basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA



# PHYSICAL SCIENCES EASY TO SCORE MANUAL

2025

## TABLE OF CONTENTS

## FORMAT OF THE QUESTION PAPER

| PAPER | TYPE OF QUESTIONS | DURATION | TOTAL MARKS |
|---|---|---|---|
| 1-Physics | 10 multiple choice questions (20 marks)<br>9 Structured questions (130marks) | 3 hours | 150 |

| WEIGHTING OF PRESCRIBED CONTENT | |
|---|---|
| Paper 1 | 150 |
| **MECHANICS**<br>• Momentum<br>• Vertical projectile motion<br>• Newton's Laws<br>• Work, energy & power | **65** |
| **WAVES, SOUND & LIGHT**<br>• Doppler effect | **15** |
| **ELECTRICITY& MAGNETISM**<br>• Electrostatics<br>• Electric circuits<br>• Electrodynamics | **55** |
| **MATTER & MATERIAL**<br>• **Photo electric effect** | **15** |

**COGNITIVE LEVELS**

| LEVEL 1 | LEVEL 2 | LEVEL 3 | LEVEL 4 |
|---|---|---|---|
| **15 %**<br>**(22,5 marks)** | **35 %**<br>**(52,5 marks)** | **40 %**<br>**(60 marks)** | **10 %**<br>**( 15 marks)** |

## STRUCTURE OF PAPER 1 (PHYSICS)

| QUESTIONS | TOPIC | Estimated marks |
|---|---|---|
| 1 | MULTIPLE CHOICE( ALL TOPICS) | 20 |
| 2 | NEWTON'S LAWS | 13 |
| 3 | VERTICAL PROJECTILE MOTION | 16 |
| 4 | MOMENTUM AND IMPULSE | 14 |
| 5 | WORK, ENERGY AND POWER | 15 |
| 6 | DOPPLER EFFECT | 10 |
| 7 | ELECTROSTATICS | 17 |
| 8 | ELECTRIC CIRCUITS | 20 |
| 9 | ELECTRODYNAMICS | 11 |
| 10 | PHOTOELECTRIC EFFECT | 14 |
| | **TOTAL MARKS** | 150 |

## QUESTION PAPER ANALYSIS (PAPER 1) FOR # 30% AND ABOVE

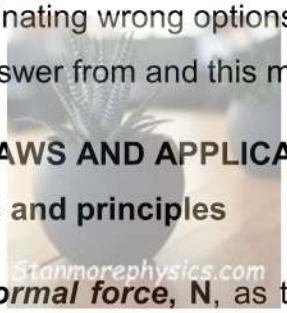
| No. | DESCRIPTIONS | MARKS |
|---|---|---|
| | | |
| 1. | Multiple Choice Questions | 10 |
| 2. | Definitions | 16 |
| 3. | Free Body diagrams | 10 |
| 4. | Formulae | 16 |
| 5. | Application of Doppler effect | 1 |
| | **TOTAL** | 53 = 35% |

## TIPS ON HOW TO ANSWER MULTIPLE CHOICE QUESTIONS

- cover the answers
- Read the questions carefully
- Answer the question without looking at the options
- Match your answer to one of the given options
- By eliminating wrong options, you will be left with fewer options to select your answer from and this makes it easier to look for the correct option

## NEWTON'S LAWS AND APPLICATION OF NEWTON'S LAWS

### Key concepts and principles




- **Define *normal force*, N**, as the force or the component of a force which a surface exerts on an object with which it is in contact, and which is perpendicular to the surface.
- **Define *frictional force*, f**, as the force that opposes the motion of an object and which acts parallel to the surface.
- **Define *static frictional force*, $f_s$**, as the force that opposes the tendency of motion of a stationary object relative to a surface.
- **Define *kinetic frictional force*, $f_k$**, as the force that opposes the motion of a moving object relative to a surface.

**Newton's first law of motion**: A body will remain in its state of rest or motion at constant velocity unless a non-zero resultant/net force acts on it.

- **Newton's second law of motion:** When a resultant/net force acts on an object, the object will accelerate in the direction of the force at acceleration directly proportional to the force and inversely proportional to the mass of the object.
- **Newton's third law of motion:** When one body exerts a force on a second body, the second body exerts a force of equal magnitude in the opposite direction on the first body.
- **Newton's Law of Universal Gravitation:** Each body in the universe attracts every other body with a force that is directly proportional to the product of their masses and inversely proportional to the square of the distance between their centres.( $= \frac{1}{2}\frac{2}{}$)

- **Weight**: The gravitational force the Earth exerts on any object on or near its surface

| Free Body Diagram | Force Diagram |
|---|---|
| A dot is used to represent the object | A box is used to represent the object. |
| The forces point away from the dot. | • The gravitational force starts from the center of the object.<br>• The normal force is drawn from the base of the box. |

**Steps to follow when drawing force or free-body diagrams.**

• Determine whether the object is moving on a horizontal surface, inclined surface or vertical.

• Identify all the forces acting on the object.

• Start by drawing Fg (always pointing vertically downwards).

• If the object is in contact with a surface, the Normal force is drawn perpendicular to the surface. (5)

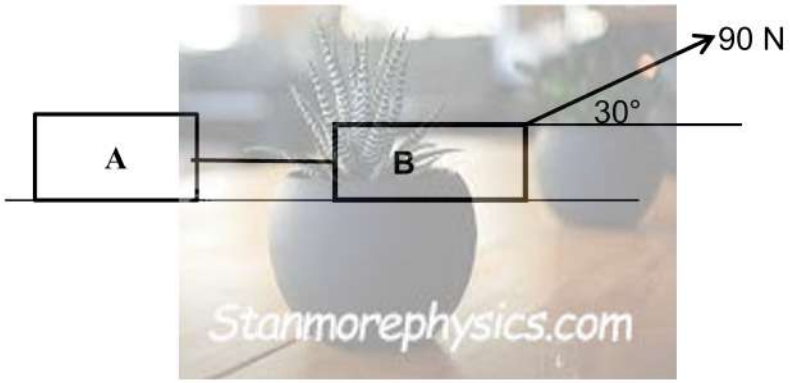
• The marks usually indicate the number of forces acting on the object.

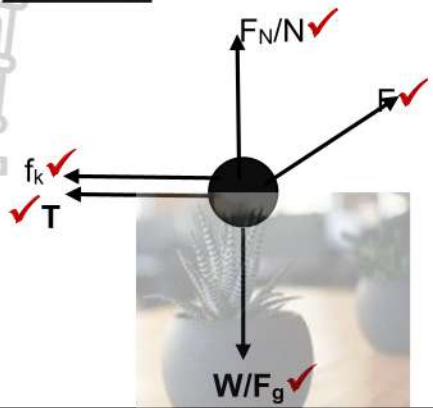
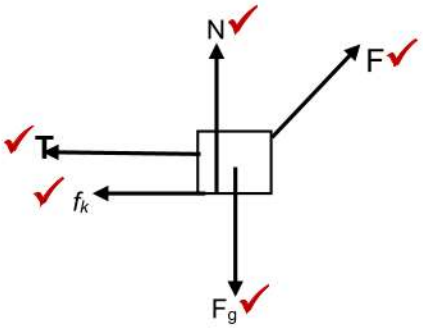
**Example on drawing of force diagrams/free-body d**

**A: HORIZONTAL SURFACE**

TWO blocks **A** and **B** are place on a rough surface. A 90 N Force is acting at an angle of 30 0 to the horizontal.

Draw a free body diagram showing all the forces acting on the block **B**.



| Free body diagram | Force diagram |
|---|---|
| **OPTION 1**<br>  <br> |  <br> |
| **5 forces = 5 marks** | |

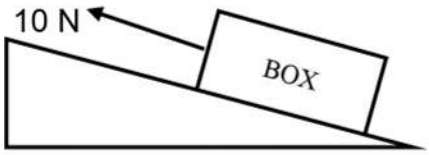
(4)

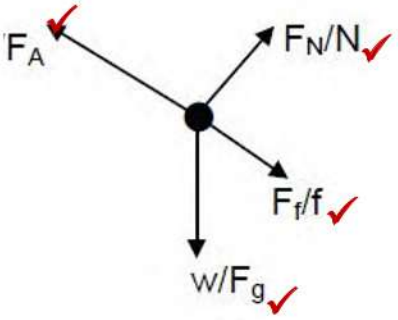
.

**B. INCLINED PLANE**

A box is pulled up a rough inclined surface by a force of 10N.

Draw a free body diagram showing all the forces acting on the box.

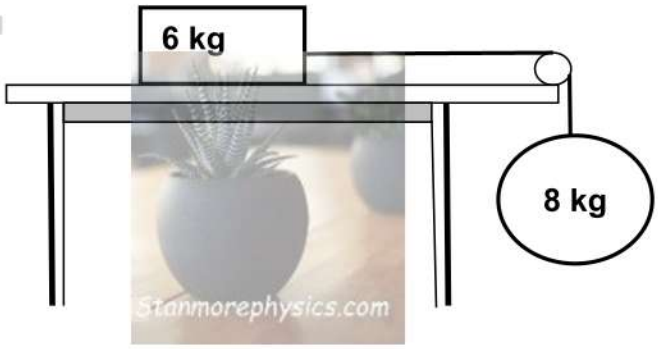



**4 forces= 4 marks**

**ACTIVITY 1**

1 The box above is now placed on a rough horizontal table and joined to a 8 kg mass by a light, inextensible string running over a frictionless pulley, as shown in the diagram below.



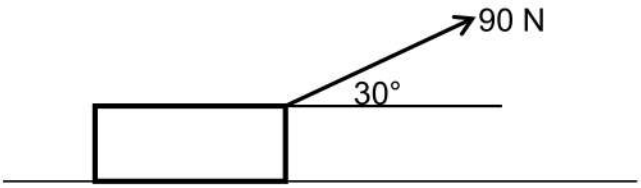

The kinetic frictional force between the 6 kg box and the surface is 7, 64 N.

1.1 Draw a free body diagram of ALL forces acting on the 8 kg mass. (2)

1.2 Calculate the magnitude of the acceleration of the 6 kg box. (5)

**[7]**

2 In the diagram below, a force of 90 N is applied to a 50 kg block at an angle of 30° to the horizontal. The block moves at a CONSTANT VELOCITY of 2 $m \cdot s^{-1}$ to the right on the rough surface.




2.1 Draw a free body diagram of ALL forces acting on the block. (4)

2.2 Calculate the magnitude of:

2.2.1 The vertical component of the applied force. (2)

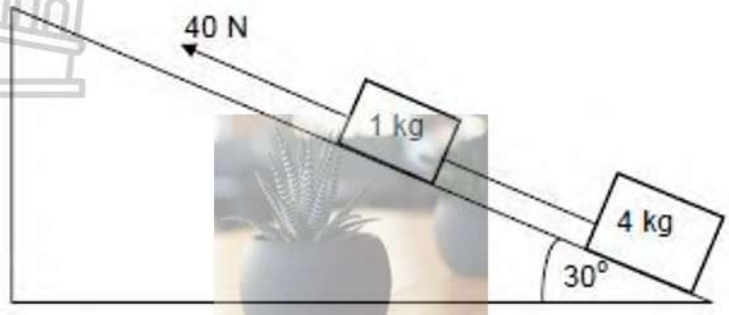
2.2.2 The normal force. (3)

2.2.3 Frictional force. (3)

2.3 What will happen to the coefficient of frictional force between the block and the surface if the angle of the applied force is decreases from $30^0$ to $26^0$? (1)

te down only INCREASES, DECREASES or REMAINS THE SAME. **[13]**

3 A block of mass 1 kg is connected to another block of mass 4 kg by a light inextensible string. The system is pulled up a rough plane inclined at 30° to the horizontal, by means of a constant 40 N force parallel to the plane as shown in the diagram below.




The magnitude of the kinetic frictional force between the surface and the 4 kg block is 10 N. The magnitude of the kinetic frictional force between the surface and the 1 kg block is 2,46 N.

3.1 Draw a labelled free-body diagram showing ALL forces acting on the 4 kg block as it moves up the incline. (4)

3.2 Calculate the magnitude of the tension in the string connecting the two blocks. (5)

3.3 A ssatellite on a research mission in space is on the earth's surface. The earth exerts a force of 5 900 N on satellite to keep it in its position, calculate the mass of the satellite. (3)

**[12]**

## PROJECTILE MOTION

### Key concepts

| | |
|---|---|
| 1 | Define Free fall as a motion in which the only force acting on an object is the force of gravity. |
| 2 | Define Projectile as an object upon which the only force acting is the force of gravity. |
| 3 | Magnitude and direction of acceleration<br>9, 8 $m.s^{-2}$ Downwards (Always down wards) |
| 4 | Keep one sign convention when solving a problem, and do not change the sign convention within a problem |

There are only five variables (terms) to deal with when using equations of motion. In a calculation, the four are known and you're required to calculate the remaining one.

| | | | |
|---|---|---|---|
| 1 | Initial velocity: | $\mathbf{v_i}$ | (vector quantity) |
| 2 | Final velocity: | $\mathbf{v_f}$ | (vector quantity) |
| 3 | Displacement: | $\mathbf{\Delta x}$ | (vector quantity) |
| 4 | Acceleration: | **a** | (vector quantity) |
| 5 | Time interval: | $\mathbf{\Delta t}$ | (scalar quantity) |

**NOTE**: if the object such as rocket; Hot-air balloon or helicopter is in motion at a **constant velocity** use the formula $\mathbf{\Delta x = v.\ \Delta t}$

| **THE CHOICE OF DIRECTION IN VERTICAL PROJECTILE MOTION** | |
|---|---|
| **IF UPWARDS IS TAKEN AS POSITIVE** | **IF DOWNWARDS IS TAKEN AS POSITIVE** |
| Acceleration a, upward or downward motion<br>a = - 9, 8 $m.s^{-2}$ | Acceleration a, upward or downward motion<br>a = + 9, 8 $m.s^{-2}$ |
| Velocity ($v_i$ or $v_f$) upwards = positive | Velocity ($v_i$ or $v_f$) upwards = negative |
| Velocity ($v_i$ or $v_f$) downwards = negative | Velocity ($v_i$ or $v_f$) downwards = positive |
| Height above the starting point ($\Delta x$) = positive | Height above the starting point ($\Delta x$) = negative |

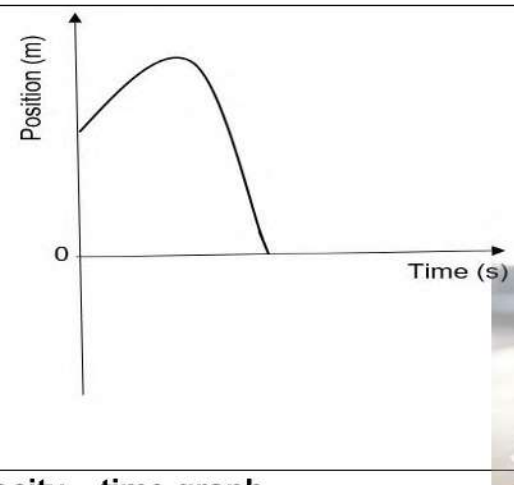
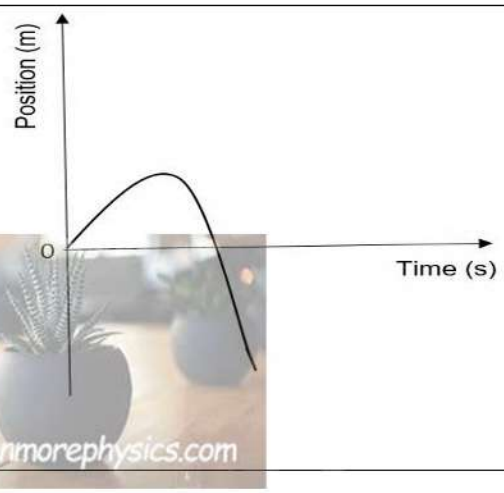
| | |
|---|---|
| Height below the starting point (Δx) = negative | Height below the starting point (Δx) =positive |
| Time interval (Δt) = positive | Time interval (Δt) = positive |

**DRAWING AND INTERPRETING GRAPHS OF MOTION OF A PROJECTILE**

**NOTE:** the direction chosen is taken into consideration when drawing the graphs

**Position – time graph**

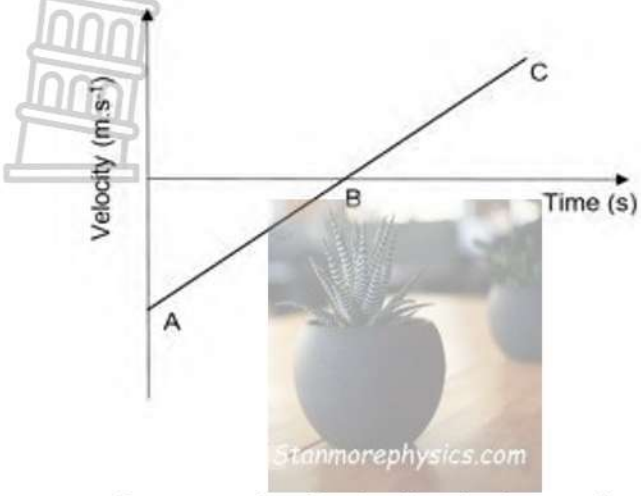
- The position – time graph of a projectile is a curve
- The x-axis corresponds to the position of the observer, it is referred to as the ZERO-POSITION E.g. an object is thrown vertically upwards from the top of a building and hits the ground below the throwing point after some

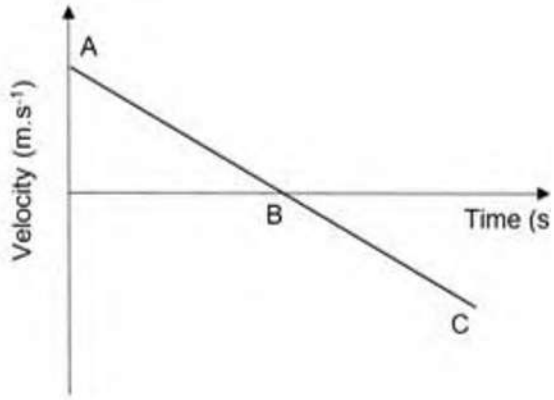
| **IF UPWARDS IS POSITIVE** | |
|---|---|
| **Take top of the building as Zero-position** | **Take Ground as Zero – position** |
|   |   |

**Velocity – time graph**

- The velocity – time graph of a projectile is a **straight line** with a positive or negative gradient
- The x-axis, where the velocity is zero, is the lowest value with regards to the velocity.
- Each segment of the line drawn towards the x-axis implies a decrease in velocity, regardless of whether the line is above or below the x-axis.

- Any segment of line drawn away from the x-axis implies an increase in velocity. e.g. Two graphs that represent the same scenario






- Segment A – B, the line is drawn directed TOWARDS the x – axis. So from A to B, the velocity DECREASES
- Segment B – C, the line is drawn directed AWAY FROM the x – axis. So from B to C, the velocity INCREASES
- The gradient of velocity – time graph represents the acceleration

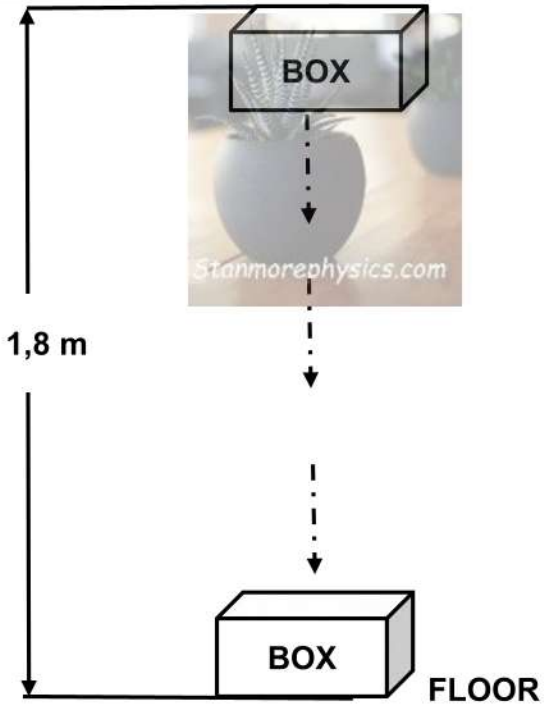
**NOTE:** The area between the line and the x – axis represents the displacement

**Acceleration – time graph**

- The acceleration of a projectile is constant
- The acceleration – time graph is a **straight horizontal line**
- The horizontal line is drawn above the x-axis from + 9,8 if Downwards was taken as positive
- The horizontal line is drawn below the x-axis from – 9,8 if Upwards was taken as positive

**ACTIVITY 2**

1 A box of mass 0, 5 kg is projected vertically downwards, at a velocity of 8 $m.s^{-1}$ towards the floor from a height of 1, 8 m. The box is in contact with the floor for 0, 01 s before it is picked up. Ignore the effects of air friction.




1.1 Is the box in a free fall directly after being projected?
Write down only YES or NO. Give a reason for the answer. (2)

1.2 Write down the magnitude and direction of the acceleration of the box immediately after it is projected. (2)

1.3 Calculate:

1.3.1 The magnitude of the velocity with which the box hits the floor. (3)

1.3.2 The time it takes the box to hit the floor (3)

1.3.3 The net force exerted by the box on the floor. (3)

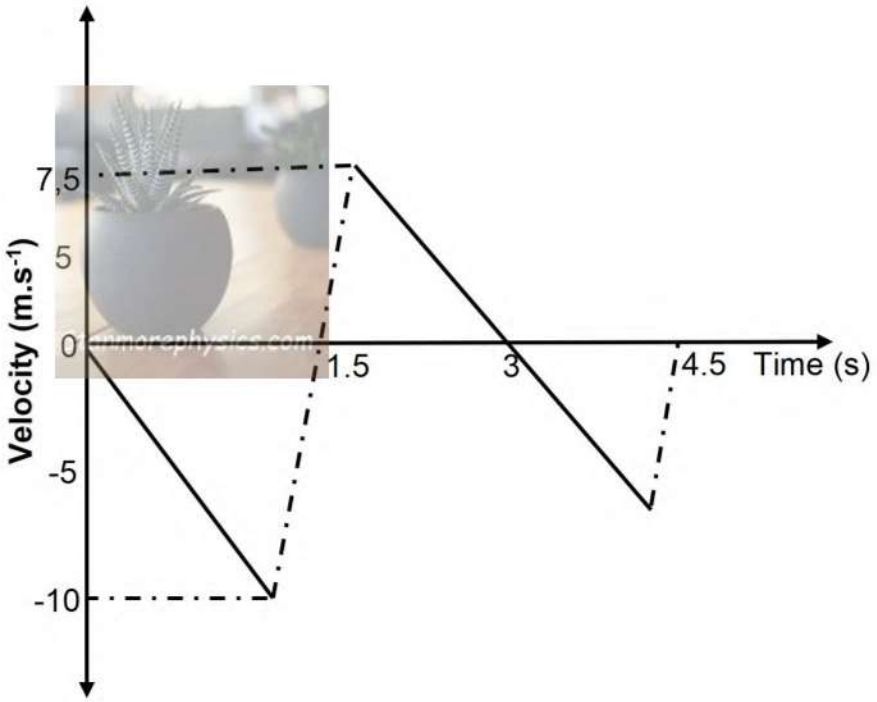
1.4 Sketch an acceleration-time graph for the motion of the box (No indication of values is required). (2)

**[15]**

2 A ball of mass 200 g is dropped vertically downwards from the top of a building to a concrete floor below. The ball

bounces off the floor. The velocity versus time graph below shows the motion of the ball. Ignore the effects of air friction.

**TAKE UPWARD MOTION AS POSITIVE.**




2.1 Use the graph **only**:

2.1.1 To determine the number of times the ball bounces off the floor. (1)

2.1.2 To determine whether the collision between the ball and the floor is elastic or inelastic. (2)

Provide a reason for the answer.

2.1.3 To calculate the height from which the ball is dropped. (3)

2.2 Calculate the impulse that the ball exerts on the floor when it strikes the floor for the first time. (3)

**[9]**

**MOMENTUM AND IMPULSE**

**Key concepts**

- **Momentum** p = mv
- Define ***momentum*** as the product of an object's mass and its velocity.
- State Newton's second law of motion in terms of momentum: The

resultant/net force acting on an object is equal to the rate of change of momentum of the object in the direction of the resultant/net force

- Define ***impulse*** as the product of the resultant/net force acting on an object and the time the resultant/net force acts on the object.

**Conservation of momentum and elastic and inelastic collisions**

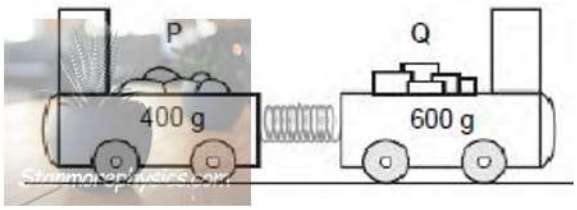
- a **closed/an isolated system** (in Physics), i.e. a system on which the resultant/net external force is zero.
- State the **principle of conservation of linear momentum**: The total linear momentum of a closed system remains constant (is conserved).
- **Elastic collision**: a collision in which both momentum and kinetic energy are conserved
- **Inelastic collision**: a collision in which only momentum and not kinetic energy is conserved.

**NOTE:**

- Momentum is a vector, therefore in any calculation first assign the vector velocity by indicating the sign convention at the beginning of the calculation.
- If asked to prove if a collision is elastic or inelastic, calculate the total initial(before) kinetic energy and the total final(after) collision SEPARATELY. Then compare and make a conclusion.

**ACTIVITY 3**

1 The diagram below shows two trolleys, P and Q, held together by means of a compressed spring on a flat, frictionless horizontal track. The masses of P and Q are $400\ \text{g}$ and $600\ \text{g}$ respectively.




When the trolleys are released, it takes $0{,}3$ for for the spring to unwind to its natural length. Trolley Q then moves to the right at $4 \cdot ^{-1}$.

1.1 State the *principle of conservation of linear momentum* in words. (2)

1.2 Calculate the:

1.2.1 Velocity of trolley P after the trolleys are released. (4)

1.2.2 Magnitude of average force exerted by the spring on trolley Q. (4)

1.3 Use a calculation to show that this is an inelastic collision. (4)

**[14]**

2 A box of mass 50 kg is thrown from the roof top and strikes the ground with a velocity of 5 $m \cdot s^{-1}$. It slides and comes to a complete stop in 0,2 seconds.

2.1 Calculate the momentum with which the box strikes the ground. (3)

2.2 Define the term *Impulse* of a force (2)

2.3 Calculate the magnitude of the net force exerted on the box by the ground. (3)

2.5 To improve passenger safety, modern cars are designed to crumple partially on impact, in addition of the presence of seat belts. Explain how seat belts in cars can improve passenger safety during an accident. Include a relevant physics equation in the explanation. (3)

**[11]**

**ANSWER**

From $F_{net} = \frac{\Delta P}{\Delta t}$ ✓ **OR:** $F_{net} = \frac{m(V_f - V_i)}{\Delta t}$

For the same change in momentum, the seat belts increase the contact time ✓
The force (exerted on passenger) decreases ✓ (3)

**WORK, ENERGY AND POWER**

**Key concepts and terms**

| | **Concept/term** | **Associated formula** |
|---|---|---|
| 1 | Define Work done | $W = F\Delta x\cos\theta$ |
| 2 | State the work – energy theorem:<br>The net/total work done on an object is equal to the change in the object's kinetic energy OR the work | $W_{net} = \Delta E_k$ |

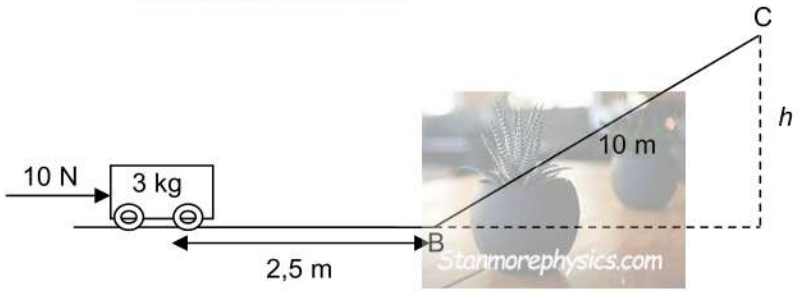
| | | |
|---|---|---|
| | done on an object by a resultant/net force is equal to the change in the object's kinetic energy. | |
| 3 | **Define Conservative force**: A force for which the work done in moving an object between two points is independent of the path taken. Examples are gravitational force, the elastic force in a spring and electrostatic forces (coulomb forces). | $W_c = -\Delta E_p$ |
| 4 | **Define Non – conservative force:** a force for which the work done in moving an object between two points depends on the path taken. Examples are frictional force, air resistance, tension in a chord, etc. | $W_{nc} = \Delta E_p + \Delta E_k$ |
| 8 | State **the law of conservation of mechanical energy:** The total mechanical energy (sum of gravitational potential energy and kinetic energy) in an isolated system remains constant. (A system is isolated when the resultant/net external force acting on the system is zero.) | $(E_p + E_k) = E_p + E_k)$ |
| 9 | **Define Power**: as the rate at which work is done or energy is expended. : | $P = \frac{W}{\Delta t}$ <br> $P_{av} = F \cdot v_{av}$ |

| **ENERGY PRINCIPLES** | **CONDITIONS UNDER WHICH IT IS USED** |
|---|---|
| $W_{net} = \Delta E_k$ | No specific condition |
| $W_c = -\Delta E_p$ | Used only for conservative forces (W and Fg//) |
| $W_{nc} = \Delta E_p + \Delta E_k$ | Used only when there is A non-conservative force (f, Fap, T) <br> 2. Mostly When height is involved ( if the object moves vertically (up or down) or the object is on an inclined surface) |
| | |

| | |
|---|---|
| Ep + Ek = Ep + Ek | 1) Only when there is NO non-conservative force (f, Fap, T)<br>2) When height is involved ( if the object moves vertically (up or down) or the object is on an inclined surface) |

**ACTIVITY 4**

1 A 3 kg trolley is at rest on a horizontal, frictionless surface. A constant horizontal force of 10 N is applied to the trolley over a distance of 2,5 m.




When the force is removed at point B, the trolley moves a distance of 10 m up the incline until it reaches the maximum height at point **C**. While the trolley moves up the incline, there is a constant frictional force of 2 N acting on it.

1.1 Draw a labelled free-body diagram showing all the forces acting on the trolley as it moves along the horizontal surface. (3)

1.2 State the WORK-ENERGY THEOREM in words. (2)

1.3 Draw a labelled free-body diagram showing all the forces acting on the trolley as it moves along the inclined surface. (3)

**[8]**

**DOPPLER EFFECT**

**Key concepts**

- State the Doppler effect as the change in frequency (or pitch) of the sound detected by a listener because the sound source and the listener have different velocities relative to the medium of sound propagation.
- State applications of the Doppler effect.

In medicine:

- Measuring the rate of blood flow.
- Measuring the rate of heart beat of a foetus

**OR/** Ultrasound (scanning)

1. In transport:

- Used in speed traps to calculate the speed of the moving vehicle.
- Used by blind persons to detect the moving vehicles/ obstacles.
- Used by flying bats/animals at night to detect the obstacles.
- Explain *red shifts* as the shift in the spectra of distant stars/galaxies towards the longer
- wave length of the red end of the spectrum.
- Explain *blue shifts* as the shift in the spectra of distant stars/galaxies towards the shorter
- wave length of the blue end of the spectrum.



- Use the Doppler effect to explain why we conclude that the universe is expanding.
- Solve problems using the equation $= \frac{\pm}{\pm}$ , when EITHER the source or the listener is moving;
- If the sound source/ observer is moving to wards each other;

  First write this formula $= \frac{\pm}{\pm}$ followed by $= \frac{+}{-}$
- If the sound source/ observer is moving away from each other, First write this formula $= \frac{\pm}{\pm}$ followed by $= \frac{-}{+}$ ,

**ACTIVITY 5**

1 Define the following terms.

1.1 Doppler effect (2)

1.2 Red shift in relation to Doppler Effect. (2)

**[4]**

2 The diagram below shows an ambulance vehicle moving on a high way. The siren of the ambulance emits sound waves of frequency 433, 64 Hz, while the wavelength of the sound waves from the ambulance detected by the nearby stationary observer is 0, 72 m. The speed of sound in air is 340 $m.s^{-1}$

2.1 Doppler effect has various practical applications in different fields of life. State ONE such applications in the field of transport. (1)

2.2 Calculate the frequency of the sound waves detected by the observer. (4)

2.3 Is the ambulance moving TOWARDS or AWAY from the observer? Give a reason **basing** on the answer in **question 3.2** (2)

2.4 Calculate the speed at which the ambulance is moving. (4)

2.5 The evidence for the expanding of our universe is obtained by studying the distances of galaxies relative to the earth. The table below shows the wavelengths and frequencies of two galaxies **A** and **B** obtained during a study of their distances relative to the earth.

| **Experiment number** | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| **Wavelength of Galaxy A (m)** | 420 | 550 | 670 | 790 |
| **Frequency of galaxy B (HZ)** | 840 | 865 | 884 | 910 |

Which galaxy **A** or **B** exhibit the red shift? Give a reason for the answer (2)

**[13]**

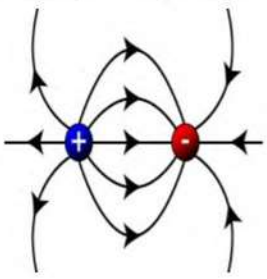
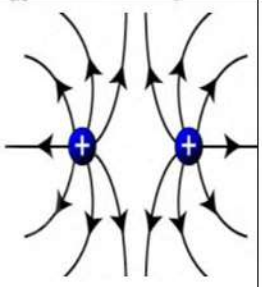
## ELECTROSTATICS

### Key concepts

| | **CONCEPT/TERM** | **Associated formula** |
|---|---|---|
| 1 | **Charge quantisation** | $n = \frac{Q}{e}$ OR $n = \frac{Q}{q_e}$ |
| 2 | **Conservation of charge** | $Q_{new} = \frac{1+2}{2}$ |

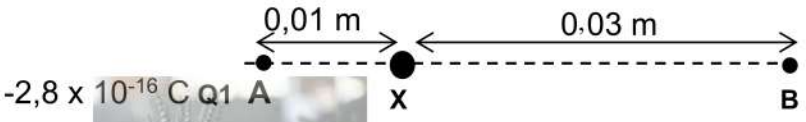
| | | |
|---|---|---|
| 3 | State **Coulomb's law** as the magnitude of the electrostatic force exerted by one-point charge ($Q_1$) on another point charge ($Q_2$) is directly proportional to the product of the magnitudes of the charges and inversely proportional to the square of the distance (r) between them: | $= \frac{1\ 2}{2}$ |
| 4 | Define **Electric field** as a region of space in which an electric charge experiences a force | |
| 5 | Define **Electric field at a point** as the electrostatic force experienced per unit positive charge placed at that point. | $= \frac{}{2}$ / $= -$ |

- Practice calculations involving the above formulae.
- Practice drawing of electric field patterns

| **ONE charge** | | **For TWO charges near each other** | |
|---|---|---|---|
| Positive charge | Negative charge | Attraction | Repulsion |
|  | |  |  |

**ACTIVITY 6**

1 The diagram below shows a small sphere **X** from which 938 electrons were removed and a point charge **Q1** with a charge of -2,8 x $10^{-16}$ C at point **A**.
Sphere **X** is 0,01 m from Charge **Q1** and 0,03 m from point **B**.




1.1 What is the nature of the charge on sphere **X**? Choose from POSITIVE or NEGATIVE. (1)

1.2 State *Coulomb's law* in words. (2)

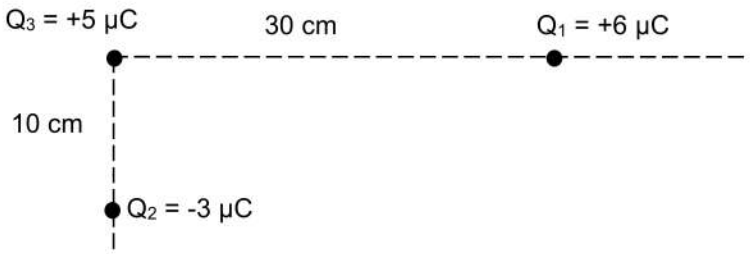
1.3 Calculate the magnitude of the charge on sphere **X**. (3)

1.4 Draw the electric field pattern due to the presence of charge Q1 and sphere X. (3)

1.6 Define *electric field at a point* in words. (2)

**[11]**

2 Three point charges, $\mathbf{Q_1}$, $\mathbf{Q_2}$ and $\mathbf{Q_3}$, carrying charges of +6 μC, -3 μC and +5 μC respectively, are arranged in space as shown in the diagram below.
The distance between $\mathbf{Q_3}$ and $\mathbf{Q_1}$ is 30 cm and that between $\mathbf{Q_3}$ and $\mathbf{Q_2}$ is 10 cm.




2.1 Define the term electric field. (2)

2.2 Draw a labelled free-body diagram showing the forces acting on point charge $Q_3$. Include the net force on the diagram. (3)

2.3 Calculate the electrostatic force between charges **Q1** and **Q3** (3)

**[8]**

## ELECTRIC CIRCUITS

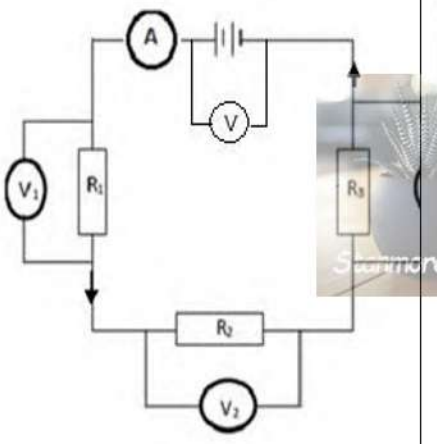
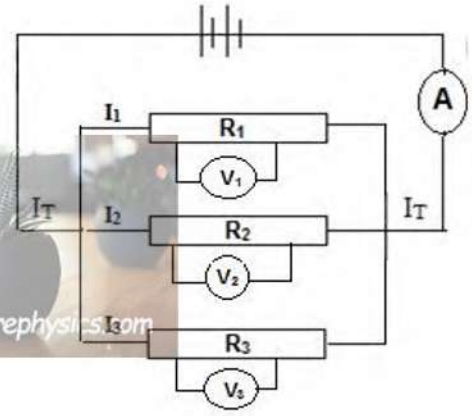
### Key concepts

**State Ohm's law in words**: The potential difference across a conductor is directly proportional to the current in the conductor at constant temperature.

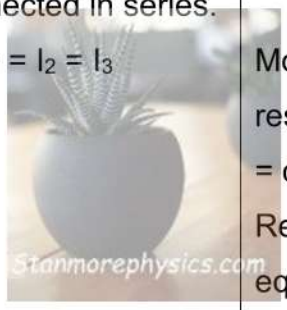
**Emf :** is the maximum energy provided by the battery per unit charge passing through it.

**Power:** is the rate at which work is done.

### GRADES 10 AND 11 CONCEPTS

| | |
|---|---|
| Resistance, current and potential difference in a series circuit. | Resistance, current and potential difference in a parallel circuit. |
| Diagram of a circuit with three resistors connected in series.<br>  <br> | Diagram of a circuit with three resistors connected in parallel.<br>  <br> |
| Effective / equivalent / total resistance:<br>The total external resistance of a combination of resistors connected in series is equal to the sum of the component resistors: | Effective / equivalent / total resistance:<br>The total external resistance of a combination of resistors connected in parallel is calculated by using the formula:<br>$\frac{1}{Rp} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$<br>The effective resistance decreases as more resistors are added in parallel and it is always |

| | |
|---|---|
| $R_T = R_1 + R_2 + R_3$ | smaller than the smallest resistance in the parallel connection or resistance of the branch. |
| Current:<br>The same current flows through each resistor when they are connected in series.<br>$I_T = I_1 = I_2 = I_3$ | Current:<br>Resistors connected in parallel act as current dividers.<br>$I_T = I_1 + I_2 + I_3$<br>More current flows into a branch with less resistance and the current flowing into a branch = current flowing out of the branch<br>Resistors of equal resistance divide current equally. |
| Potential difference:<br>Resistors connected in series act as potential dividers.<br>$V_T = V_1 + V_2 + V_3$<br>They divide the total voltage/ potential difference across the battery. | Potential difference:<br>The potential difference across resistors connected in parallel is the same and it is the same as the voltage across the whole parallel connection.<br>$V_P = V_1 = V_2 = V_3$ |

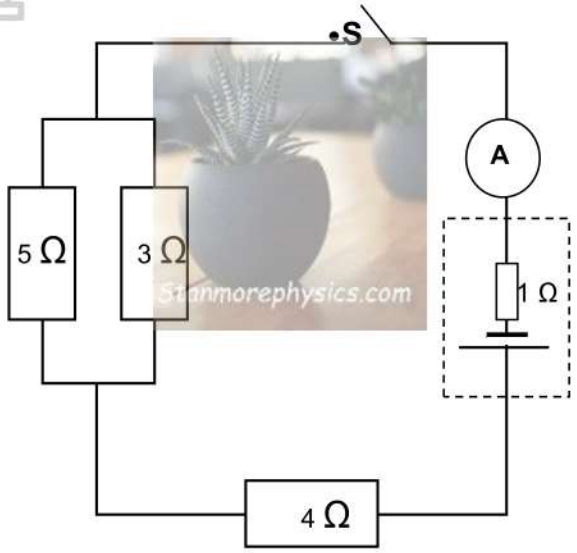



**Tips on solving circuit problems**

- Analyse the given statement, diagram or graph and write down the data
- Trace the flow of current when all the switches are closed, to determine the connection of resistors.
- Identify the resistors in parallel and series connection
- Use the correct formulae from the formula sheet.

**ACTIVITY 7**

1 A battery of an unknown emf and an internal resistance of 1 Ω is connected to three resistors and an ammeter of negligible resistance, as shown below.




1.1 State Ohm's law in words. (2)

When switch S is closed, the power dissipated in 4 Ω resistor is 1,8 W.

1.2 Calculate:

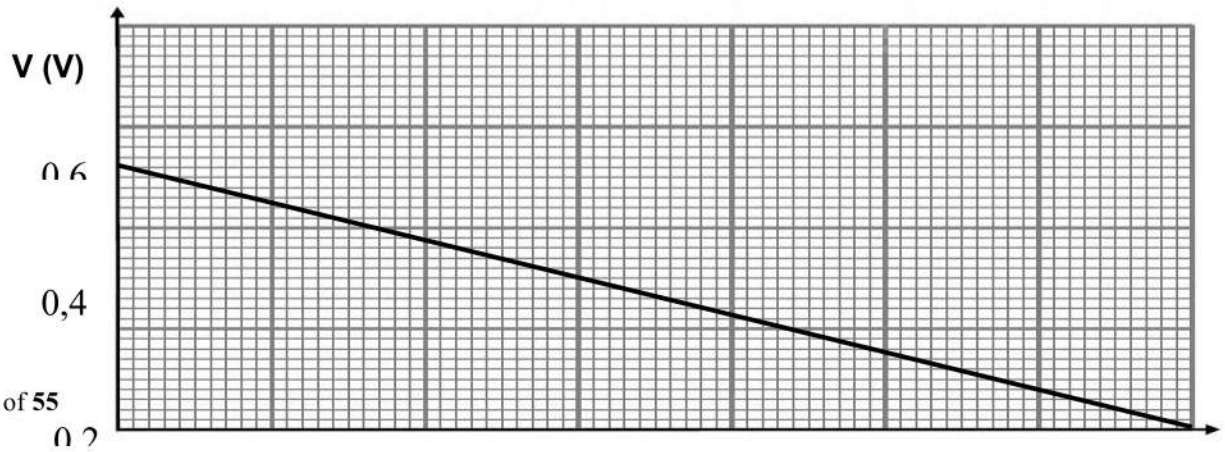
1.2.1 The effective resistance of resistors in the circuit. (4)

1.2.2 the reading on ammeter A. (3)

1.2.3 Emf of the battery. (3)

**[12]**

2 The graph below is obtained from an experiment to calculate the internal resistance of a battery.



2.1 Define the term emf (2)

2.2 Use the graph to determine the emf of the battery (1)

2.3 Calculate the gradient of the graph (3)

2.4 Which physical quantity is represented by the magnitude of the gradient of the graph (1)

**[7]**

**Power and electricity cost**

**Example**

A heater marked 3000W is switched on for 4 hours. For the first hour, it is on the highest setting, and for the last 3 hours, it is on lowest setting.

How much energy does it transfer to the room in kWh? (3)

What is the cost of heating the room if the electricity costs 70c per kWh? (3)

**Answers**

| 1.1 | 1.2 |
|---|---|
| Data: P = 3000 W = 3 kW,<br>$\Delta t$ = 3 hr<br>W = P$\Delta$t = (3)(3) = 9 KWh | Cost = W (KWh) x Price per KWh<br>= (9)(R0,70)<br>Cost = R 6, 30 |

**ACTIVITY 8**

A motor operates at a voltage of 240 V and a current of 9,5 A.

It takes 12 minutes to completely dry her hair.

ESKOM charges energy usage at R1,47 per unit.

Calculate the cost of operating the motor for the 5 hours.(1 unit = 1 kW·**h)**

1.1 Define the term power. (2)

1.2 Calculate :

1.2.1 The power dissipated in the motor. (3)

1.2.2 The cost of operating the dryer for the 5 hours. (4)

**[9]**

## ELECTRODYNAMIC (GENERATORS AND MOTORS)

### Key concepts

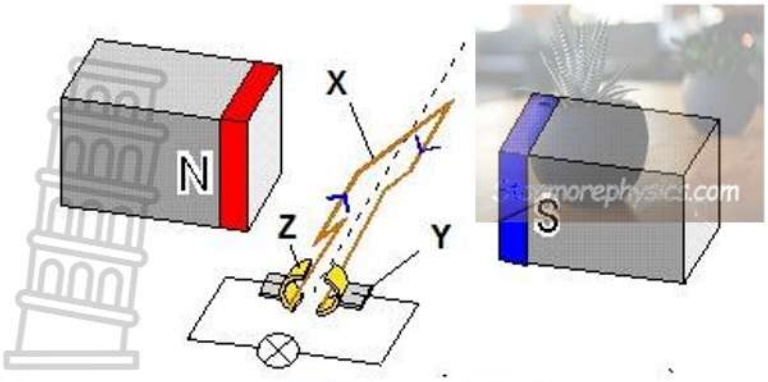
**Define the term *rms* for an alternating voltage or an alternating current**. The rms value of AC is the DC potential difference/current which dissipates the same amount of energy as AC.

| | **DC generator** | **AC generator** |
|---|---|---|
| Principle of operation | Electromagnetic Induction | Electromagnetic Induction |
| Energy conversion | Mechanical to electrical | Mechanical to electrical |
| Coil makes contact with | Split-ring commutator and brushes | Slip rings and brushes |
| Uses | Electroplating with metals, electrolysis for manufacture of chlorine, refining of aluminium, copper, manganese. Many DC generators are driven by AC motors. | Electricity generation at power stations. Generators at amusement parks, hospitals and other essential services, building sites, for lights at accident scenes, etc. |

| | Motors | generator |
|---|---|---|
| Principle of operation | Motor rule | Electromagnetic Induction |
| Energy conversion | Electrical to mechanical | Mechanical to electrical |

### ACTIVITY 9

The diagram below shows a simplified version of a generator. A light bulb of 25 Ω is connected to it with wires of negligible resistance.




1.1 What type of generator (AC or DC) is represented in the diagram? (1)

1.2 State the energy conversion in generators. (1)

1.3 Write down the name of component labelled. (1)

1.3.1 x (1)

1.3.2 Y (1)

1.4 Write down one function of the parts labelled:

1.4.1 X (1)

1.4.2 Y (1)

**[7]**

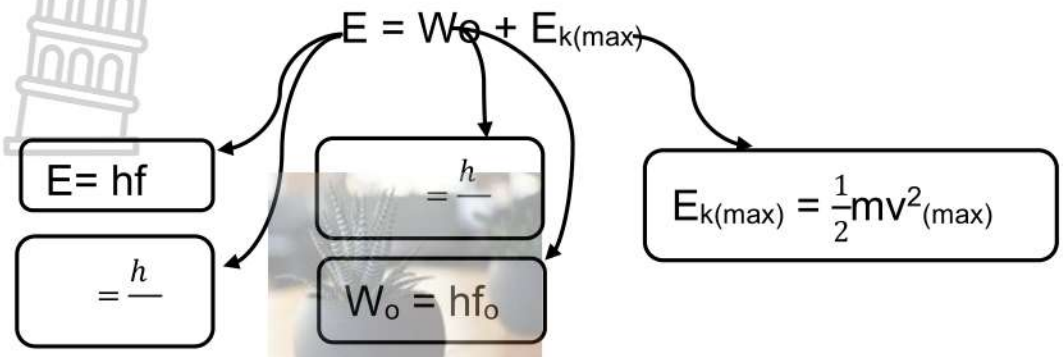
## PHOTO-ELECTRIC EFFECT

**Define the *photoelectric effect*** as the process whereby electrons are ejected from a metal surface when light of suitable frequency is incident on that surface.

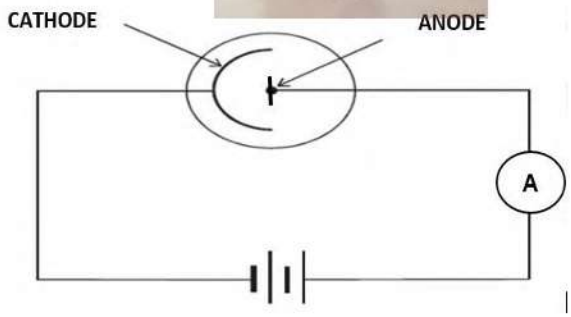
**Define *threshold frequency*, $f_o$**, as the minimum frequency of light needed to emit electrons from a certain metal surface.

**Define *work function*, $W_o$**, as the minimum energy that an electron in the metal needs to be emitted from the metal surface.

Note: the calculations in Photo-electric effect **are baes** on the following photo-electrical equation.




**Photocell**



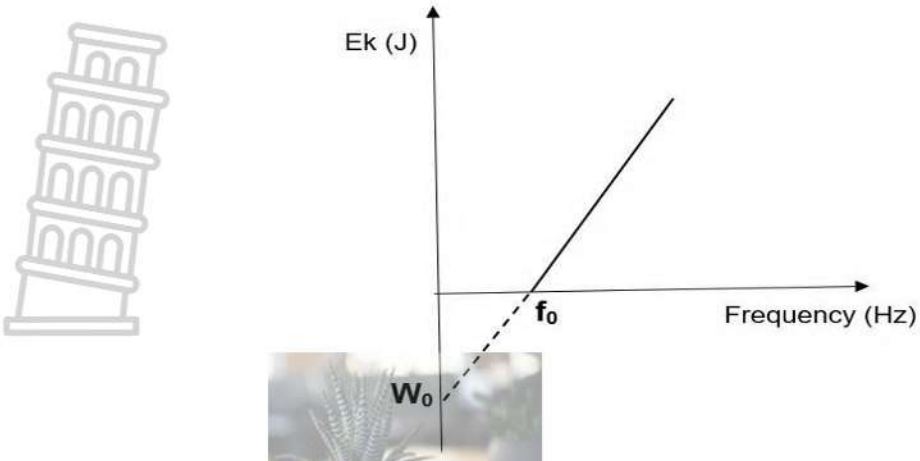

- The frequency of the incident light influences the speed of photoelectrons
- The intensity of the incident light influences the number of photoelectrons/current
- **If the frequency of the incident light is increased**

- The speed (Kinetic energy) of the photoelectrons increases
- The Ammeter reading (Number of photoelectrons) remains the same

- **If the intensity of the incident light is increased**

- The speed of photoelectrons remains the same
- The Ammeter reading increases

- Interpretation of a basic graph under photoelectric effect



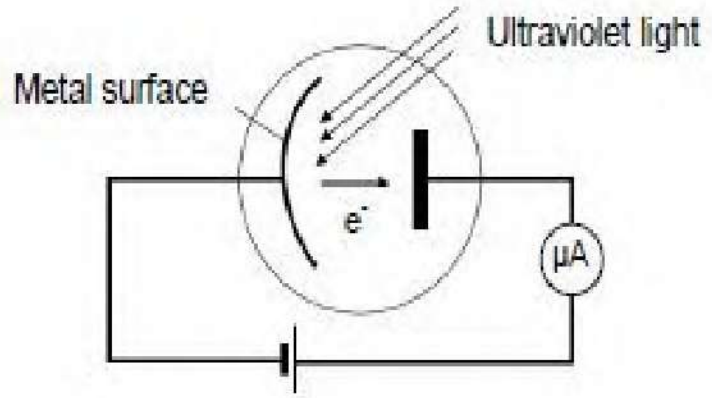

The x-intercept represents the threshold frequency (fo)

The y-intercept represents the work function (Wo)



**ACTIVITY 10**

A photocell in the diagram below is used to determine the maximum kinetic energy of ejected photoelectrons.




The incomplete results obtained are shown in the table below.

| WORK FUNCTION OF THE METAL (J) | MAXIMUM KINETIC ENERGY OF PHOTOELECTRONS (J) | WAVELENGTH OF INCIDENT RADIATION (M) |
|---|---|---|
| $3{,}36 \times 10^{-19}$ | $2{,}32 \times 10^{-19}$ | |

1.1 Define the term photo electric effect. (2)

1.2 Use the information in the table to calculate:

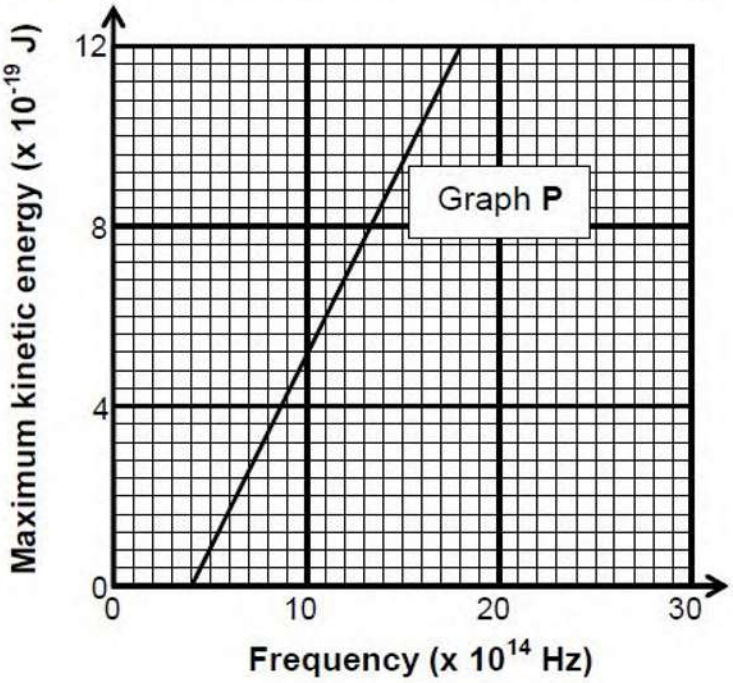
1.2.1 The threshold frequency of incident light. (3)

1.2.2 The wave length ( $\lambda$) of the photon. (4)

**[9]**

2 The Graph below shows how the maximum kinetic energy of electrons emitted from the cathode of a photoelectric cell varies with the frequency of the incident radiation.

**Graph of maximum kinetic energy versus frequency**




2.1 Define the term threshold frequency. (2)

2.2 Use the information in the graph to write down the threshold frequency of incident light. (1)

2.3 Calculate the work function of the cathode electrode. (3)

**[6]**

## CHEMISTRY PAPER TWO

### FORMAT OF THE QUESTION PAPER

| PAPER | TYPE OF QUESTIONS | DURATION | TOTAL MARKS |
|---|---|---|---|
| **2-Chemistry** | 10 multiple choice questions<br>- 20 marks<br>Structured questions-<br>130 marks | 3 hours | 150 |

| WEIGHTING OF PRESCRIBED CONTENT | |
|---|---|
| **Paper 1** | **150** |
| **Chemical change**<br>• Reaction rates<br>• Chemical equilibrium<br>• Acids and bases<br>• Galvanic cell<br>• Electrolytic cell | **92** |
| **Matter and material**<br>Organic chemistry<br>- Nomenclature<br>- Physical properties<br>- Chemical properties | **58** |
| **TOTAL MARKS** | **150** |

### COGNITIVE LEVELS

| LEVEL 1 | LEVEL 2 | LEVEL 3 | LEVEL 4 |
|---|---|---|---|
| **15 %**<br>**(22,5 marks)** | **40 %**<br>**(60 marks)** | **35 %**<br>**(52,5 marks)** | **10 %**<br>**( 15 marks)** |

**STRUCTURE OF PAPER 2 (Chemistry)**

| QUESTIONS | TOPIC | Sub-topic | Estimated marks |
|---|---|---|---|
| 1 | MULTIPLE CHOICE ( ALL TOPICS) | | 20 |
| 2 | Organic molecules | Nomenclature | 15 |
| 3 | Organic molecules | Physical properties | 14 |
| 4 | Organic molecules | Chemical properties | 15 |
| 5 | Reaction rates | | 19 |
| 6 | Chemical equilibrium | | 21 |
| 7 | Acids and bases | | 18 |
| 8 | Electro chemistry | Galvanic cell | 15 |
| 9 | Electro chemistry | Electrolytic cell | 13 |
| | **TOTAL MARKS** | | 150 |

**QUESTION PAPER ANALYSIS (PAPER 2) FOR # 30% AND ABOVE**

| No. | DESCRIPTIONS | MARKS |
|---|---|---|
| 1. | Multiple Choice Question | 10 |
| 2. | Definitions | 09 |
| 3. | Nomenclature (IUPAC) | 10 |
| 4. | Formulae | 04 |
| 5. | Physical Properties | 04 |
| 6. | General formulae | 02 |
| 7. | Types of reactions | 04 |
| 8. | Balancing of equation | 04 |
| 9. | Function of salt bridge | 01 |
| 10. | Calculating of EMF | 04 |
| 11. | Writing of half reactions | 02 |
| | **TOTAL** | **54 = 36%** |

## ORGANIC MOLECULES

### PART 1: Nomenclature

**Boiling point:** The temperature at which the vapour pressure of a substance equals atmospheric pressure. The stronger the intermolecular forces, the higher the boiling point.

**Melting point:**

- The temperature at which the solid and liquid phases of a substance are at equilibrium.
- The stronger the intermolecular forces, the higher the melting point.

**Vapour pressure:**

- The pressure exerted by a vapour at equilibrium with its liquid in a closed system.

**Hydrocarbon**: Organic compounds that consist of hydrogen and carbon only.

**Homologous series**: A series of organic compounds that can be described by the same general formula OR in which one member differs from the next with a $CH_2$ group.

**Saturated compounds**: Compounds in which there are no multiple bonds between C atoms in their hydrocarbon chains.

**Unsaturated compounds**: Compounds with one or more multiple bonds between C atoms in their hydrocarbon chains.

**Functional group**: A bond or an atom or a group of atoms that determine(s) the physical and chemical properties of a group of organic compounds.

**Structural isomer**: Organic molecules with the same molecular formula, but different structural formulae

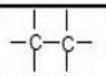
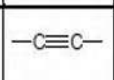
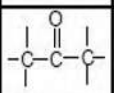
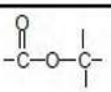
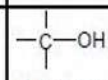
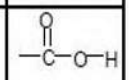
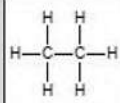
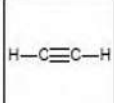
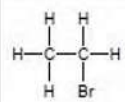
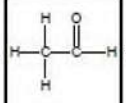
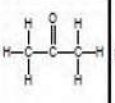
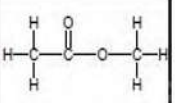
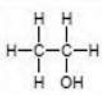
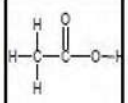
**Chain isomers**: Same molecular formula, but different types of chains, e.g. butane and 2-methylpropane.

**Positional isomers**: Same molecular formula, but different positions of the side chain, substituents or functional groups on the parent chain, e.g. 1-choropropane and 2-chloropropane or but-2-ene and but-1-ene

**Functional isomers**: Same molecular formula, but different functional groups, e.g. methyl methanoate and ethanoic acid

| | |
|---|---|
| Primary alcohol | The C atom bonded to the hydroxyl group is bonded to ONE other C atom. |
| Secondary alcohol | The C atom bonded to the hydroxyl group is bonded to TWO other C atoms |
| Tertiary alcohol | The C atom bonded to the hydroxyl group is bonded to THREE other C atoms |
| Primary haloalkane | The C atom bonded to the halogen is bonded to ONE other C atom. |
| Secondary haloalkane | The C atom bonded to the halogen is bonded to TWO other C atom. |
| Tertiary haloalkane | The C atom bonded to the halogen is bonded to THREE other C atoms. |



| ORGANIC MOLECULES | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Homologous series | Hydrocarbons | | | Haloalkanes | Aldehydes | Ketones | Esters | Alcohols | Carboxylic acids |
| | Alkanes | Alkenes | Alkynes | | | | | | |
| General formula | $C_nH_{2n+2}$ | $C_nH_{2n}$ | $C_nH_{2n-2}$ | $C_nH_{2n+1}X$ X = F, Cl, Br or I | $C_nH_{2n}O$ | $C_nH_{2n}O$ | $C_nH_{2n}O_2$ | $C_nH_{2n+1}OH$ | $C_nH_{2n}O_2$ |
| Functional group |  Only C-H and C-C single bonds |  Carbon-carbon double bond |  Carbon-carbon triple bond |  Halogen atom bonded to a saturated C atom |  Formyl group |  Carbonyl group bonded to two C atoms |  |  Hydroxyl group bonded to a saturated C atom |  Carboxyl group |
| Example structural formula |  |  |  |  |  |  |  |  |  |
| Example IUPAC name | Ethane | Ethene | Ethyne | Bromoethane | Ethanal | Propanone | Methyl ethanoate | Ethanol | Ethanoic acid |
| Intermolecular | London forces | | | | | | | | |

Note: The number of C atoms in the longest carbon chain (not always the straight chain) that contains the functional group determines the **parent name**.

Step 3: number the carbon atoms in the chain from the side nearest to functional group

- **Alkanes and haloalkanes:** Number from the side that will give the substituents the smallest numbers.
- **Alkenes, alkynes, alcohols, ketones:** Number from the side that will the functional group the smallest number. The functional group receives a number that is written

between parent name and suffix.

- **Aldehydes and carboxylic acids:** Number from the C atom that forms part of the functional group.

**Step 4 name and Arrange substituents in alphabetical order** in the IUPAC name (*bromo, chloro, ethyl, methyl*)

- If two or more of the same substituents occur, use di- and tri- in front of the name of the substituent e.g. *dimethyl* or *tribromo*. (*Di-* and *tri* are ignored when arranging substituents in alphabetical order.)
- When there are two (or more) identical groups on the same C atom, the number of the C atom is repeated with commas between the numbers e.g. ***2,4,4-tri**methylhexan-3-one*

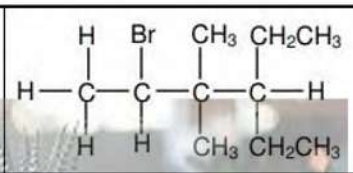
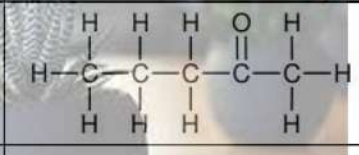
**Note:** when naming halo alkanes;

- Halogen substituents do not get preference over alkyl groups
- Numbering should start from the end nearest to thee first substituents
- When substituents, e.g. Br, and Cl or Cl and methyl have the same number when numbering from different ends of chain, preference is given to alphabetical order

Example

**Activities**

The letters **A** to **E** in the table below represent five organic compounds.

| | | | |
|---|---|---|---|
| **A** |  | **B** | $C_xH_y$ |
| **C** |  | **D** | $CH_3(CH_2)_2CH(OH)CH_2CH_3$ |
| **E** | $CH_3CH_2CH_2CH_2CH_2CH_2CHCH_2$ | | |

1.1 Write down the LETTER that represents EACH of the following:

1.1.1 A ketone (1)

1.1.2 A hydrocarbon (1)

1.1.3 An alkene (1)

1.2 Write down the:

1.2.1 IUPAC name of compound **A** (2)

1.2.2 IUPAC name of compound **C** (2)

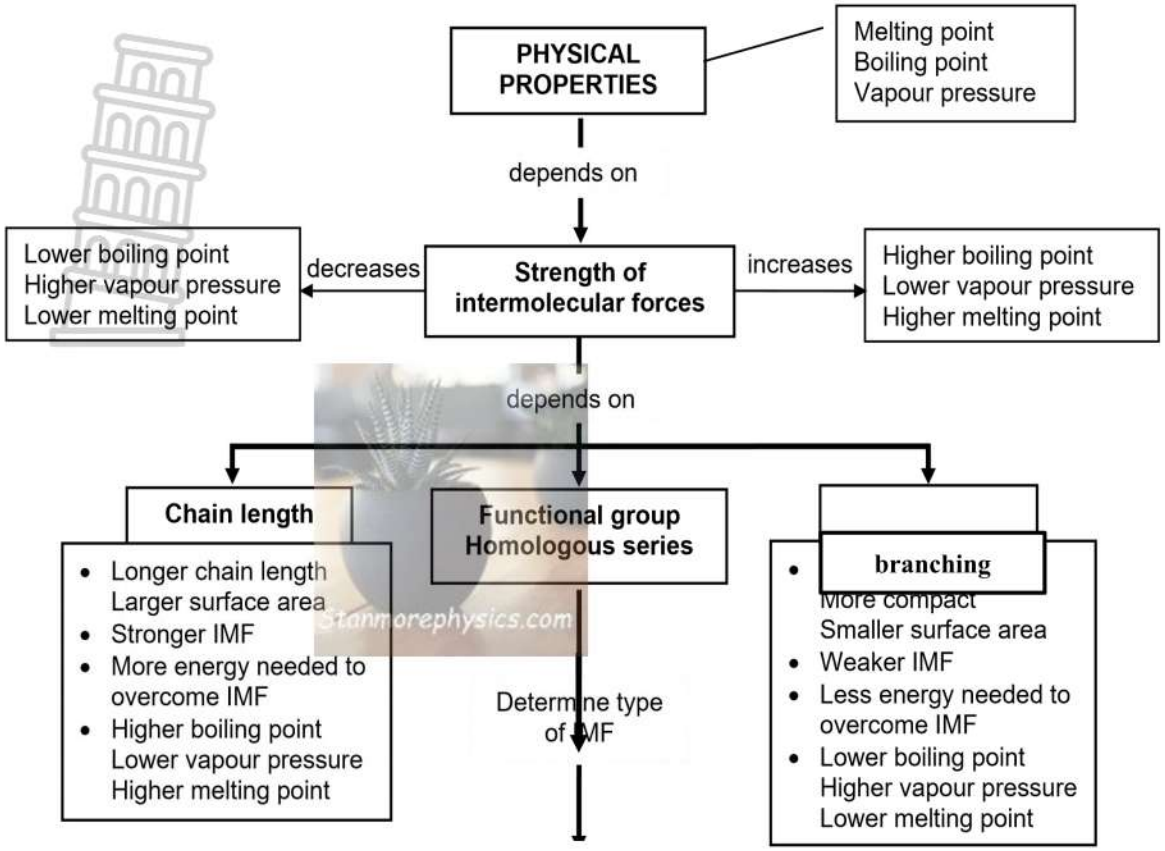
1.2.3 IUPAC name of the STRAIGHT CHAIN FUNCTIONAL ISOMER of compound **C** (2)

1.2.4 Type of alcohol **D** (1)

**[10]**

**PART B: physical properties**

| **Homologous series** | **Main intermolecular forces** |
|---|---|
| Alkanes, Alkenes, Alkynes | London forces (**Van der Waals forces**) Weak |
| Aldehydes, Ketones, Esters, Halo alkanes | Dipole-dipole forces **(Van der Waals forces)** Stronger |
| Alcohols, Carboxylic acids | **Hydrogen bond strongest** |




**Note:** boiling points of carboxylic ac... .s higher than that of alcohols, although both have hydrogen bonds

**Explanation**

- Between molecules of both alcohols and carboxylic acids are hydrogen bond
- But alcohols have one site of hydrogen bond formation and carboxylic acids have two sites of hydrogen bond formation
- hydrogen bond s in carboxylic acids are stronger than the hydrogen bonds in alcohols
- more energy is needed to overcome hydrogen bonds in carboxylic acids than in alcohols

**ACTIVITY**

Three sets of organic molecules are shown below.

**SET 1** Propane and butane.

**SET 2** Butane and 2-methylpropane.

**SET 3** Propan-1-ol and ethanoic acid.

1.1

In **SET 1**, which compound propane or butane has a higher boiling point?

Use the **molecular structure**, **intermolecular forces** and **energy** to explain the

answer.

**ANSWER**

Butane ✓

-Increase in carbon chain increases the molecular mass and the contact area/surface area. ✓

-This increases the strength of intermolecular forces/London forces in butane. ✓

- More energy is required to overcome the intermolecular forces/London forces in butane. ✓

**OR:**

-Decrease in carbon chain decreases the molecular mass and the contact area/surface area (over which intermolecular forces/London forces work (in propane). ✓

-This decreases the strength of intermolecular forces/London forces (in propane). ✓

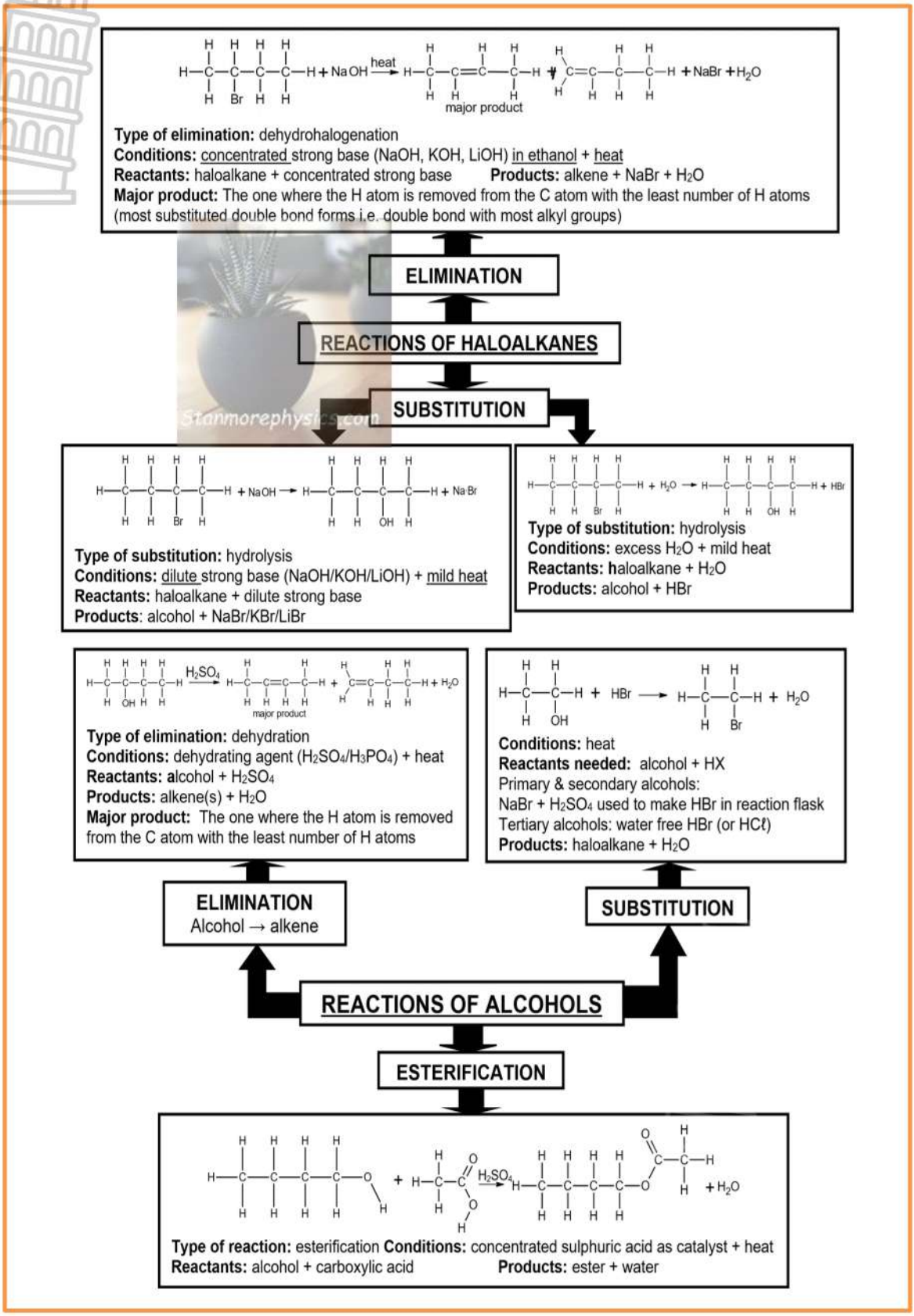
- Less energy is required to overcome the intermolecular forces/London forces (in propane). ✓

(4)

1.2 In **SET 2**, explain why the vapour pressure of butane is lower than the vapour pressure of 2-methylpropane.
Refer to the **molecular structure, intermolecular forces** and **energy.** (3)

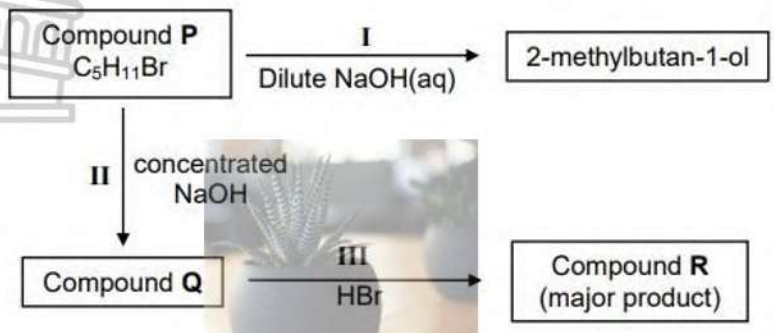
In **SET 3**, which one, Propan-1-ol or ethanoic acid has the higher boiling point? Explain the answer by referring to the **molecular structure**, **intermolecular forces** and **energy.** (5)

## PART C: CHEMICAL PROPERTIES



**ACTIVITY**

Compound **P** is used as a starting reactant in each of two reactions as shown in the flow diagram below.




**I**, **II** and **III** represent organic reactions.

1.1 Name the type of reaction represented by **I** and II (2)

1.2 Is 2-methylbutan-1-ol a PRIMARY, SECONDARY or TERTIARY alcohol?
Give a reason for the answer. (2)

1.3 Write down the STRUCTURAL FORMULA of compound **P**. (2)

1.4 To which homologous series does compound **Q** belong? (1)

1.5 Name the type of reaction represented by **III**. (1)
Choose from ADDITION, ELIMINATION or SUBSTITUTION

1.6 Write down the IUPAC name of compound **R**. (1)

**REACTION RATES**

**Define heat of reaction (ΔH)** as the energy absorbed or released in a chemical reaction.

**Define exothermic reactions** as reactions that release energy.

**Define endothermic reactions** as reactions that absorb energy

**Define activation energy** as the minimum energy needed for a reaction to take place.

**Define an activated complex** as the unstable transition state from reactants to products.

Define a catalyst as a substance that increases the rate of a chemical reaction without itself undergoing a permanent change.

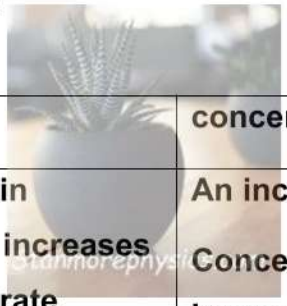
**Define reaction rate** as the change in concentration of reactants or products per unit time.

**Conditions required for a chemical reaction to take place**

- molecules must have energy equal to or greater than activation energy
- molecules must react with correct orientation.

**Factors affecting reaction rates**

- Temperature
- Concentration
- State of division (surface area)
- catalyst



| **temperature** | **concentration** | **Nature of reactants** |
|---|---|---|
| **An increase in temperature increases the reaction rate**<br>Increasing temperature increases the average kinetic energy of particles - **More effective collisions per unit time** | **An increase in Concentration increases the reaction rate**<br>Increasing concentration increases the number of particles that are colliding **- More effective collisions per unit time** | Using a more reactive substance increases the reaction rate<br>more particles collide effectively<br>More effective collisions per unit time |
| **Surface area (state of division)** | **Catalyst** | **-** |
| **An increase in surface area increases the reaction rate**<br>Increasing surface area increases the number of particles that are exposed<br>**More effective collisions per unit time** | **Adding a catalyst increases the reaction rate**<br>More particles have enough energy as the catalyst lowers the activation energy<br>**More effective collisions per unit time** | |

**ACTIVITY**

The reaction of sulphuric acid (H2SO4) with calcium carbonate (CaCO3) to investigate some of the factors which influences the reaction rate.

$Zn(s) + 2HC\ell\,(aq) \rightarrow ZnC\ell_2\,(aq) + H_2(g)$

The experimental results are shown in the table below.

| Experiment | REACTION CONDITIONS | | |
|---|---|---|---|
| | Concentration of $HC\ell$ ( · $^{-}$ ) | Reaction Temperature (°C | State of division of Zn |
| 1 | 0,5 | 34 | granules |
| 2 | 0,5 | 34 | powder |
| 3 | 0,8 | 36 | powder |
| 4 | 0,4 | 36 | Powder |
| 5 | 0,4 | 34 | powder |

1.1 Which **experiment 1** or **2** have a higher reaction rate? Use the collision theory to explain the answer. (4)

1.2 Use the collision theory to explain why the **experiment 3** has a higher reaction rate than **experiment 4** (3)

1.3 Which **experiment 4** or **5** have a higher reaction rate? Use the collision theory to explain the answer. (4)

1.4 Use collision theory to explain how a catalyst influences the rate of a chemical reaction. (3)

**[14]**

## CHEMICAL EQUILIBRIUM

**An open system** continuously interacts with its environment.

**a closed system** is isolated from its surroundings.

**A reversible reaction** is a reaction where the products can be converted back to reactants and visa versa.

**Chemical equilibrium**: is a dynamic equilibrium when the rate of the forward reaction equals the rate of the reverse reaction.

**Le Chatelier's principle**: When the equilibrium in a closed system is disturbed, the system will re-instate a new equilibrium by favouring the reaction that will oppose the disturbance.

**factors that influence the position of an equilibrium**

- concentration
- temperature.
- pressure (in gases only),



| **TEMPERATURE** | |
|---|---|
| **If Temperature is increased** | **If Temperature is decrease** |
| - The system favours the reaction that will decrease the temperature<br>- Increase in temperature favours the Endothermic reaction<br>- Mention which reaction is favoured, forward or reverse<br>- Mention the change in concentrations of reactants and products | - The system favours the reaction that will increase the temperature<br>- Decrease in temperature favours the Exothermic reaction<br>- Mention which reaction is favoured, forward or reverse<br>- Mention the change in concentration of reactants and products |
| **PRESSURE** | |
| **If pressure is increased** by decreasing the volume of the container | **If pressure is decreased** By increasing the volume of the container |

| | |
|---|---|
| - The system favours the reaction that will decrease the pressure<br>- Increase in pressure favours the reaction that proceeds towards the fewer number of moles<br>- Mention the reaction that is favoured, forward or reverse<br>- Mention the change in concentration of reactants and products | - The system favours the reaction that will increase the pressure<br>- Decrease in pressure favours the reaction that proceeds towards the greater number of moles<br>- Mention the reaction that is favoured, forward or reverse<br>- Mention the change in concentration of reactants and products |
| **CONCENTRATION** | |
| **If concentration of a reactant is increased** | **If concentration of a reactant is decreased** |
| - The system favours the reaction that will decrease that reactant's concentration<br>- Forward reaction is favoured<br>- Concentration of reactants will decrease and concentration of products will increase | - The system favours the reaction that will increase that reactant's concentration<br>- Reverse reaction is favoured<br>- Concentration of reactants will increase and concentration of products will decrease |
| **If concentration of a product is increased** | **If concentration of a product is decreased** |
| - The system favours the reaction that will decrease that product's concentration<br>- Reverse reaction is favoured<br>- Concentration of reactants will increase and concentration of products will decrease | - The system favours the reaction that will increase that product's concentration<br>- Forward reaction is favoured<br>- Concentration of reactants will decrease and concentration of products will increase |

**Note**: The Kc value can only change if the temperature changes.

- Kc value increases if forward reaction is favoured

- Kc value decreases if reverse reaction is favoured

Writing KC expression

aA + bB $\rightarrow$cC+ dD

- Do not write Kc expression as $= \frac{[\quad]}{[\quad]}$, rather write directly the
- Only concentration of aqueous solutions(aq) and gases(g) appear in Kc expression. Concentration of solids and pure liquids remain constant, they are not included in Kc expression
- A high Kc value (Kc >1) means that the concentration of products is greater than the concentration of reactants
- A lower Kc value (Kc < 1) means that the concentration of products is lower than the concentration of reactants

**EXAMPLE**

Write Kc expression for each of the following chemical equations

$2HI(g) \rightarrow H_2(g) + I_2(g)$

$= \frac{[\ _2][\ _2]}{[\ ]^2}$

$CaCO_3(s) \rightarrow$ **CaO(s) +** $CO_2(g)$

$= \frac{1}{[\ 2]^2}$

Aa (g)+ Bb(l) $\rightarrow$ Cc (g) + Dd(s)

$= \frac{[\ ]}{[\ ]}$

**ACTIVITY**

Carbon reacts with sulphur according to the following balanced chemical equation

C(s) + 2S(g) $\rightleftharpoons$CS2 (g) $\Delta > 0$

1.1 State Le chatelier's principle (2)

1.2 State if the above reaction is homogeneous or heterogeneous reaction. (1)

1.3 Write down the Kc expression. (1)

1.4 State whether the reaction is endothermic or exothermic.

Write down a reason for the answer. (1)

**[5]**

**ACIDS AND BASES**

**An acid according to Lowry–Bronsted theory**: is a proton ($H^+$ ion) donor

**A base according to Lowry – Bronsted theory**: is a proton ($H^+$ ion) acceptor:

**An acid according to Arrhenius theory**: A substance that produces hydrogen ions ($H^+$ /$H_3O^+$ /hydronium ions) in aqueous solution.

**A base according to Arrhenius theory**: A substance that produce hydroxide ions ($OH^-$) in aqueous solution.

**Strong acid**: An acid that ionises completely in water to form a high concentration of $H_3O^+$ ions.

**Weak acid**: An acid that ionises incompletely in water to form a low concentration of $H_3O^+$ ions.

**Strong base:** A base that dissociate completely in water to form a high concentration of $OH^-$ ions.

**Weak base:** A base that dissociates/ionises incompletely in water to form a low concentration of $OH^-$ions

Concentrated acid:

**Weak bases:** dissociates/ionises incompletely in water to form a low concentration of $OH^-$ions

**Concentrated acids:** contain a large amount (number of moles) of acid in proportion to the volume of water.

**Dilute acids:** contain a small amount (number of moles) of acid in proportion to the volume of water.

**Concentrated base:** contains a large amount (number of moles) of base in proportion to the volume of water.

**Dilute bases**: contain a small amount (number of moles) of base in proportion to the volume of water **Standard solution:** a solution containing a precisely known concentration of an element or a substance.

**Concentration:** the amount of solute a given solution contains at a given temperature.

**Kw**: is the equilibrium constant for the ionisation of water or the ion product of water.

**Auto-ionisation of water:** i.e. the reaction of water with itself to form H3O + ions and $OH^-$ ions.

**Hydrolysis:** is the reaction of a salt with water.

**Equivalence point of a titration:** is the point at which the acid/base has completely reacted with the base/acid.

**End point of a titration:** is the point where the indicator changes colour.

**Conjugate acid-base pair**: is an acid base pair which differ by one proton.



$HCl(aq) + H_2O(l) \rightarrow Cl^-(aq) + H_3O+(aq)$

Identify the conjugate acid-base pairs

**ANSWER**

HCl and $Cl^-$

$H_3O+$and $H_2O$

**Ampholyte:** is a substance that can act as either a base or an acid. It is an acid in the presence of a strong base and a base in the presence of a strong acid.

| | | |
|---|---|---|
| $H_2O$ | Acid<br>Base | $H_2O \rightarrow H^+ + OH^-$<br>$H_2O + H^+ \rightarrow H_3O^+$ |
| $HSO_4^-$ | Acid<br>Base | $HSO_4^- \rightarrow H^+ + SO_4^{2-}$<br>$HSO_4^- + H^+ \rightarrow H_2SO_4$ |
| $H_2PO_4^-$ | Acid<br>Base | $H_2PO_4^- \rightarrow H^+ + HPO_4^{2-}$<br>$H_2PO_4^- + H^+ \rightarrow H_3PO_4$ |
| $HCO_3^-$ | Acid<br>Base | $HCO_3^- \rightarrow H^+ + CO_3^{2-}$<br>$HCO_3^- + H^+ \rightarrow H_2CO_3$ |
| $HPO_4^{2-}$ | Acid<br>Base | $HPO_4^{2-} \rightarrow H^+ + PO_4^{3-}$<br>$HPO_4^{2-} + H^+ \rightarrow H_2PO_4^-$ |

| Acid | Formula | Strong / Weak |
|---|---|---|
| Hydrochloric acid | HCl | Strong |
| Nitric acid | $HNO_3$ | Strong |
| Sulphuric acid | $H_2SO_4$ | Strong |
| Phosphoric acid | $H_3PO_4$ | Strong |
| Carbonic acid | $H_2CO_3$ | Weak |
| Ethanoic acid | $CH_3COOH$ | Weak |
| Oxalic acid | $(COOH)_2$ | Weak |

| | |
|---|---|
| **Monoprotic acid** | An acid that can donate only proton<br>**Examples**: HCl, $HNO_3$ |
| **Di protic acid** | An acid that can donate two protons<br>**Examples:** $H_2SO_4$ |

**Hydrolysis of salts**

Hydrolysis produces a solution which may be acidic, basic or neutral.

- If $H_3O^+$ ions are formed, the solution is acidic (PH is less than 7)
- If $OH^-$ ions are formed, the solution is basic (PH is greater than 7)
- If $H_3O^+$and $OH^-$ ions are not formed, the solution is neutral l(PH = 7)

**Note:** Reaction of strong acid and weak base produces acidic solution
Reaction of weak acid and strong base produces basic solution
Reaction of strong acid and strong base produces neutral solution

**ACTIVITY 1**

Nitric acid ( $_3$), an important acid used in industry, is a strong acid.

1.1 Give a reason why nitric acid is classified as a strong acid (1)

1.2 Write down the NAME or FORMULA of the conjugate base of nitric acid. (1)

1.3 Calculate the pH of a $0{,}3 \cdot ^{-3}$ nitric acid solution. (3)

**[4]**

**ACTIVITY2**

Write down the balanced chemical equation for the reaction of the following compounds with water

2.1 $NH_4Cl$ (3)

2.2 $Na_2CO_3$ (3)

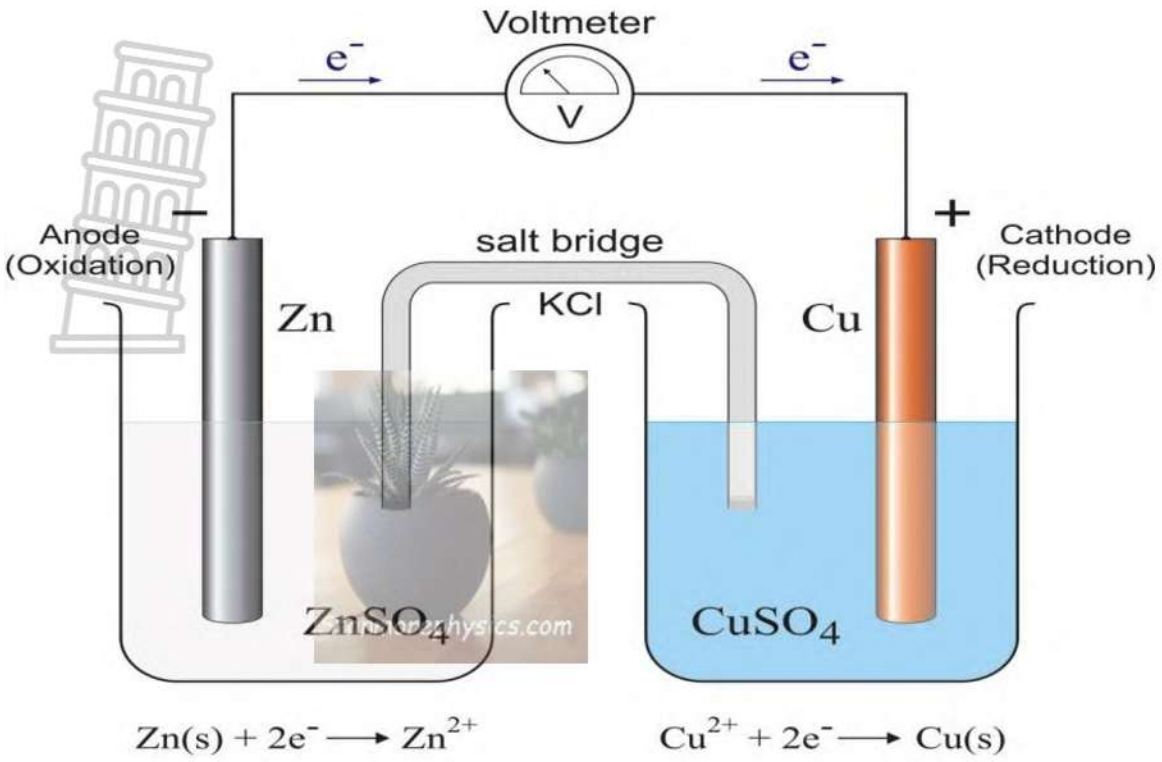
21.2 State whether the resultant solution in Q 1.1is acidic, basic or neutral. Give a reason for the answer (2) **[6]**

## ELECTROCHEMICAL REACTIONS

**Electrolytic cells and galvanic cells**

- Define the ***galvanic cell*** as a cell in which chemical energy is converted into electrical energy. A galvanic (voltaic) cell has self-sustaining electrode reactions.
- Define the ***electrolytic cell*** as a cell in which electrical energy is converted into chemical energy.
- Define o**xidation** and **reduction** in terms of electron ($e^-$) transfer:
  **Oxidation** is a loss of electrons. **Reduction** is a gain of electrons.
- Define oxidation and reduction in terms of oxidation numbers:
  **Oxidation:** An increase in oxidation number
  **Reduction:** A decrease in oxidation number
- Define an ***oxidising agent*** and a *reducing agent* in terms of oxidation and reduction:
  **Oxidising agent**: A substance that is reduced/gains electrons.
  **Reducing agent:** A substance that is oxidised/loses electrons.
- Define an *anode* and a *cathode* in terms of oxidation and reduction:
  **Anode**: The electrode where oxidation takes place
  **Cathode:** The electrode where reduction takes place
- Define an ***electrolyte*** as a solution/liquid/dissolved substance that conducts electricity through the movement of ions
- **Electrolysis**: The chemical process in which electrical energy is converted to chemical energy OR the use of electrical energy to produce a chemical change.

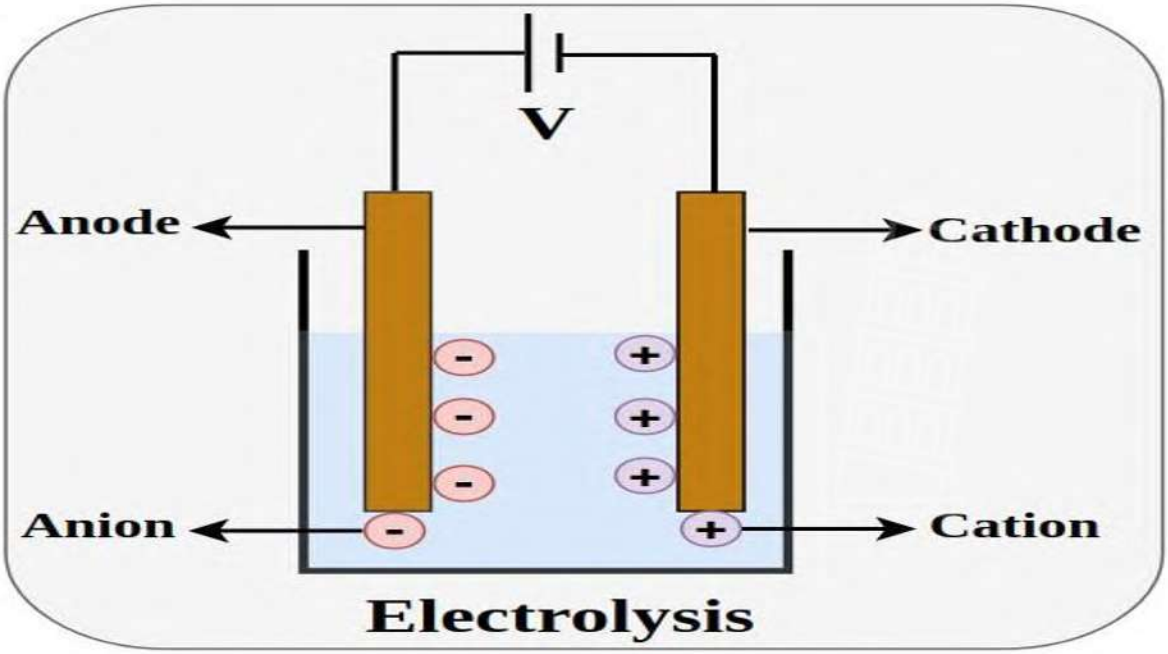
# GALVANIC CELL




$Zn(s) + 2e^- \longrightarrow Zn^{2+}$ $\qquad$ $Cu^{2+} + 2e^- \longrightarrow Cu(s)$

$$Zn(s) \mid ZnSO_4(aq) \,||\, CuSO_4(aq) \mid Cu(s)$$

# ELETROLYTIC CELL




## SUMMARY ON ELECTROCHEMISTRY

| GALVANIC (voltaic) cells | ELECTROLYTIC cells |
|---|---|
| chemical → electrical energy | electrical → chemical energy |
| the reaction is ***spontaneous***, produces electrical energy | ***not spontaneous***, electrical energy must be supplied |
| the ***anode*** is the ***negative*** electrode, the cathode is positive | ***anode*** is ***positive*** and cathode is the negative electrode. |
| oxidation happens at the anode, reduction happens at the cathode | oxidation happens at the anode, reduction happens at the cathode |
| the ½ -cells in different containers connected by a ***salt bridge*** | both electrodes may be in ***same container*** with one electrolyte. |
| ***electrons*** are supplied by the ***species being oxidized***. They move from anode to the cathode in the external circuit. | ***external battery supplies*** the ***electrons***. They enter through the cathode and come out through the anode. |

**BASIC COMPONENTS:**

- Two electrodes (inert / active)
- An electrolyte – solution or a molten ionic compound that conducts electricity through the motion of ions.

**ELECTROLYTIC CELL**

Type of **electrochemical cell** in which electrical energy is converted into chemical energy

**ELECTROLYSIS**

A chemical process in which electrical energy is converted to chemical energy OR the use of electrical energy to produce a chemical change

**Electrolysis of solutions using INERT electrodes**

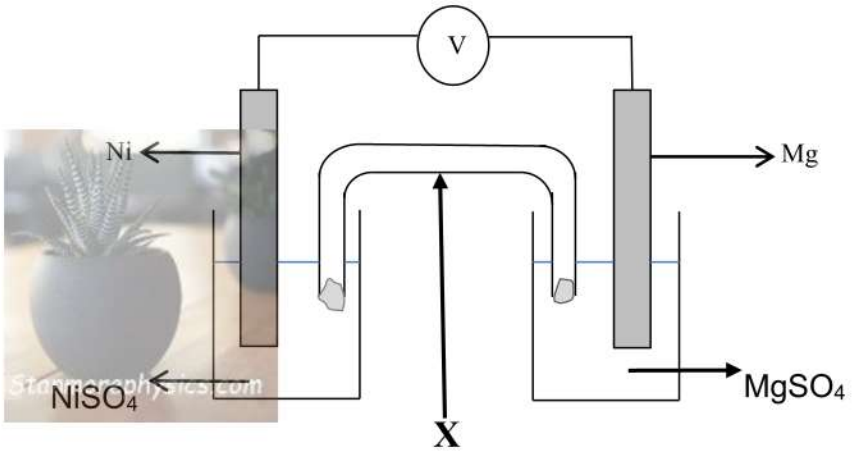
1. **Electrolysis of sodium chloride solution**
   - Both electrodes are made of graphite or carbon.
   - $C\ell^-$ ions are oxidised at the anode
     $2C\ell^- \rightarrow C\ell_2 + 2e^-$
   - $H_2O$ is reduced at the cathode
     $2H_2O + 2e^- \rightarrow H_2 + 2OH^-$
   - Net reaction
     $2H_2O(\ell) + 2C\ell^-(aq) \rightarrow H_2(g) + 2OH^-(aq) + C\ell_2(g)$
2. **Electrolysis of copper (II) chloride solution**
   - Both electrodes are made of graphite or carbon.
   - $C\ell^-$ ions are oxidised at the anode
     $2C\ell^- \rightarrow C\ell_2 + 2e^-$
   - $Cu^{2+}$ ions are reduced at the cathode
     $Cu^{2+} + 2e^- \rightarrow Cu$

**Electrolysis of solutions using ACTIVE electrodes**

1. **Refining of copper**
   - Anode is made of impure copper. Copper is oxidised at this electrode.
     $Cu \rightarrow Cu^{2+} + 2e^-$
   - Cathode is made of pure copper. $Cu^{2+}$ ions are reduced at this electrode.
     $Cu^{2+} + 2e^- \rightarrow Cu$
1. **Electroplating e.g. with silver**
   - The object to be electroplated forms the cathode, reduction of $Ag^+$ ions occurs at this electrode.
     $Ag^+(aq) + e^- \rightarrow Ag(s)$
   - Silver metal forms the anode. Ag metal atoms from the metal become oxidised.
     $Ag(s) \rightarrow Ag^+(aq) + e^-$
   - Electrolyte is a concentrated solution containing ions of the metal that is to be electroplated e.g. $Ag^+$ ions.

**ACTIVITY**

A standard electrochemical cell is set up using nickel (Ni) and electrode **Z** as shown in the diagram below.




1.2 Write down:

1.2.1 The energy conversion that takes place in this cell. (1)

1.2.2 A balanced equation the this cell. (3)

1.2.3 The cell notation of the cell. (1)

1.2.2 ONE standard condition required for the cell to operate. (1)

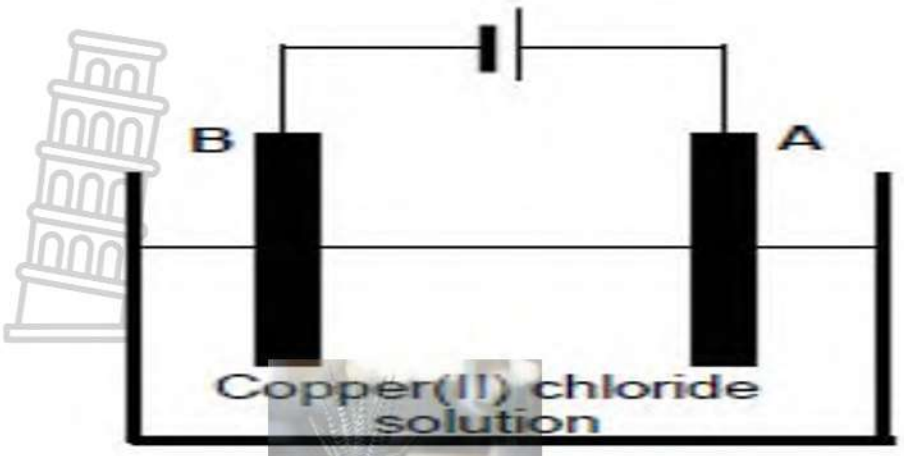
1.2.3 The name of the component X (1)

1.2.4 ONE function of the component X. (1)

1.3 Calculate the emf of the cell. (3)

**[11]**

2 The electrochemical cell below is set up to demonstrate the purification of copper.




1.1 Define the term oxidation in terms of electron transfer. (2)

1.2 Write down the type of electrochemical cell illustrated above. (1)

1.3 Which electrode **A** or **B** is the anode? (1)

1.4 Is the chemical reaction in the above cell endothermic or exothermic? (1)

**[5]**