{I}$ for series and parallel circuits (maximum four resistors).

Power, energy

- Define *power* as the rate at which work is done.
- Solve problems using $P = \frac{W}{\Delta t}$.
- Solve problems using $P = VI$, $P = I^2R$ or $P = \frac{V^2}{R}$.
- Solve circuit problems involving the concepts of power and electrical energy.
- Deduce that the kilowatt hour (kWh) refers to the use of 1 kilowatt of electricity for 1 hour.
- Calculate the cost of electricity usage given the power specifications of the appliances used, the duration and the cost of 1 kWh.

Internal resistance, series and parallel networks

- Solve problems involving current, voltage and resistance for circuits containing arrangements of resistors in series and in parallel (maximum four resistors excluding internal resistance).
- Define the term *emf* as the maximum energy provided by a battery per unit charge passing through it.
- Solve circuit problems using $\varepsilon = V_{load} + V_{internal\ resistance}$ or $\varepsilon = IR_{ext} + Ir$.
- Solve circuit problems, with internal resistance, involving series-parallel networks of resistors (maximum four resistors).

REVISION OF GRADE 11 WORK

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INTRODUCTION

The study of electrical circuits is essential to understand the technology that uses electricity in the real-world. We depend on electricity and electrical appliances to make many things possible in our daily lives. This becomes very clear when there is a power failure and we can’t use the kettle to boil water for tea or coffee, can’t use the stove or oven to cook dinner, can’t charge our cellphone batteries, watch TV, or use electric lights.

FUNDAMENTAL QUANTITIES IN ELECTRIC CIRCUITS

Three quantities which are fundamental to electric circuits are current, voltage (potential difference) and resistance.

1. Electrical current (I): is defined as the rate of flow of charge through a circuit.

Thus : $I = \frac{Q}{\Delta t}$ Where : Q = amount of charge in Coulombs (C);

Δt = time in seconds.

Electrical current is measured in **amperes** (A) using an **ammeter**.

2. Potential difference or voltage (V): is the amount of energy per unit charge needed to move that charge between two points in a circuit.

Thus : $V = \frac{W}{Q}$ Where : W = amount of energy in joules (J);

Q = amount of charge in Coulombs (C).

Potential difference or voltage is measured in **volts** (V) using a **voltmeter**.

3. Resistance (R): is a measure of how 'hard' it is to push current through a circuit element.

OR: Resistance is the opposition to the flow of current.

Resistance is measured in **ohms** (Ω).

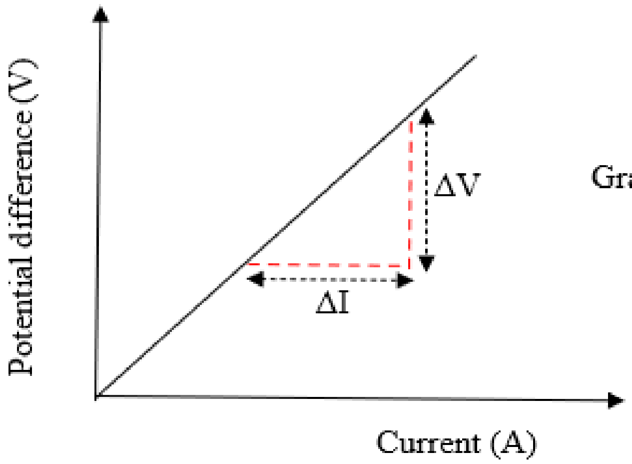
Factors affecting the resistance of a conductor

- **The length of the resistor:** the longer the wire, the greater the resistance;
- **The diameter (thickness) of the resistor**: the thinner the wire, the greater the resistance;
- **The temperature of the resistor:** the higher the temperature, the greater the resistance;
- **The type of material that the resistor is made from.** Different substances have different resistances, e.g. tungsten (W) has a very high resistance but copper (Cu) has a very low resistance.

OHM'S LAW: states that the potential difference across a conductor is directly proportional to the current in the conductor provided the temperature remains the same.

Mathematically : $V = IR$ or $R = \frac{V}{I}$ or $I = \frac{V}{R}$

Graphically :



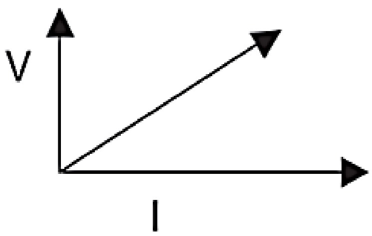
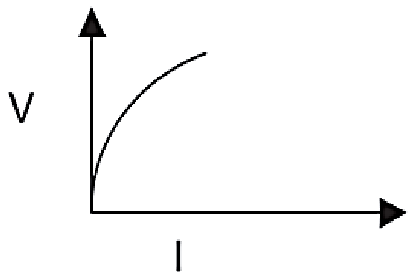
$$\text{Gradient} = \frac{\Delta V}{\Delta I} = R$$

NOTE: The gradient of the straight-line graph is related to the resistance of the conductor.

Ohmic conductors: are those conductors that obey Ohm's law.

Non-ohmic conductors: are those conductors that do not obey Ohm's law.

The table below shows a comparison of Ohmic and non-ohmic conductors.

	Ohmic conductor	Non-ohmic conductor
Obeys Ohm's Law or not?	Obeys Ohm's Law when voltage or current is varied	Does not obeys Ohm's Law when voltage or current is varied
Graph of the voltage vs. the current across conductors	 Shape: Straight line from the origin $V / I = R$	 Shape: Curve $V / I \neq R$
Examples	circuit resistors nichrome wire.	light bulb diodes transistors

VERIFYING OHM'S LAW

The following experiment can be carried out to investigate the relationship between current, potential difference(voltage) and resistance.

INVESTIGATIVE QUESTION: What is the relationship between the current and the potential difference in a conductor when temperature is constant?

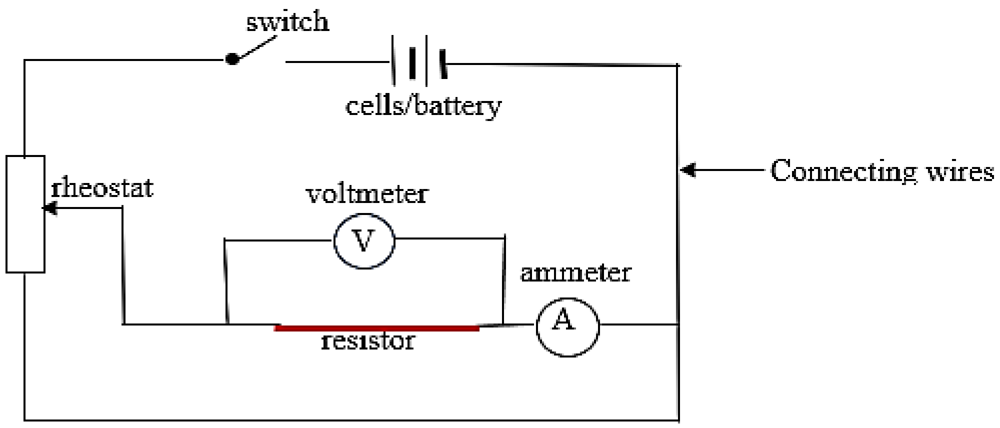
HYPOTHESIS: The potential difference in a conductor is directly proportional to the current in the conductor provided the temperature remains the same.

VARIABLES INVOLVED: **Independent variable**: current in the resistor;
Dependent variable: potential difference or voltage;
Controlled variable: temperature.

APPARATUS: voltmeter, ammeter, variable resistor or rheostat, batteries or cells, switch and connecting wires.

METHOD:

Step 1: connect the apparatus as shown in the diagram below.



Step 2: take current and voltmeter readings. Record the results in a table.

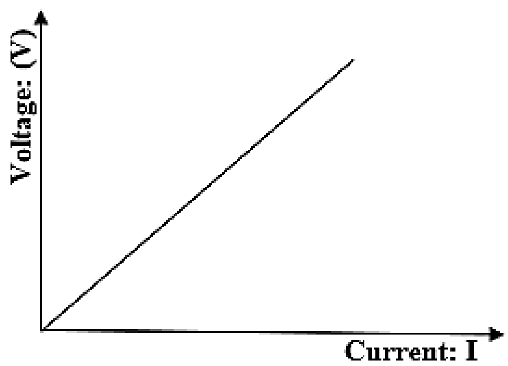
Step 3: To obtain a new pair of readings adjust the rheostat to change the current in the resistor and voltage across it. Switch off the circuit between readings so as to allow the resistor to remain at room temperature.

Step 4: Obtain at least seven pairs of readings over a wide range of current as possible.

Table of values

Current (I) (A)	Voltage (V) (V)	$\frac{V}{I}$ ($V.A^{-1}$)
0.05	0.3	6.0
0.10	5.9	5.9
0.15	0.9	6.0
0.20	1.2	6.0
0.30	1.9	6.3
0.40	2.3	5.8
0.45	2.6	5.8

Graph of voltage versus current



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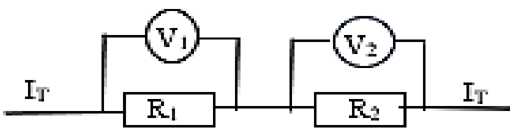
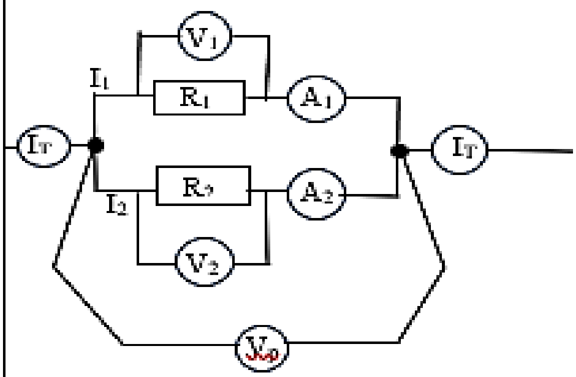
RESISTORS IN SERIES AND PARALLEL CONNECTIONS COMPARED

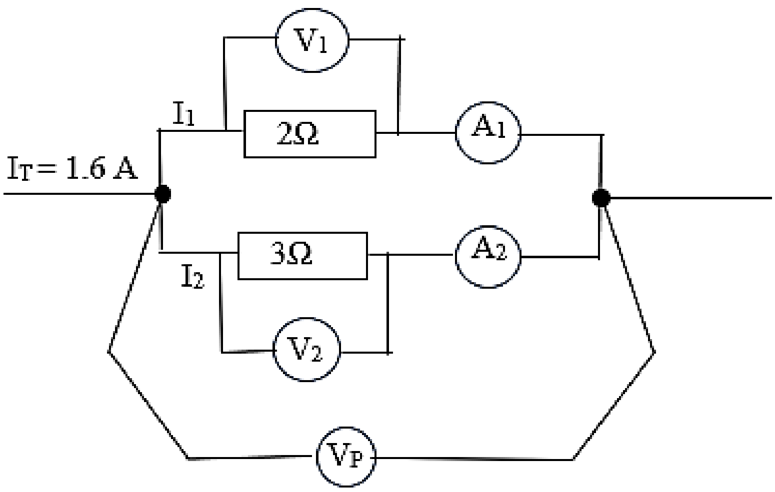
SERIES CONNECTIONS	PARALLEL CONNECTIONS
	
1. The total current across the series connection is the same. $I_T = I_1 = I_2$ ………………	1. The total current in parallel connections is shared by resistors in parallel according to the ratio of their resistances. $I_T = I_1 + I_2 +$ …………… Resistors in parallel are a current divider.
2. Total voltage in series connection is shared by resistors according to the ratio of their resistances. $V_T = V_1 + V_2 +$ ………………… Resistors in series are a voltage divider.	2. The voltage in parallel connections remains the same. $V_P = V_1 = V_2 =$ …………………
3. The total resistance in series connection is the sum of all the resistors. $R_T = R_1 + R_2 +$ ……………	2. The reciprocal of the total resistance in parallel connections is equal to the total of the reciprocals of each resistor. $\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} +$ …………

CLASS ACTIVITY 1:

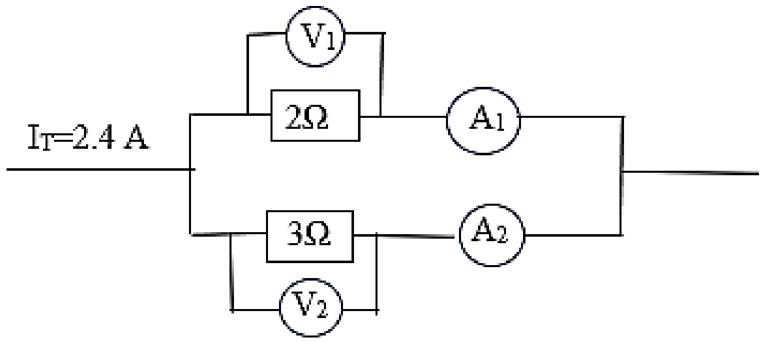
Consider the parallel connections below.

Calculate ALL the unknown values.

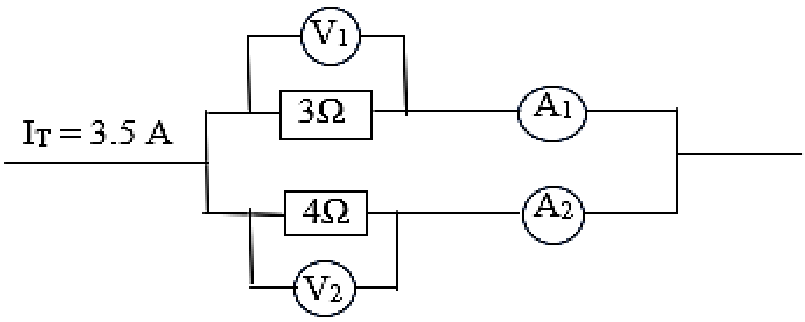
1.1



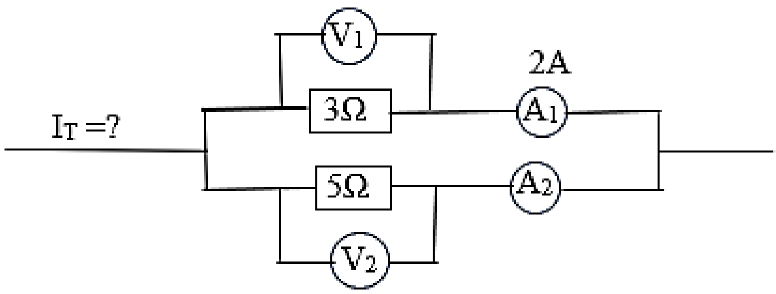
1.2



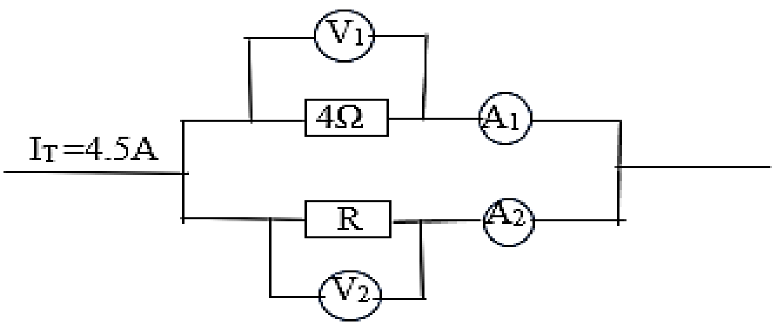
1.3



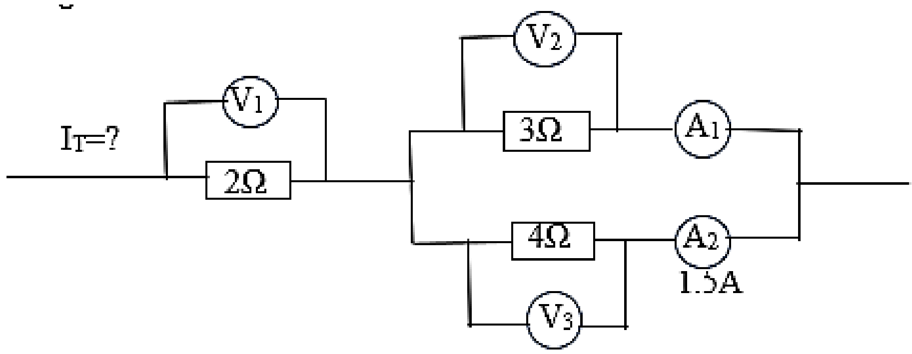
1.4 The reading on **A₁** is 2A.



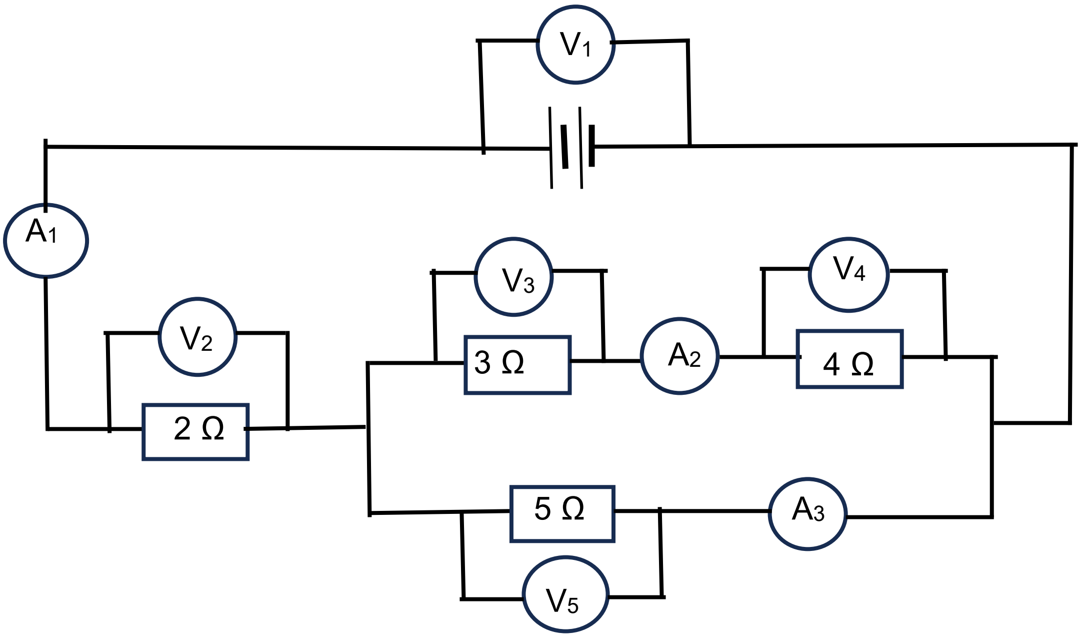
1.5 The reading on **A₁** is 2.5 A and the resistance of resistor **R** is unknown.



1.6 The reading on A_2 is 1.5 A



1.7 The reading on **A_2** is 2.5 A.



ELECTRICAL POWER: Electrical power is the rate at which electrical energy is converted in an electric circuit.
It is calculated as follows:

$P = \frac{W}{\Delta t}$	P = VI	$P = I^2 R$	$P = \frac{V^2}{R}$

Power is measured in **watts** (W).

ENERGY (W): is the ability to do work.
It is calculated as follow

W = Vq	W = VI Δ t	$W = I^2R\,\Delta t$	$W = \frac{V^2 \Delta t}{R}$

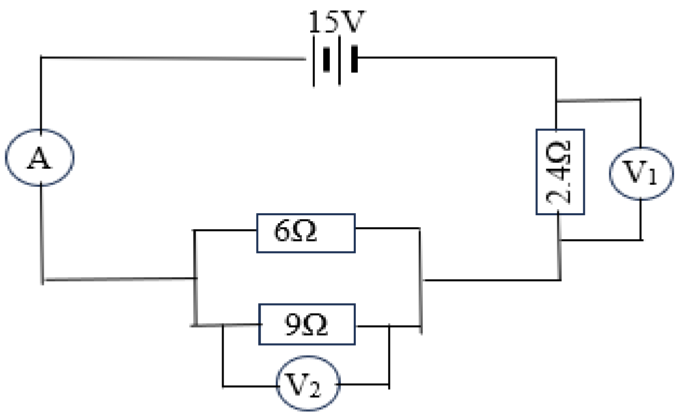
Energy is measured in **joules** (J).

COST OF USING ELECTRICITY: is calculated as follows:

Cost = Power(in kW) x Δt (in hours) x Unit price

CLASS ACTIVITIES

1. Refer to the diagram below.



1.1 Calculate the total resistance of the circuit. (3)

1.2 Calculate the reading on the ammeter. (3)

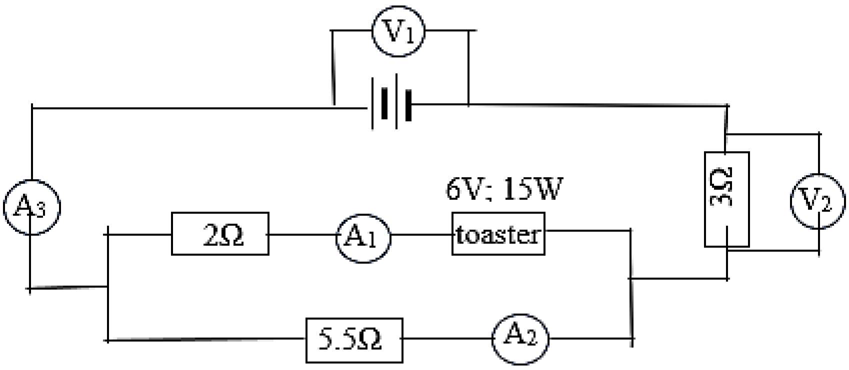
1.3 Calculate the reading on voltmeter V_1. (3)

1.4 Calculate the reading on voltmeter V_2. (3)

1.5 Calculate the current in the 9 Ω resistor. (3)

[15]

2. Refer to the circuit diagram below. The toaster is rated 6V; 15W.



2.1 Calculate the:

2.1.1 reading on the ammeter A_1. (3)

2.1.2 reading on the ammeter A_2. (4)

2.1.3 reading on the ammeter A_3. (3)

2.1.4 reading on the voltmeter V_2. (3)

2.1.5 reading on the voltmeter V_1. (3)

2.2 Calculate the energy dissipated in the 5.5Ω resistor in 5 minutes. (3)

2.3 Calculate the cost of using the toaster for 2 hours per day for 30 days if the unit cost of electricity is R1.50 per kWh. (3)

[22]

T

GRADE 12 WORK

1. **Electromotive force /emf** (ε): is the total amount of electric energy supplied by the cell to every coulomb of charge that passes through it.
   OR
   Electromotive force is the potential difference across the battery when there is no current flowing in the cicuits.
   Like potential difference, emf is also measured in **volts** (V).
2. **Internal resistance (r)**: is the small resistance inside the battery or amount of energy used up inside the cell or battery.
   The volts used up in the cell are referred to as the "**lost volts**" (V_{lost} / $V_{internal}$).
3. **FORMULA**

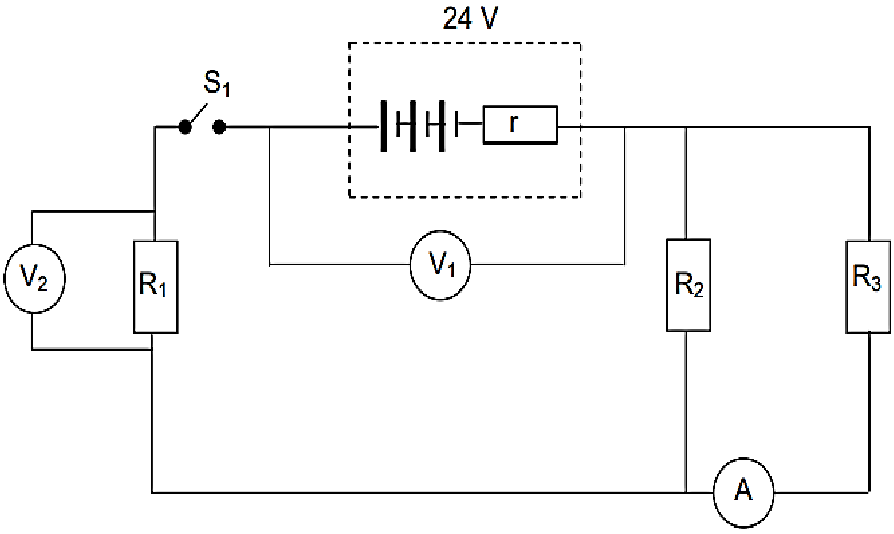
emf (ε) = $V_{ext.} + V_{int.}$
emf (ε)= $IR_{ext.} + Ir$
emf (ε) = $I(R + r)$

Where: I = total current in the circuit;
R = total resistance in the circuit;
r = internal resistance of the battery.

CLASS ACTIVITIES

ACTIVITY 1

An electric circuit is set up as shown in the diagram below. The resistance of the switch, ammeter and connecting wires are negligible. The voltmeters have a very high resistance.



The resistance of R_1 is 1,5 Ω, the resistance of R_2 is 10 Ω, while the resistance of R_3 is unknown.

When the switch is closed, the ammeter reads 1,2 A and the voltmeter V_2 reads 4,5 V.

1.1. Calculate the value of the resistance of R_3. (7)

1.2. Calculate the internal resistance, r, of the battery. (5)

1.3. R_3 is replaced with another resistor of greater resistance.

1.3.1 Will the reading on the voltmeter V_1 connected across the terminals of the battery **increase**, **decrease** or **remain the same**? (1)

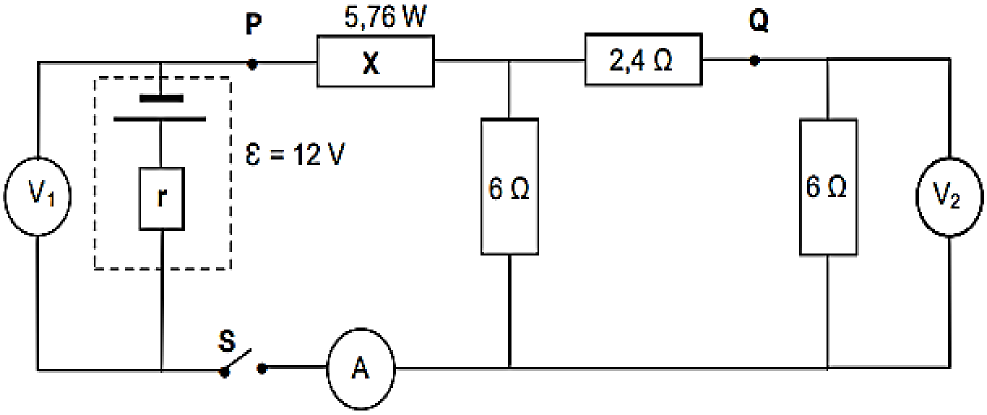
1.3.2. Explain the answer to question 1.1.3, making reference to relevant formulae. (4)

[17]

ACTIVITY 2

The battery in the circuit shown below has an emf of 12 V and an unknown internal resistance r.

The resistance of the connecting wires and the ammeter is negligible.



Switch **S** is **OPEN**.

2.1 Write down the reading on:

2.1.1 Voltmeter V_1. (1)

2.1.2 Voltmeter V_2. (1)

Switch **S** is now **CLOSED**.

The reading on the ammeter is 1,2 A and the power dissipated in resistor **X** is 5,76 W.

2.2 Define the term power. (2)

Calculate the:

2.3 Resistance of resistor **X**. (3)

2.4 Total EXTERNAL resistance of the circuit. (3)

2.5 Reading on voltmeter V_2. (5)

A length of wire of negligible resistance is used to connect point **P** to point **Q** in the circuit.

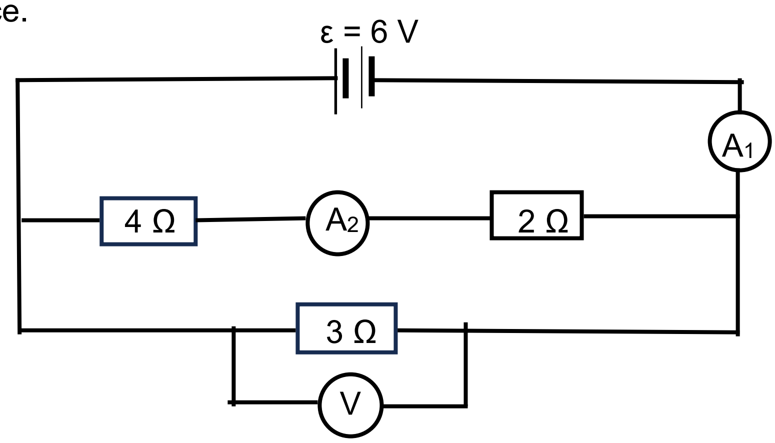
2.6 How will the reading on voltmeter V_1 be affected? Choose from **INCREASES**, **DECREASES** or **NO EFFECT**. Explain the answer. (4)

[19]

STRUCTURED EXAM QUESTIONS

QUESTION 1

In the circuit diagram below the battery has emf of 6 V and negligible internal resistance.



1.1 Calculate the:

1.1.1 Effective resistance in the circuit. (3)

1.1.2 Reading on ammeter $\mathbf{A_1}$. (3)

1.1.3 Reading on ammeter $\mathbf{A_2}$. (3)

1.1.4 Power dissipated by the 4 Ω resistor. (3)

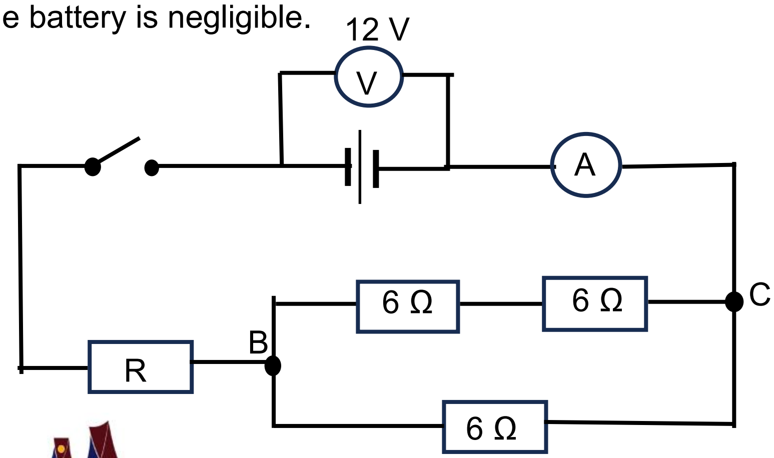
1.2 What is the reading on voltmeter **V**? No calculation is required. (1)

1.3 A kettle is rated 1 500 W. Calculate how much a learner will pay for electricity for using the kettle for 4 hours. Eskom charges 1 kWh electricity at R2,05. (4)

[17]

QUESTION 2

In the circuit diagram below the emf of the battery is 12 V. The internal resistance of the battery is negligible.



2.1 Define the term emf in words. (2)

2.2 Calculate the total effective resistance between **B** and **C**. (2)

2.3 When the switch is closed, the ammeter reads 2.75 A.

Calculate:

2.3.1 the resistance of resistor **R**. (4)

2.3.2 the current through the resistor 6 Ω in the bottom branch. (2)

A learner connects a conducting wire with negligible resistance directly between **B** and **C**.

2.4 How will the power dissipated by resistor **R** be affected?

Choose from INCREASES, DECREASES or REMAIN THE SAME.

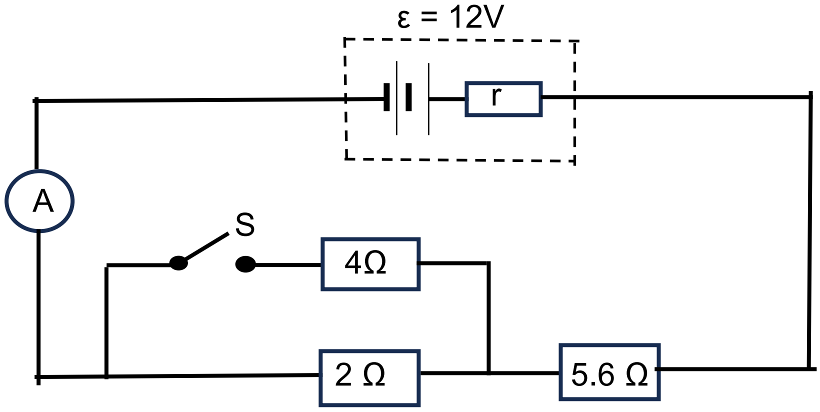
Explain your answer. (3)

[13]

QUESTION 3

The circuit diagram below represents a combination of resistors in series and parallel.

The battery has an emf of 12 V and an unknown internal resistance r.



With switch S **OPEN**, ammeter **A** gives a reading of 1.2 A.

Calculate the:

3.1 total resistance of the circuit. (3)

3.2 internal resistance of the battery. (3)

3.3 energy dissipated in the 2 Ω resistor in 180 seconds. (3)

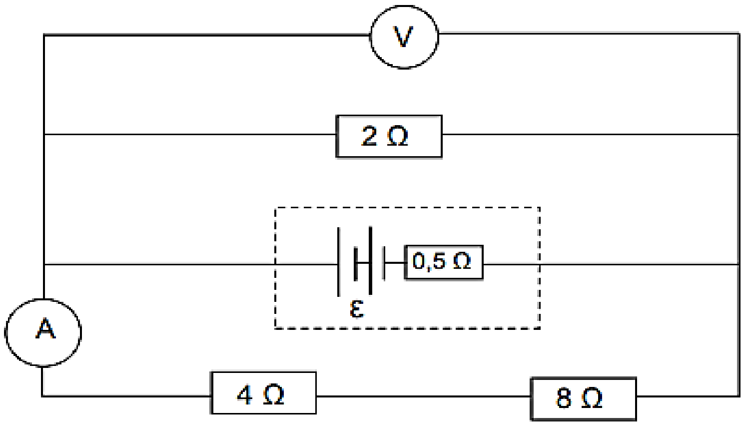
Switch **S** is now **CLOSED**.

3.4 Explain how the power dissipated by the 5.6 Ω resistor will change after the switch **S** is closed. (4)

[13]

QUESTION 4

A battery of an unknown emf and an internal resistance of 0,5 Ω is connected to three resistors, a high-resistance voltmeter and an ammeter of negligible resistance, as shown below.



The reading on the ammeter is 0,2 A.

4.1 Calculate the:

1.1.1 Reading on the voltmeter. (3)

1.1.2 Total current supplied by the battery. (4)

1.1.3 Emf of the battery. (5)

4.2 How would the voltmeter reading change if the 2 Ω resistor is removed from the circuit? Write down INCREASE, DECREASE or REMAIN THE SAME.

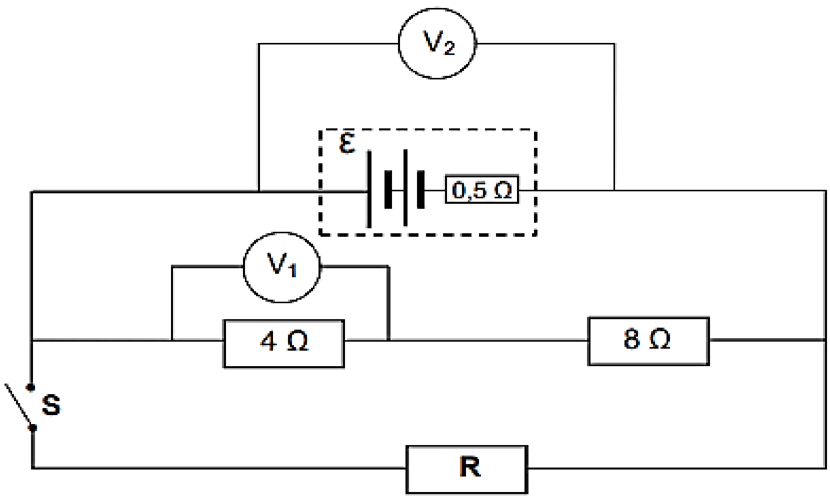
Explain the answer. (3)

[15]

QUESTION 5

In the circuit below a battery of UNKNOWN emf and an internal resistance of 0,5 Ω is connected to two resistors of 4 Ω and 8 Ω each, and a resistor **R** of unknown resistance.

Ignore the resistance of the connecting wires.



5.1 The three external resistors are ohmic conductors.
Explain the meaning of the term ohmic conductor. (2)

5.2 When switch S is **OPEN**, voltmeter $\mathbf{V_1}$ reads 3.2 V.
Calculate the:
5.2.1 Current through the battery. (3)
5.2.2 Emf of the battery. (4)

5.3 When switch **S** is **CLOSED**, voltmeter $\mathbf{V_2}$ reads 8.8 V.
5.3.1 Calculate the resistance of resistor **R**. (5)
5.3.2 The battery becomes heated when voltmeter $\mathbf{V_2}$ is replaced by a connecting wire. Explain this observation. (3)

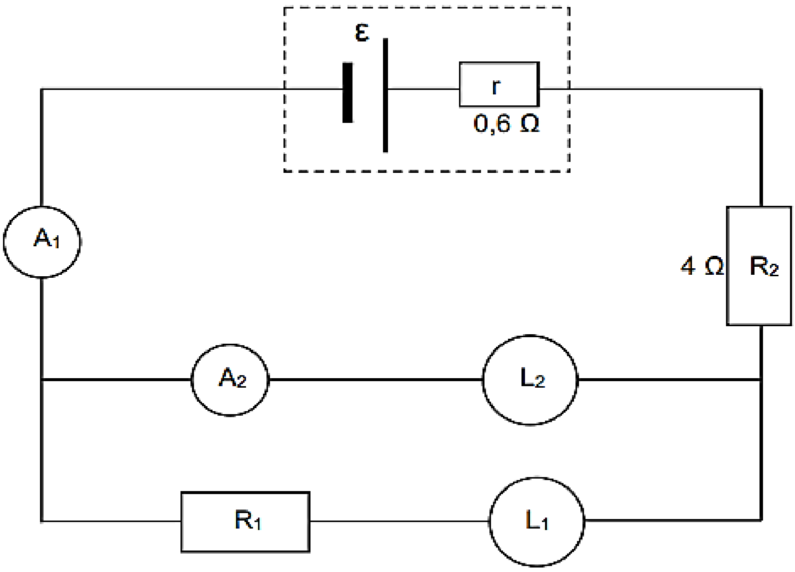
[17]

QUESTION 6

$\mathbf{L_1}$ and $\mathbf{L_2}$ are two light bulbs that have the following ratings:

L_1: 36 W; 20 V and L_2: 48 W; 32 V

The two bulbs are connected as shown in the circuit diagram below. The battery has an internal resistance of 0,6 Ω while the conducting wires and the ammeters have negligible resistance. $\mathbf{R_1}$ and $\mathbf{R_2}$ are resistors.

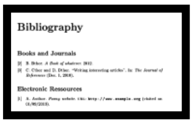


6.1 Define the term power. (2)

6.2 If both light bulbs operate as RATED, calculate the:
6.2.1 Reading on ammeter $\mathbf{A_2}$. (3)
6.2.2 Reading on ammeter $\mathbf{A_1}$. (3)
6.2.3 Resistance of resistor $\mathbf{R_1}$. (4)
6.2.4 Emf of the battery. (4)

6.3 Bulb $\mathbf{L_1}$ burns out after a while. Assume that the resistance of bulb $\mathbf{L_2}$ remains constant. Will bulb $\mathbf{L_2}$ continue to glow after bulb $\mathbf{L_1}$ burns out? Choose from YES or NO. Support your answer with a suitable calculation. (5)

[21]



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3	DBE Past examination papers:
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5	NOV. 2021 (G.12)
6	NOV. 2025 (G.12)
7	NOV.2020 (G.12)
8	JUNE 2025 (G.12)
9	NOV. 2022 (G.12)
10	EC. NOV. 2022 (G.11)
11	MP. JUNE 2025 (G.11)
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15	NOV. 2024 (G.12)