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Province of the
EASTERN CAPE
EDUCATION

PHYSICAL SCIENCES

AUTUMN CLASSES

GRADE 12

TERM 1

TEACHER AND LEARNER CONTENT MANUAL

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SUBJECT: PHYSICAL SCIENCES

GRADE 12

TERM 1

TEACHER AND LEARNER CONTENT MANUAL

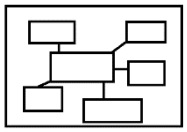
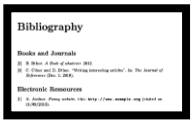
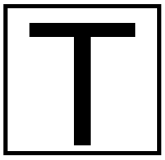
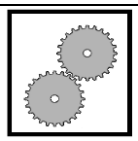
Topic(s)

1. Newton's Laws of Motion

CONTENTS **PAGE**

TOPIC 1: Newton's Laws of Motion ○ Examination guideline and outcomes ○ Important terms and definitions ○ Worked examples. ○ Activities	**4 - 19**

ICON DESCRIPTION

 MIND MAP	 EXAMINATION GUIDELINE	 CONTENTS	 ACTIVITIES
 BIBLIOGRAPHY	 TERMINOLOGY	 WORKED EXAMPLES	 STEPS

NEWTON'S LAWS: EXAMINATION GUIDELINES

Different kinds of forces: weight, normal force, frictional force, applied force (push or pull), tension (strings or cables)

- Define *normal force,* N, as the force or component of a force which the surface exerts on an object with which it is 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 friction,* f_s*,* as the force that opposes the tendency of motion of a stationary object relative to a surface.
  Define *kinetic frictional,* f_k*,* as the force that opposes the motion of a moving object relative to the surface.
  Know that a frictional force:
  - Is proportional to the normal force.
  - Is independent of the area of contact.
  - Is independent of the velocity of motion.
- Solve problems using $f_s^{max} = \mu_k N$ where f_s^{max} is the maximum static frictional force and μ_s is the coefficient of static friction.
  NOTE:
  - If the force, F, applied to a body parallel to the surface does not cause the object to move, F is equal in magnitude to the static frictional force.
  - The static frictional force is a maximum (f_s^{max}) just before the object starts to move across the surface.
  - If the applied force exceed f_s^{max} , a resultant net force accelerate the object.
- Solve problems using $f_k = \mu_k N$, where f_k is the kinetic frictional force and μ_k the coefficient of kinetic friction.

Force diagrams, free-body diagrams

- Draw force diagrams.
- Draw free-body diagrams. (This is a diagram that shows the relative magnitudes and directions of the forces acting on a body/particle that has been isolated from its surroundings)
- Resolve two-dimensional forces (such as the weight on an object on an inclined plane) into its parallel (x) and perpendicular (y) components.
- Determine the resultant or net force of two or more forces.

Newton's first, second and third laws of motion.

- State 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.
- Discuss why it is important to wear a seatbelt using Newton's first law of motion.
- State Newton's second law of motion: When a net force acts on an object, the object will accelerate in the direction of the net force and acceleration is directly proportional to the force and inversely proportional to the mass of the object.

- Draw force diagrams and free-body diagram for object that are in equilibrium or accelerating.
- Apply Newton's laws to variety of equilibrium and non-equilibrium problems including:
    - A single object:
        - Moving on horizontal plane with or without friction
        - Moving on an inclined plane with and without friction
        - Moving in the vertical plane (lifts, rockets, etc)
    - Two-body systems (joined by a light inextensible string) by applying Newton's laws of motion separately to EACH of the bodies:
        - Both on the horizontal plane with and without friction
        - One on a horizontal plane with and without friction, and a second hanging vertically from a string over a frictionless pulley
        - Both on an inclined plane with or without friction
        - Both hanging vertically from a string over frictionless pulley.
- State Newton's third law of motion: When object A exert a force on object B, object B SIMULTANEOUSLY exert an oppositely directed force of equal magnitude on object A
- Identify action-reaction pairs.
- List the properties of action reaction pairs.

Newton's Law of Universal Gravitation

- State Newton's Law of Universal Gravitation: Each body in the universe attract every other body with a force that is directly proportional to the product of their masses and inversely proportional to the square of the distances between their centres.
- Solve problems using $F = \frac{Gm1m2}{r2}$
- Describe weight as a gravitational force the earth exert on any object on or near its surface.
- Calculate weight using the expression w = mg.
- Calculate weight of an object on other planets with different values of gravitational acceleration
- Distinguish between *weight* and *mass.*
- Explain *weightlessness.*

IMPORTANT TERMS AND DEFINITIONS

NEWTON'S LAWS OF MOTION	
NORMAL FORCE: N	The force or the component of a force in which a surface exerts on an object with which it is in contact, and that is perpendicular to the surface.
KINETIC FRICTIONAL FORCE: f_k	The force that opposes the motion of a moving object relative to a surface
STATIC FRICTIONAL FORCE: f_s^{max}	The force that opposes the tendency of a motion of a stationary object relative to a surface.
NEWTON'S FIRST LAW OF MOTION:	A body will remain in a 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 net force acts on an object, the object will accelerate in the direction of the force and the acceleration is directly proportional to the force and inversely proportional to the mass of the object.
NEWTON'S THIRD LAW OF MOTION:	When object A exerts a force on object B, object B simultaneously exert oppositely directed force of equal magnitude on object A.
NEWTON'S LAW OF UNIVERSAL GRAVITATION:	Each body in the universe attracts every other body with the force that is directly proportional to the product of their masses and inversely proportional to the square of the distance between their centres.
WEIGHT:	The gravitational force the Earth exerts on any object on or near its surface measured in Newton (N).
MASS:	The amount of matter in a body measured in kilogram (kg).
INERTIA:	The resistance of a body to change in its state of uniform motion or rest
WEIGHTLESSNESS:	The sensation experienced when all contact forces are removed

DATA FOR PHYSICAL SCIENCES GRADE 12
PAPER 1 (PHYSICS)

TABLE 1: PHYSICAL CONSTANTS/*TABEL 1: FISIESE KONSTANTES*

NAME/*NAAM*	SYMBOL/*SIMBOOL*	VALUE/*WAARDE*
Acceleration due to gravity *Swaartekragversnelling*	g	9,8 $m \cdot s^{-2}$
Universal gravitational constant *Universele gravitasiekonstante*	G	6,67 x 10^{-11} $N \cdot m^2 \cdot kg^{-2}$
Radius of the Earth *Radius van die Aarde*	R_E	6,38 x 10^6 m
Mass of the Earth *Massa van die Aarde*	M_E	5,98 x 10^{24} kg
Speed of light in a vacuum *Spoed van lig in 'n vakuum*	c	3,0 x 10^8 $m \cdot s^{-1}$

FORCE/*KRAG*

$F_{net} = ma$	$p = mv$
$f_s^{max} = \mu_s N$	$f_k = \mu_k N$
$F_{net}\Delta t = \Delta p$ $\Delta p = mv_f - mv_i$	$w = mg$
$F = G\frac{m_1 m_2}{d^2}$ or/*of* $F = G\frac{m_1 m_2}{r^2}$	$g = G\frac{M}{d^2}$ or/*of* $g = G\frac{M}{r^2}$

CONTENT

Key concepts

- Important definitions & Laws
- Free-body diagrams
- Calculations:
    - Normal force
    - Frictional force
    - Acceleration
    - Tension
    - Components of Force applied and gravitational force.
- Law of Universal Gravitation
    - Calculation of Gravitational force
    - Calculation of Gravitational acceleration

Quantity Name	Quantity Symbol	Unit Name	Unit Symbol
Normal force	N	Newtons	N
Frictional Force	f	Newtons	N
Kinetic Friction	f_k	Newtons	N
Maximum Static friction	f_s^{max}	Newtons	N
Tension	T	Newtons	N
Net Force	F_{net}	Newtons	N
Mass	m	Kilograms	Kg
Acceleration	a	Metres per second squared	$m.s^{-2}$
Coefficient of friction	μ	No unit	

FRICTION FORCE AND NORMAL FORCE

NORMAL FORCE (N)

The force or the component of a force in which a surface exerts on an object with which it is in contact, and that is perpendicular to the surface.

- **Normal force** is the force exerted by a flat surface on an object with which it is in contact.
- Always acts perpendicular (at right angle, 90^0) to the surface.
- **Normal force** equal to the gravitational force F_g, or the net of F_g and other forces acting perpendicular to the surface.

FRICTIONAL FORCE (f)

- **Frictional Force** is caused by one surface tending to move over another, while in contact

- Resist the movement of an object.

  - Prevents it from moving.
  - Or makes it move slower.

KINETIC FRICTIONAL FORCE (f_k)

$$f_k = \mu_k N$$

$f_k - kinetic\ frictional\ force\ (N)$
$\mu_k - coefficient\ of\ kinetic\ frictional\ force\ (no\ unit)$
$N - Normal\ force(N)$

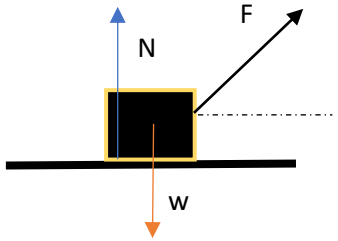
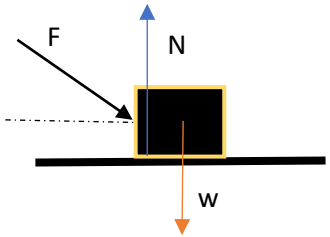
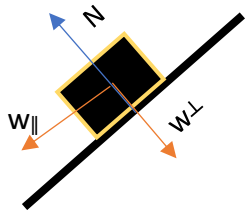
MAXIMUM STATIC FRICTIONAL FORCE (f_s^{max})

$$f_s^{max} = \mu_k N$$

$f_s^{max} - Static\ frictional\ force\ (N)$
$\mu_s - coefficient\ of\ Static\ frictional\ force\ (no\ unit)$
$N - Normal\ force(N)$

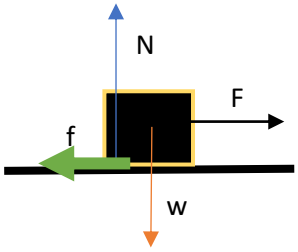
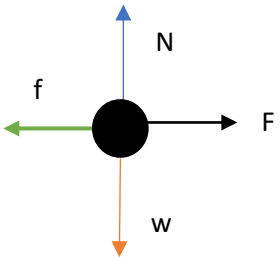
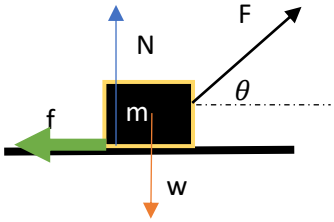
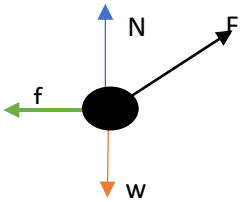
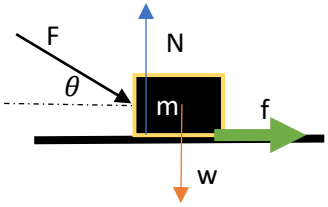
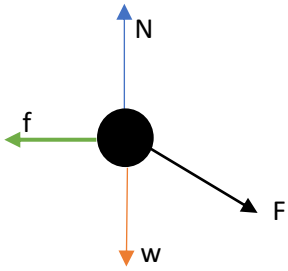
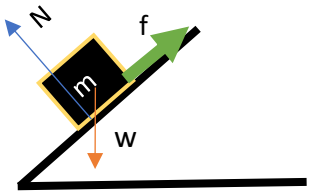
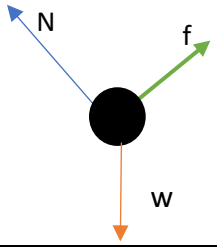
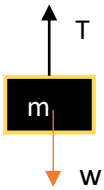
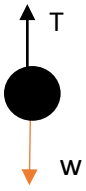
Normal force qual to gravitational force or the net of F_g and other forces acting perpendicular to the surface.

$$F_{net} = ma = 0$$
$$N + (-w) = 0$$
$$N = w$$
$$N = mg$$
$$f_k = \mu_k N$$
$$f_k = \mu_k mg$$

PULLING at an angle	PUSHING at an angle	**For an object on the inclined plane Normal force will equal the magnitude of perpendicular component of weight ($w_{\perp}$)**
 $F_{net} = ma = 0$ $N + F_y + (-w) = 0$ $N = w - F_y$ $N = mg - Fsin\theta$ $f_k = \mu_k N$ $f_k = \mu_k(mg - Fsin\theta)$ • When the angle is increased, the normal will decrease, hence the frictional force will also decrease. • When the angle is decreased, the normal force will increase, hence the frictional force will also increase.	 $F_{net} = ma = 0$ $N + (-F_y) + (-w) = 0$ $N = w + F_y$ $N = mg + Fsin\theta$ $f_k = \mu_k N$ $f_k = \mu_k(mg - F_a sin\theta)$ • When the angle is increased, the normal will increase, hence the frictional force will also increase. • When the angle is decreased, the normal force will decrease, hence the frictional force will also decrease.	 $F_{net} = ma = 0$ $N + (-w_{\perp}) = 0$ $N = w_{\perp}$ $N = wcos\theta$ $N = mgcos\theta$ $f_k = \mu_k N$ $f_k = \mu_k(mgcos\theta)$ • When an angle is increased, the normal force will decrease, hence the frictional force will also decrease. • When an angle is decreased, the normal force will increase, hence the frictional force will also increase.
Any change made on an angle will affect the co-efficient of kinetic friction		

FORCE DIAGRAM AND FREE BODY DIAGRAM

- **A free body diagram** is a picture of an object of interest drawn as a dot and all the forces acting on it are drawn as arrows pointing away from the dot (**in a free body diagram the object is represented by a dot**)
- **Force diagram**: force diagram is a representation of all the forces acting on the object. It is drawn as an arrow.

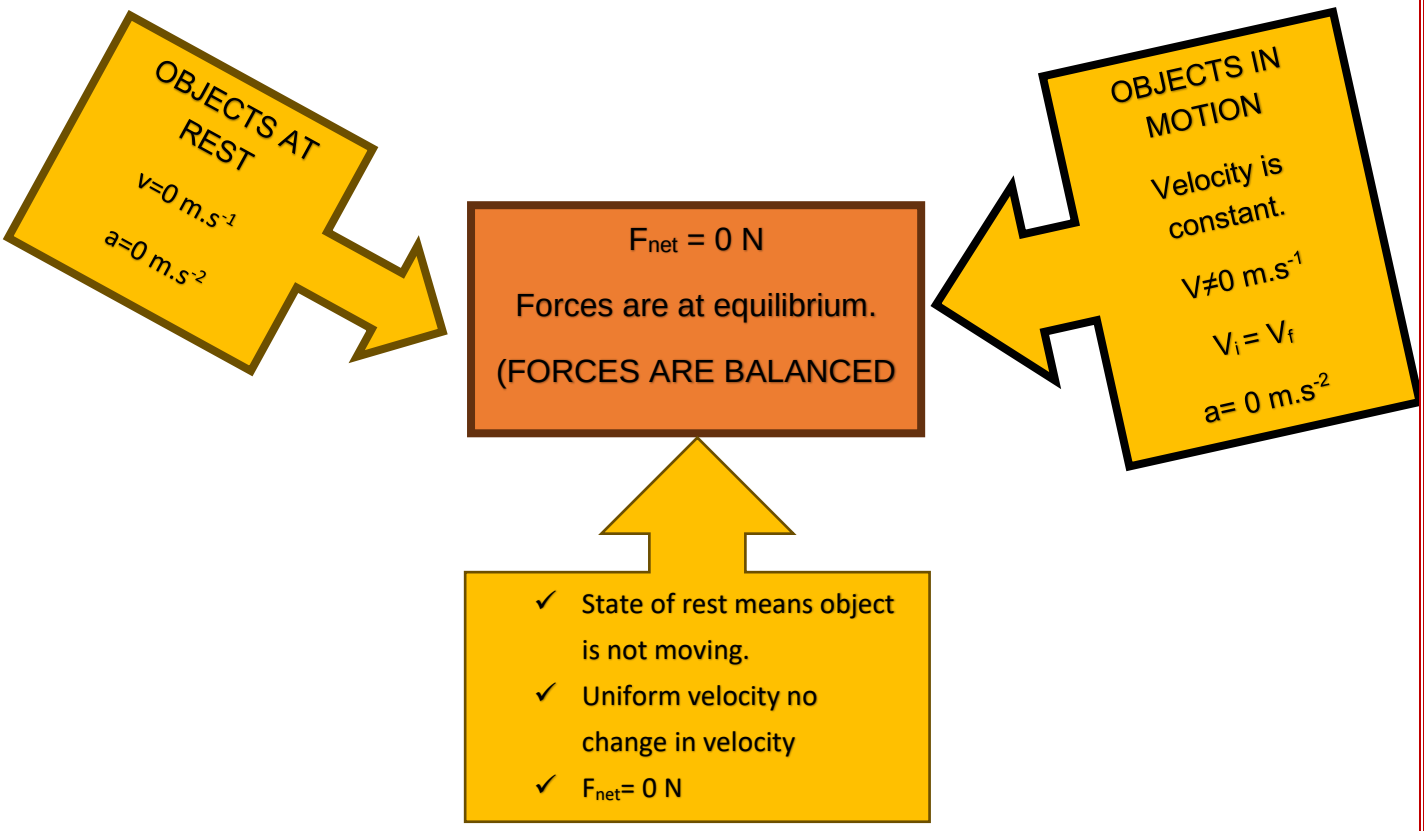
Examples	FORCE DIAGRAM	FREE BODY DIAGRAM
EXAMPLE 1 Force **A** is applied to the right, on an object resting on a rough surface.		
EXAMPLE 2 Force **A** is exerted on an object, mass **m** and pulls the object at an angle, **ɵ** to the horizontal along a rough surface.		
EXAMPLE 3 Force **A** is applied on an object, mass **m** and pushes the object at an angle, **ɵ** to the horizontal surface and experiences frictional force **f**.		
EXAMPLE 4 Object m, resting on an inclined plane and experiences a frictional force **f**		
EXAMPLE 5 Object **m** is suspended on a ceiling with a light inextensible string.		

NB: More examples must be done on an inclined plane and two-body systems (joined by a light inextensible string).

NEWTON'S LAWS OF MOTION

NEWTON'S FIRST LAW

A body will remain in its state of REST or motion at CONSTANT VELOCITY unless a non-zero resultant/net force act on it.



Newton's first law is sometimes referred as **INERTIA**.

Inertia: Is a tendency of an object to resist any change in its state of rest or uniform motion.

Application: The importance of wearing seatbelts:

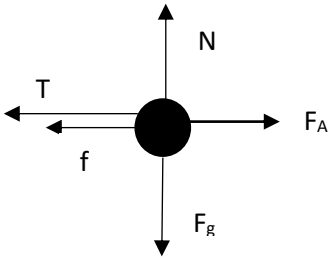
- We wear seat belts in cars. Why?
- This is to protect us when the car is involved in an accident. If a car is travelling at 120 km.h^{-1}, the passengers in the car are also travelling at 120 km.h^{-1} due to inertia.
- When the car suddenly stops a force is exerted on the car (making it slow down), but not on the passengers. The passengers will carry on moving forward at –120 km.h^{-1} according to Newton first law.
- If they are wearing seat belts, the seat belts will stop them and therefore prevent them from getting hurt.

EXAMPLE 1

Two objects are being pulled over a straight rough horizontal surface with a force of 900 N. The mass of object **A** is 130 Kg, and the mass of object **B** is 95 Kg. The two objects are connected by a light inextensible rope.

The two objects move at constant velocity.

1.1 Draw a labelled free-body diagram to show all the forces acting on object **A**. (5)



F_A	✓
T	✓
N	✓
Fg	✓
f	✓

1.2 Calculate the magnitude of the kinetic frictional force between object **A** and the surface if the coefficient of kinetic friction is 0.45. (3)

$f_k = \mu_k N$✓
$f_k = \mu_k mg$
$f_k = (0.45)(130)(9.8)$✓
$f_k = 573.3\ N$✓

1.3 Name and state the Law that is relevant for the scenario above. (3)

NEWTON'S FIRST LAW

A body will remain in its state of REST or motion at CONSTANT VELOCITY unless a nonzero resultant/net force act on it.

NEWTON'S SECOND LAW OF MOTION:

When a net force acts on an object, the object will accelerate in the direction of the net force and acceleration is directly proportional to the force and inversely proportional to the mass of the object.

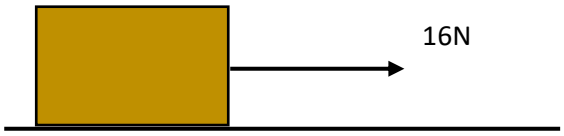
$F_{net} = ma$

- Directly proportional means as the acceleration increases also the F_{net} increases or acceleration decreases also the F_{net} decreases.
- $a \propto F_{net}$

- Inversely proportional means that as the acceleration increases the mass decreases.
- $a = \frac{1}{m}$

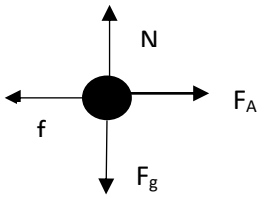
EXAMPLE 2

A 5kg block is placed on a horizontal surface. A horizontal force of 16 N is applied on the block, the block accelerates to the right as shown in the diagram below.



A frictional force between the block and the surface is 5 N

2.1 Draw a free-body diagram of all forces acting on the block as it accelerates (4)



F_A	✓
N	✓
Fg	✓
f	✓

2.2 State the law in words that can be used to explain why the block is accelerating (2)

When a net force acts on an object, the object will accelerate in the direction of the net force and acceleration is directly proportional to the force and inversely proportional to the mass of the object. ✓✓

2.3 Calculate the acceleration of the block.

$\boldsymbol{F_{net} = ma}$✓

$\boldsymbol{F_A - T = ma}$

$\boldsymbol{16 - 5 = 5a}$✓

$\boldsymbol{a = 2.2\ m.s^{-2}}$✓

2.4 The magnitude of the force is now increased to 25 N. Explain how the magnitude of acceleration will be affected (3)

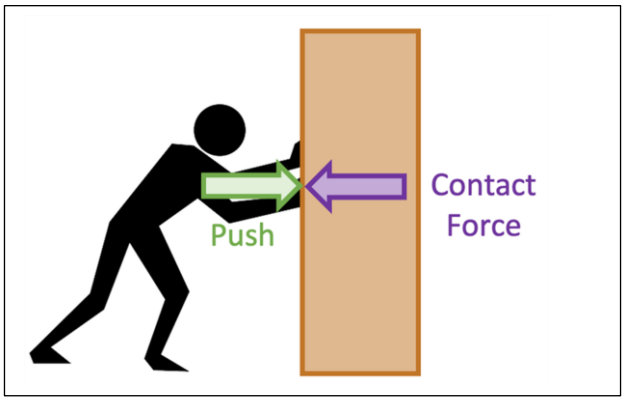
F_{net} = ma
According to Newton's second law F_{net} is directly proportional to acceleration. ✓

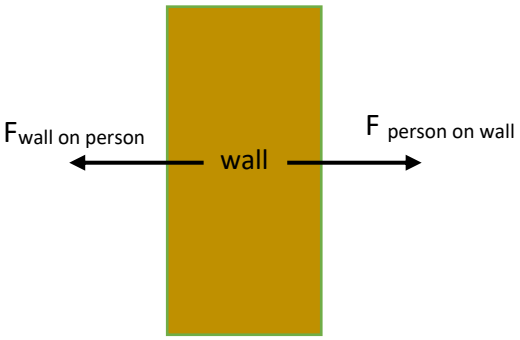
Acceleration will increase, an increase in the net force will increase acceleration since ✓

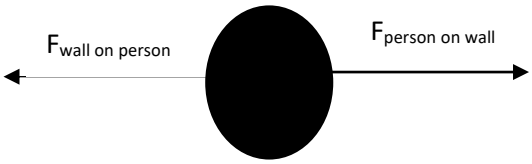
NEWTON'S THIRD LAW

When object A exert a force on object B, object B SIMULTENEOUSLY exert an oppositely directed force of equal magnitude on object A.

Person (OBJECT A) Wall (OBJECT B)







PROPERTIES OF ACTION-REACTION PAIRS

They are not balanced as the act on the different objects.

- Two forces of Action and Reaction have the same **magnitude**, but act in opposite directions.
- They act on different objects.
- They act along the same line.
- They arise from the same interaction.
- They occur simultaneously.

Newton's law of Universal Gravitation

Each body in the universe attracts every other body with the force that is directly proportional to the product of their masses and inversely proportional to the square of the distance between their centres.

$$F = \frac{Gm_1m_2}{r^2}$$

- The force of attraction between two objects is directly proportional to the product of their masses.

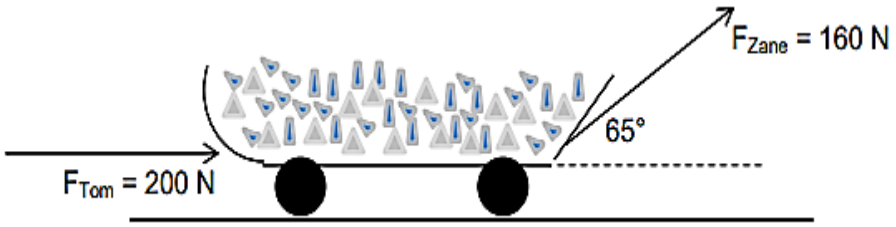
$$F \propto m_1m_2$$

- And inversely proportional to the square of the distance between their centres.

$$\mathbf{F} \propto \frac{\mathbf{1}}{r^2}$$

QUESTION 1

1.1 Tom is pushing and Zane is pulling a trolley, loaded with crushed stone, over a rough surface on a construction site. The mass of the trolley and its contents is 350 kg. Tom pushes with a force of 200 N and Zane pulls with a force of 160 N using a string, which makes an angle of 65° with the horizontal, as shown in the diagram below.



1.1.1 Define tension force and give an example of such a force in the diagram above. (3)

1.1.2 How will the frictional force on the trolley be affected by Zane's applied force? Write only INCREASES, DECREASES or REMAINS CONSTANT. (2)

1.1.3 Draw a free-body diagram of ALL the forces acting on the trolley and its contents. (5)

1.2 If the net force acting on the trolley and its contents is 205 N, calculate the coefficient of kinetic friction (μ_k) between the surface and the trolley. (6)

[16]

QUESTION 2

Two blocks, P and Q, resting on a rough horizontal surface, are connected by a light inextensible string. The string forms an angle of 25˚ to the horizontal. The blocks have masses 5 kg and 8 kg respectively. A constant force F is applied to the 8 kg block, as shown below.

The two blocks now move to the RIGHT at a CONSTANT SPEED of 3 m·s–1

2.1 State Newton's first law of motion in words. (2)

2.2 Draw a labelled free-body diagram for block P. (4)
The tension in the string between the blocks is 5 N.

2.3 Calculate the horizontal component of the tension in the string (T). (2)
Block P and Q experience constant frictional forces of 2,5 N and 1 N respectively.

2.4 State the definition of a net force (resultant force) in words. (2)

2.5 Calculate the magnitude of force F. (2)
The string connecting P and Q suddenly breaks while force F is still being applied.

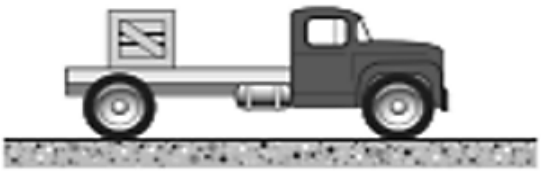
2.6 Is the direction of the acceleration of block Q now towards LEFT or RIGHT? Explain your answer. (3)

2.7 How will the net force acting on block P be affected when the string breaks? Choose from INCREASES, DECREASES or REMAINS THE SAME. (1)

[17]

QUESTION 3

3.1 A 360 kg crate rests on the back of a truck with a rough surface. The mass of the truck is 4 550 kg, and it is travelling at a speed of 105 km·h-1 to the right. The driver applies brakes, and the truck slows down to a speed of 62 km·h^{-1} in 7 s.



3.1.1 If the crate is not secured with ropes, explain what will happen to it when the driver applies the brakes. (2)

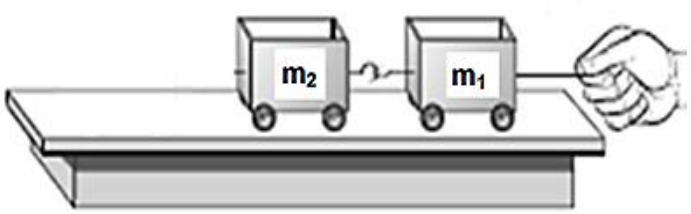
3.1.2 NAME and STATE in words Newton's law of motion used to answer QUESTION 3.1.1. (3)

3.1.3 Draw a labelled free-body diagram of ALL the forces acting on the crate as the driver applies the brakes. (3)

3.1.4 Calculate the acceleration of the truck as the driver applies the brakes. (4)

3.1.5 Calculate the force applied by the brakes on the truck. (4)

3.2 Two toy cars with frictionless rollers are tied together and pulled, as shown in the diagram below.
The mass of each car is as follows: m1 = 0,75 kg and m2 = 0,8 kg
The cars are pulled to the right with a horizontal force of 6,5 N.



3.2.1 State Newton's Second Law of Motion in words. (2)

3.2.2 Calculate the acceleration of the system. (4)

3.2.3 Calculate the force exerted by car m_1 on car m_2. (3)

[25]

JENN

Training and Consultancy

The path to enlightened education

SUBJECT: PHYSICAL SCIENCES

GRADE 12

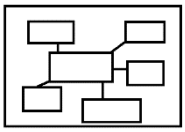
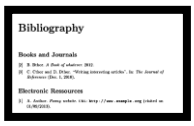
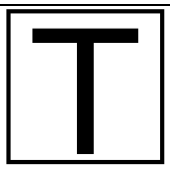
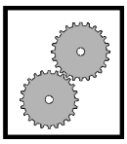
TERM 1

TEACHER AND LEARNER CONTENT MANUAL

Topic(s)

2. Vertical Projectile Motion

ICON DESCRIPTION

 MIND MAP	 EXAMINATION GUIDELINE	 CONTENTS	 ACTIVITIES
 BIBLIOGRAPHY	 TERMINOLOGY	 WORKED EXAMPLES	 STEPS

CONTENTS **PAGE**

TOPIC 1: Vertical Projectile Motion ○ Examination guideline and outcomes ○ Important terms and definitions ○ Worked examples. ○ Activities	**21 - 43**

EXAMINATION GUIDLINES

- Explain what is meant by a projectile, i.e., an object which has been given an initial velocity and then it moves under the influence of the gravitational force only.
- Define free fall as motion during which the only force acting on an object is the gravitational force.
- Use equations of motion to determine the position, velocity, and displacement of a projectile at any given time.
- **Sketch position versus time (x vs. t), velocity versus time (v vs. t) and acceleration versus time (a vs. t) graphs for:**
  - A free-falling object
  - An object thrown vertically upwards
  - An object thrown vertically downwards
  - Bouncing objects (restricted to balls)
- **For a given x vs. t, v vs. t or a vs. t graph, determine:**
  - Position
  - Displacement
  - Velocity or acceleration at any time t
- **For a given x vs. t, v vs. t or a vs. t graph, describe the motion of the object:**
  - Bouncing
  - Thrown vertically upwards
  - Thrown vertically downward

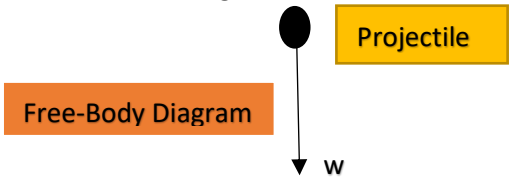
IMPORTANT TERMS AND DEFINITIONS

Projectile - an object which has been given an initial velocity and then it moves under the influence of the gravitational force only.

Free-Fall - as motion during which the only force acting on an object is the gravitational force.

Projectile

- An object that is launched into the air (**downwards or upwards**) by:
  - ✓ Kicking
  - ✓ Hitting or
  - ✓ Throwing it.
- After that, it moves under the influence of gravitational force only.



Motion of a Projectile

- The motion of an object which is thrown vertically (**downwards or upwards**). After the initial force that launches the object, it only experiences the force of gravity.
- The object is called a **projectile**

Description	Velocity	Change in Velocity	Gravitational acceleration
Object moves upwards	Upwards	Slowing down (decreases)	Downwards
Object moves downwards	Downwards	Speeding up (increases)	Downwards

Free-Fall

The motion of an object in the gravitational field of the earth under the influence of gravitational force only.

Acceleration due to gravity

- All free-falling bodies have the same **constant gravitational acceleration**.
- This acceleration is **9,8 m.s^{-2} downwards** at any point of its motion whether:
  - ✓ **moving up** or
  - ✓ **moving down** or
  - ✓ **at the maximum height (turning point)**

Equations of Motion (BIG FOUR)

$$v_f = v_i + a\Delta t$$

$$v_f^2 = v_i^2 + 2a\Delta y$$

$$\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$$

$$\Delta y = (\frac{v_i + v_f}{2})\Delta t$$

V_i = initial velocity (m.s^{-2})

V_f = final velocity (m.s^{-1})

a = gravitational acceleration = 9.8 m.s^{-2}

Δt = time (s)

Δy = displacement (m)

Each of the BIG FOUR equations is missing one of the five fundamental quantities.

PROBLEM SOLVING STRATEGY

STEP 1: Read the statement carefully. Identify key words.

MOTION

$v_f = v_i + a\Delta t$	$\Delta x = v_i\Delta t + \frac{1}{2}a\Delta t^2$ or/of $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$
$v_f^2 = v_i^2 + 2a\Delta x$ or/of $v_f^2 = v_i^2 + 2a\Delta y$	$\Delta x = \left(\frac{v_i + v_f}{2}\right)\Delta t$ or/of $\Delta y = \left(\frac{v_i + v_f}{2}\right)\Delta t$

STEP 2: Make sense of the statement (Draw a diagram)

STEP 3: Choose direction (upward as +; downward as – OR vice versa)

STEP 4: Tabulate/Outline the given data.

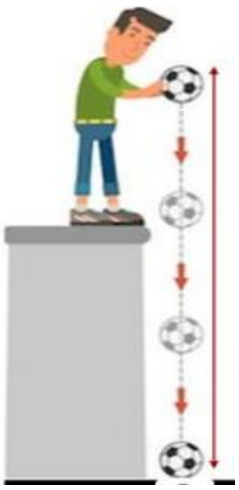
STEP 5: Identify the suitable formula from the **DATA SHEET**

STEP 6: Substitute the known values into the formula and solve for unknown variable.

N.B. It is advisable to take the direction of motion as positive.

Description of Vertical Projectile Motion

SCENARIO A1: When a projectile is DROPPED (from rest) from a certain height above the ground.



$V_i = 0\ m.s^{-1}$

$V_f > 0\ m.s^{-1}$

- $a = 9.8\ m.s^{-2}$ downwards
- Velocity is increasing as the ball is moving downwards
- $V_i = 0\ m.s^{-1}$
- Velocity is at maximum as the ball hits the ground
- V_f (at the bottom) $> V_i > 0\ m.s^{-1}$

positive or negative sign are used to define direction for upwards and downwards

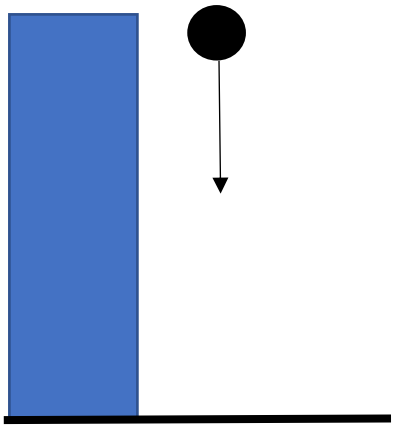
If two objects are released from different heights, they have the same acceleration, but they strike the ground at different times and have a different velocity.

Ignoring air resistance; If a **ball** and a **rock** are released from the same height at the same time, they will strike the ground at the same time, and their final velocity will be the same.

But their **momentum (mv)** and **kinetic energy (½mv2)** are not the same, due to a **difference in mass**.

WORKED EXAMPLE 1

A ball is dropped from a height of a building and reaches the ground after 2.02 s. Ignore the effects of air resistance.



1.1 Calculate the velocity at which the ball hits the ground.

1.2 Calculate the height of the building.

1.3 Draw the velocity time graph. Indicate the final velocity and the time it takes to reach the ground.

1.4 Taking the ground as reference point draw the position – time graph.

SOLUTIONS

1.1 ***STEP 1:*** Choose direction

Take downwards as **POSITIVE**

STEP 2: Identify the unknown variable first

V_f = +?

STEP 3: Collect any other given data

a	Δt	V_i	V_f	Δy
+9.8 $m.s^{-2}$	2.02 s	0 $m.s^{-1}$	?	?

STEP 4: Select an appropriate equation, substitute, calculate, get an answer with correct unit, **AND** indicate direction where necessary

$v_f = v_i + a\Delta t$

$v_f = (0) + (+9.8)(2.02)$

$v_f = 19.8\, m.s^{-1}\, downwards$

1.2 ***STEP 1:*** Choose direction

Take downwards as **POSITIVE**

STEP 2: Identify the unknown variable first

Δy = +?

STEP 3: Collect any other given data

a	**Δt**	**V_i**	**V_f**	**Δy**
+9.8 $m.s^{-2}$	2,02 s	0 $m.s^{-1}$	?	?

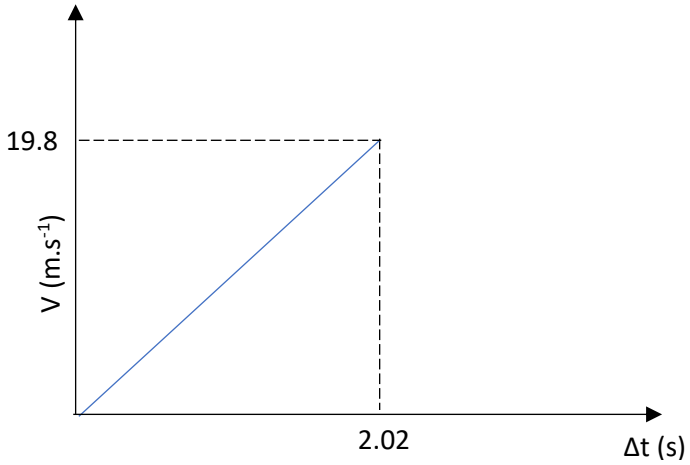
STEP 4: Select an appropriate equation, substitute, calculate, get an answer with correct unit, **AND** indicate direction where necessary

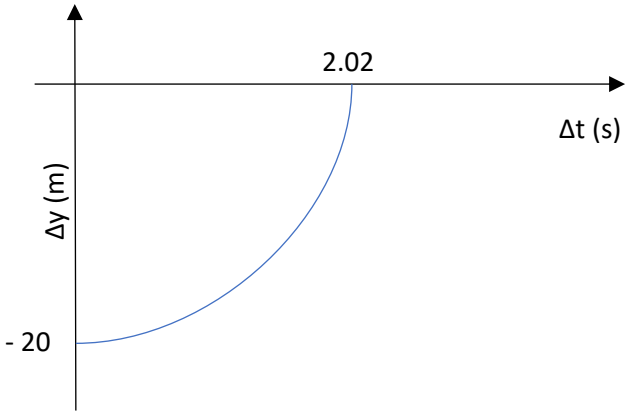
$$\Delta y = v_i \Delta t + \frac{1}{2} a \Delta t^2$$

$$\Delta y = (0)(2.02) + \frac{1}{2}(+9.8)(2.02^2)$$

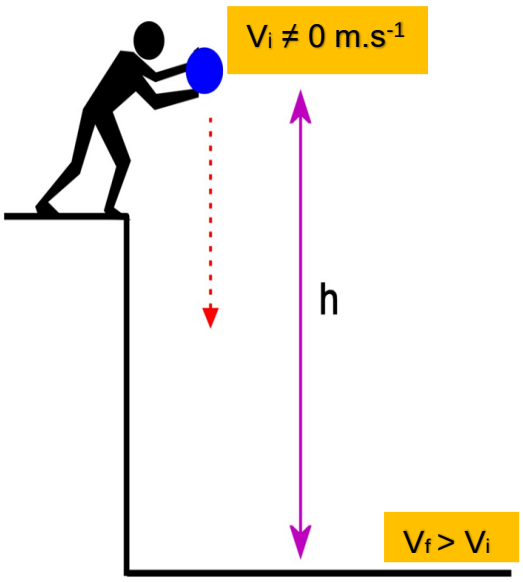
$$\Delta y = 20\ m$$

1.3





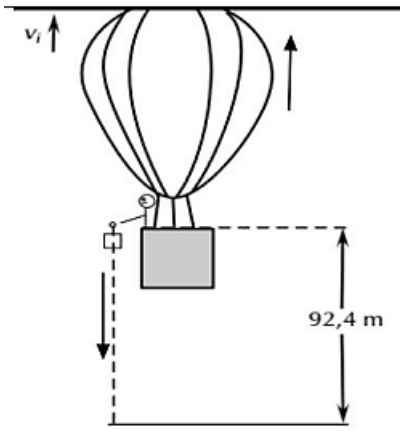
<u>SCENARIO A2</u>: When an object is THROWN (Given an initial velocity) from a certain height above the ground.



- $a = 9.8\ m.s^{-2}$ downwards
- Velocity is increasing as the ball is moving downwards
- $V_i \neq 0\ m.s^{-1}$ $V_i > 0\ m.s^{-1}$
- Velocity at maximum as the ball hits the ground
- V_f (at the bottom) > V_i

positive or negative sign are used to define direction for upwards and downwards motion

HOT AIR BALLOON



- **V_i = V of HOT AIR BALLOON**
- **Therefore $V_i > 0$ m.s^{-1}**

Take downwards as POSITIVE (no upwards motion)

V_i = V HOT AIR BALLOON

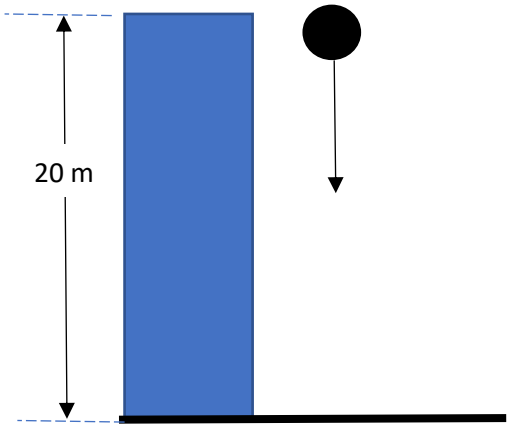
V_f = +

Δy = +

A = +9.8 m.s^{-1}

WORKED EXAMPLE 2

A ball is thrown vertically down from a height of a building with a velocity of 10 m.s^{-1}. Ignore the effects of air resistance.



2.1 Calculate the velocity at which the ball hits the ground.

2.2 Calculate the time it takes then ball to hit the ground.

2.3 Draw the velocity time graph. Indicate the final velocity and the time it takes to reach the ground.

2.4 Taking the point of projection as reference point draw the position – time graph.

SOLUTIONS

2.1 ***STEP 1:*** Choose direction

Take downwards as **POSITIVE**

STEP 2: Identify the unknown variable first

V_f = +?

STEP 3: Collect any other given data

a	Δt	V_i	V_f	Δy
+9.8 $m.s^{-2}$	?	+10 $m.s^{-1}$	?	20 m

STEP 4: Select an appropriate equation, substitute, calculate, get an answer with correct unit, **AND** indicate direction where necessary

$$v_f^2 = v_i^2 + 2a\Delta y$$

$$\sqrt{v_f^2 = (10)^2 + 2(9.8)(20)}$$

$$v_f = 22.18\, m.s^{-1}\, downwards$$

2.2 ***STEP 1:*** Choose direction

Take downwards as **POSITIVE**

STEP 2: Identify the unknown variable first

Δt = +?

STEP 3: Collect any other given data

a	Δt	V_i	V_f	Δy
9.8 $m.s^{-2}$	?	+10 $m.s^{-1}$	22.18 $m.s^{-1}$	20

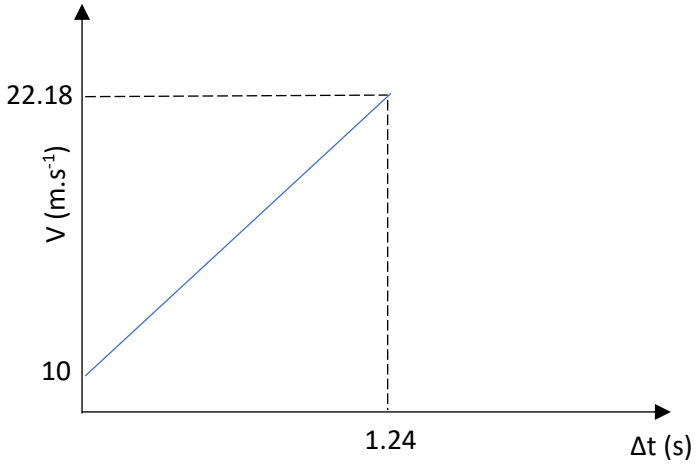
STEP 4: Select an appropriate equation, substitute, calculate, get an answer with correct unit, **AND** indicate direction where necessary

$$\Delta \boldsymbol{y} = (\frac{\boldsymbol{v_i} + \boldsymbol{v_f}}{\boldsymbol{2}})\Delta \boldsymbol{t}$$

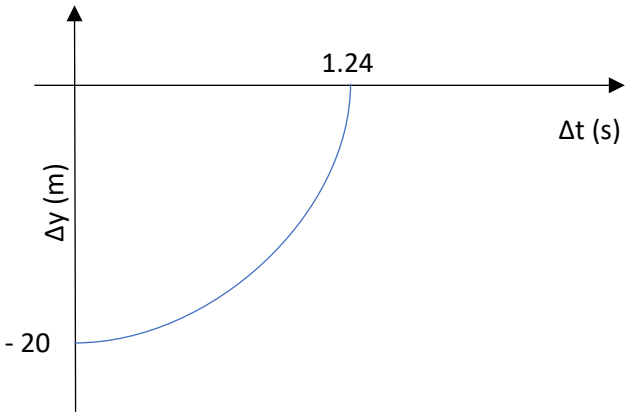
$$(\boldsymbol{20}) = [\frac{(\boldsymbol{10}) + (\boldsymbol{22.18})}{\boldsymbol{2}}]\Delta \boldsymbol{t}$$

$\Delta t = 1.24\ s$

2.3

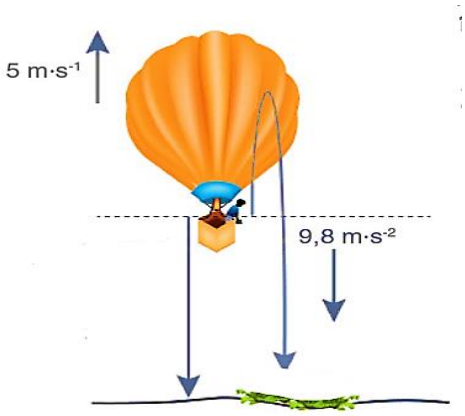


2.4



EXAMPLE 3

A hot air balloon ascends with a constant velocity of 5 m·s^{-1}. A ball is dropped from the hot air balloon at a height of 50 m and falls vertically towards the ground.



3.1 Determine the distance between the hot air balloon and ball after 2 seconds

3.2 and the velocity of the ball when it reaches the ground.

SOLUTIONS

3.1 ***STEP 1:*** Choose direction

Take downwards as **POSITIVE**

STEP 2: Identify the unknown variable first

Δy = -? Distance travelled by balloon

STEP 3: Collect any other given data

a	Δt	V_i	V_f	Δy
0 $m.s^{-2}$	2 s	- 5 $m.s^{-1}$	?	-?

STEP 4: Select an appropriate equation, substitute, calculate, get an answer with correct unit, **AND** indicate direction where necessary

$$\Delta y = v_i \Delta t + \frac{1}{2} a \Delta t^2$$

$$\Delta y = (-5)(2) + \frac{1}{2}(0)(2^2)$$

$$\Delta y = -10\ m$$

$$\Delta y = 10\ m\ upwards$$

STEP 1: Choose direction

Take downwards as **POSITIVE**

STEP 2: Identify the unknown variable first

Δy = +? Distance travelled by

STEP 3: Collect any other given data

a	Δt	V_i	V_f	Δy
9.8 $m.s^{-2}$	2 s	- 5 $m.s^{-1}$	?	?

STEP 4: Select an appropriate equation, substitute, calculate, get an answer with correct unit, **AND** indicate direction where necessary

$$\Delta y = v_i \Delta t + \frac{1}{2} a \Delta t^2$$

$$\Delta y = (-5)(2) + \frac{1}{2}(9.8)(2^2)$$

$$\Delta y = 9.6\ m\ downwards$$

$$\therefore Total\ Distance = 10 + 9.6$$

$$= 19.6\ m\ apart$$

3.2

a	Δt	V_i	V_f	Δy
9.8 $m.s^{-2}$	?	- 5 $m.s^{-1}$	?	+50 m

$$v_f^2 = v_i^2 + 2a\Delta y$$

$$v_f^2 = (-5)^2 + 2(9.8)(50)$$

$$v_f = \sqrt{25 + 980}$$

$$v_f = 13.70\ m.s^{-1}\ downwards$$

SCENARIO B1: The projectile is thrown vertically upwards from a starting point, turns around and returns to the starting point.

$V_{f(up)} = V_{i(down)} = 0\ m.s^{-1}$

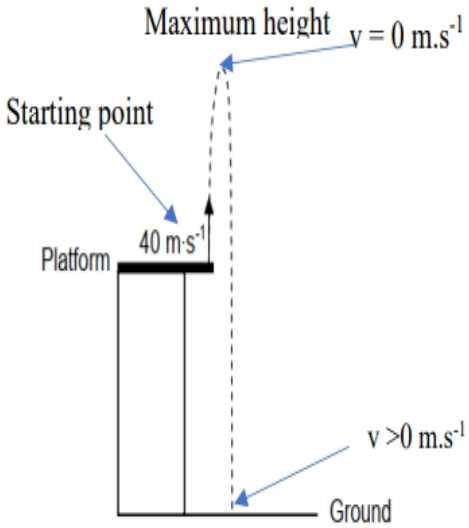
$V_f > V_i$

- $a = 9.8\ m.s^{-2}$ downwards
- Velocity is increasing as the ball is moving downward
- Velocity decrease as ball is moving upward
- V_i (up) = V_f (down)
- V_f (up) = V_i (down) = $0\ m.s^{-1}$
- Δt (for upward motion) = Δt (down)

$V_{i(up)} = V_{f(down)}$

positive or negative sign are used to define direction for upwards and downwards

SCENARIO B2: The projectile is thrown upwards from the starting point above the ground, turns around and moves downwards PAST THE STARTING POINT TO THE GROUND.



- $a = 9.8\ m.s^{-2}$ downwards
- Velocity is increasing as the ball is moving downward
- Velocity decrease as ball is moving upward
- $V_i \neq 0\ m.s^{-1}$
- V_f (up) = V_i (down) = $0\ m.s^{-1}$
- V_f (down) > V_i(up)

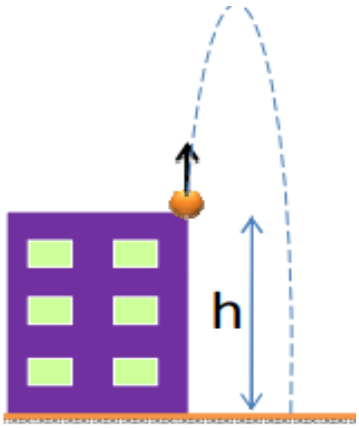
positive or negative sign are used to define direction for upwards and downwards

Starting Point as Reference Point:

- Δy below the starting point has the same sign as downward motion
- Δy above the starting point has the same sign as upward motion

WORKED EXAMPLE 4

A ball is projected vertically upward with a velocity of 30 $m.s^{-1}$. It strikes the ground after 8s.



4.1 Calculate the maximum height reach by the ball above the point of projection.

4.2 Determine the height of the building.

4.3 Draw the position vs. time graph for the motion take the point of projection as zero point

SOLUTIONS

4.1 ***STEP 1:*** Choose direction

Take downwards as **POSITIVE**

STEP 2: Identify the unknown variable first

Δy = -?

STEP 3: Collect any other given data

a	Δt	V_i	V_f	Δy
+9.8 $m.s^{-2}$	?	- 30 $m.s^{-1}$	0 $m.s^{-1}$	?

STEP 4: Select an appropriate equation, substitute, calculate, get an answer with correct unit, **AND** indicate direction where necessary

$v_f^2 = v_i^2 + 2a\Delta y$

$0 = (-30)^2 + 2(9.8)\Delta y$

$\Delta y = -45.92\ m$

$\therefore\ \Delta y = 45.92\ m\ above\ point\ of\ projection$

4.2 ***STEP 1:*** Choose direction

Take downwards as **POSITIVE**

STEP 2: Identify the unknown variable first

Δy = +?

STEP 3: Collect any other given data

a	Δt	V_i	V_f	Δy
+9.8 $m.s^{-2}$	8 s	-30 $m.s^{-1}$	?	+?

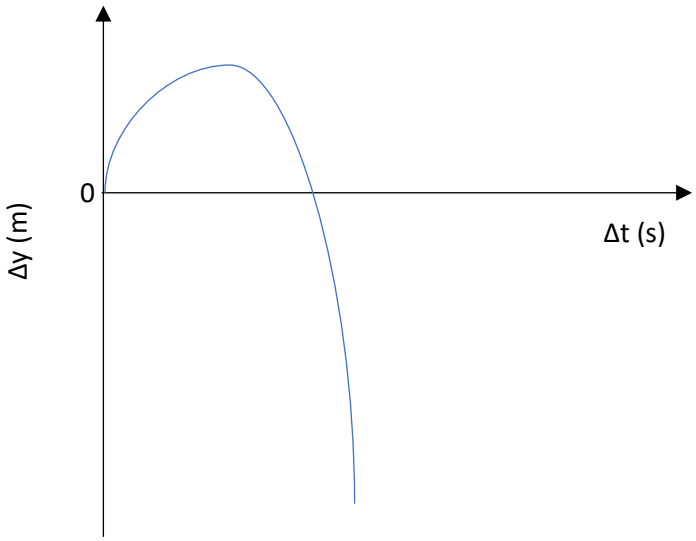
STEP 4: Select an appropriate equation, substitute, calculate, get an answer with correct unit, **AND** indicate direction where necessary

$$\Delta y = v_i \Delta t + \frac{1}{2} a \Delta t^2$$

$$\Delta y = (-30)(8) + \frac{1}{2}(9.8)(8)^2$$

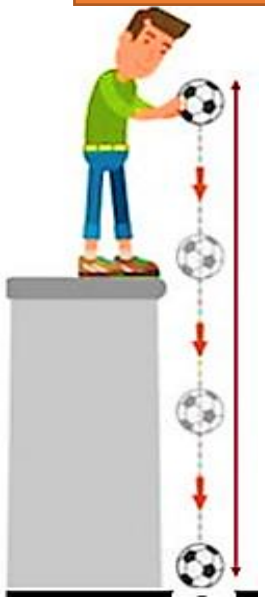
$$\Delta y = 73.6\ m\ heigh$$

4.3



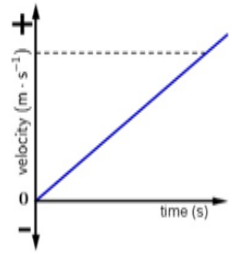
GRAPHS: The projectile is DROPPED from the starting point above the ground, turns around and moves downwards BACK TO THE STARTING POINT.

When drawing vertical projectile motion graphs, we need to use SIGN CONVENTION. Therefore, CHOOSE A DIRECTION

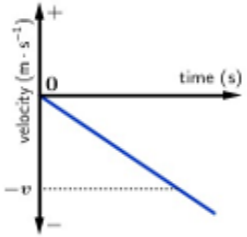


Velocity – Time Graph

DOWNWARDS taken as POSITIVE



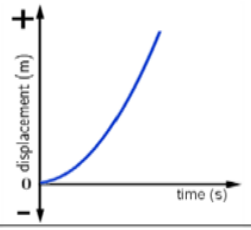
UPWARDS taken as POSITIVE



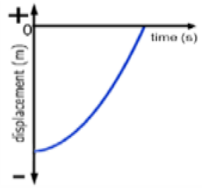
Position – Time Graph

DOWNWARDS taken as POSITIVE

Take the POINT OF RELEASE as ZERO REFERENCE

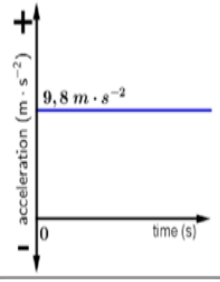


Take the GROUND as ZERO REFERENCE

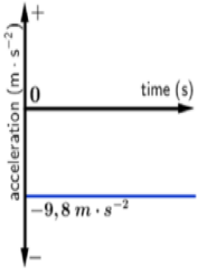


Acceleration – Time Graph

DOWNWARDs taken as POSITIVE

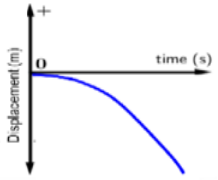


UPWARDS taken as POSITIVE

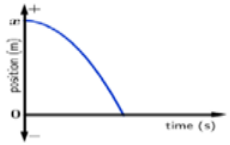


UPWARDS taken as POSITIVE

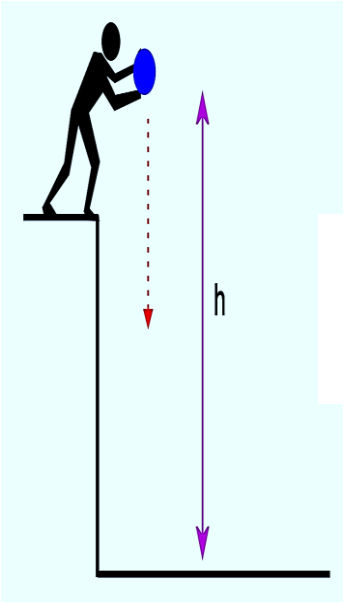
Take the POINT OF RELEASE as ZERO REFERENCE ($x = 0$)



Take the GROUND as ZERO REFERENCE ($x = 0$)

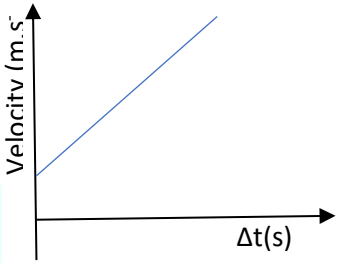


GRAPHS: The projectile is thrown upwards from the starting point above the ground, turns around and moves downwards BACK TO THE STARTING POINT.

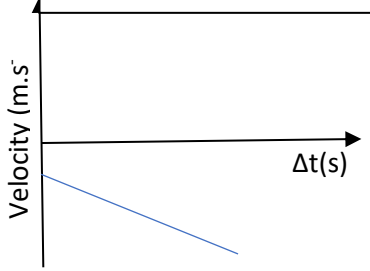


Velocity – Time Graph

DOWNWARDS taken as Positive



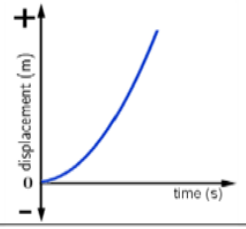
DOWNWARDS taken as Negative



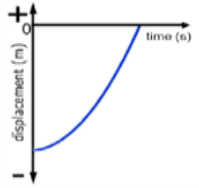
Position – Time Graph

DOWNWARDS taken as POSITIVE

Take the POINT OF RELEASE as ZERO REFERENCE

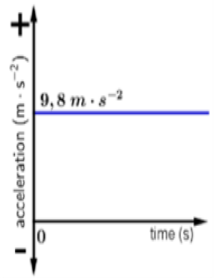


Take the GROUND as ZERO REFERENCE

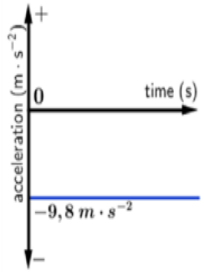


Acceleration – Time Graph

DOWNWARDs taken as POSITIVE

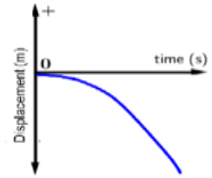


UPWARDS taken as POSITIVE

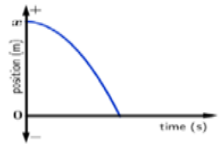


UPWARDS taken as POSITIVE

Take the POINT OF RELEASE as ZERO REFERENCE ($x = 0$)

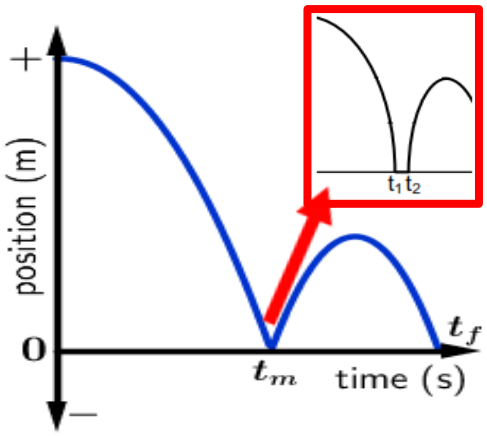


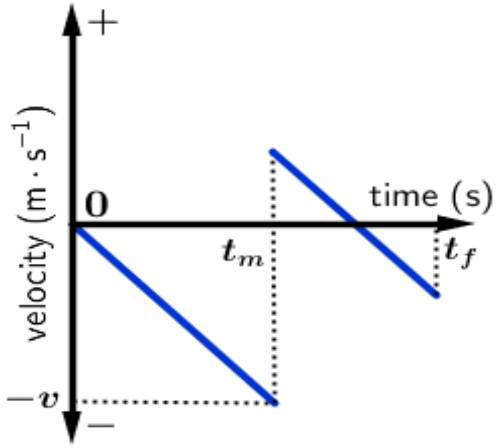
Take the GROUND as ZERO REFERENCE ($x = 0$)

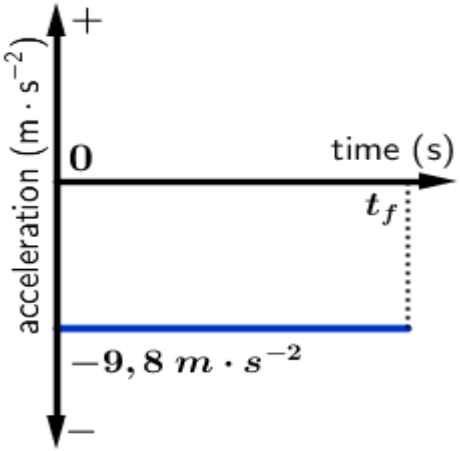


The Bouncing Ball

a ball is dropped from a height and ***bounces up off the ground***, coming to rest on the ground thereafter (up is +, ground is zero level)







In some graphs, the time interval of the bounce is indicated by a space between t_1 and t_2

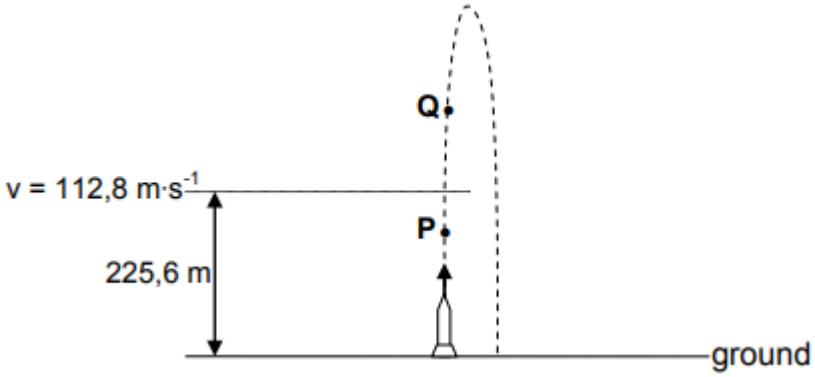
Note the transition when the ball bounces ... a **dotted line** must connect the two parts of the velocity graph …

Acceleration constant throughout, but note the discontinuity at t_m

QUESTION 1

A stationary rocket on the ground is launched vertically upwards. After 4 s, the rocket's fuel is used up and it is 225,6 m above the ground. At this instant the velocity of the rocket is 112,8 $m \cdot s^{-1}$. The diagram below shows the path followed by the rocket. Ignore the effects of air friction.

Assume that g does not change during the entire motion of the rocket.



1.1 Write down the direction of the acceleration of the rocket at point:

1.1.1 **P** (1)

1.1.2 **Q** (1)

1.2 At which point (**P or Q**) is the rocket in free fall? Give a reason for the answer. (2)

1.3 TAKING UPWARD MOTION AS POSITIVE, USE EQUATIONS OF MOTION to calculate the time taken from the moment the rocket is launched until it strikes the ground. (6)

1.4 Sketch a velocity versus time graph for the motion of the rocket from the moment it runs out of fuel until it strikes the ground. Take the time when the rocket runs out of fuel as t = 0 s.

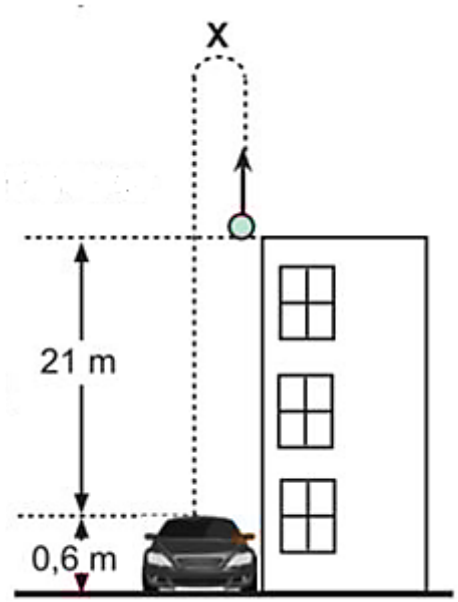
Indicate the following values on the graph:

- Velocity of the rocket when it runs out of fuel
- Time at which the rocket strikes the ground (5)

[12]

QUESTION 2

A car, 0,6 m high, is parked next to a block of flats. A learner leans over the edge. Of the roof of the building, 21 m above the roof of the car. The learner throws a ball, with a mass of 500 g, vertically upwards. The ball moves upwards to point X, falls back past the top of the building and hits the roof of the car after 2,88 s.



Ignore all effects of air resistance.

2.1 Write down the following experienced by the ball at point X:

2.1.1 Magnitude of the net force. (1)

2.1.2 Direction of the acceleration. (1)

2.2 Calculate the:

2.2.1 Magnitude of the velocity with which the ball was thrown upwards. (4)

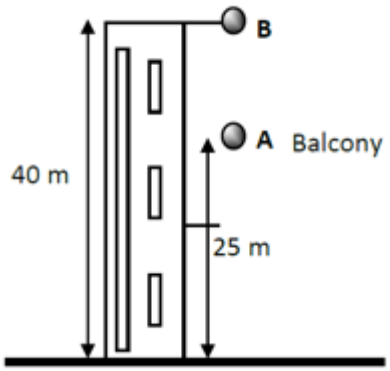
2.2.2 Maximum height that the ball will reach above the ground. (4)

2.5 The ball hits the roof of the parked car and bounces form the roof with a speed of 18 $m.s^{-1}$. The ball is in contact with the roof of the car for 0,1 s. Calculate the magnitude of the force that the roof of the car exerts on the ball. (5)

[15]

QUESTION 3

Ball **A** is dropped from a balcony 25 m from the ground. AT THE SAME TIME an identical ball **B**, is projected vertically downwards from the top of a building 40 m from the ground as shown in the diagram below.



The balls hit the ground simultaneously. Ignore the effects of air resistance.

3.1 Define the term Projectile. (2)

3.2 Calculate the magnitude of the:

3.2.1 Velocity with which of ball **A** reaches the ground (3)

3.2.2 Velocity with which **B** must be projected to reach the ground at the same time as **A**. (4)

3.3 On the same set of axes, sketch a velocity versus time graph for each ball (**A and B**), for the entire motion. Take down as positive.

Show the following on your graph:

- Initial velocity of both balls **A** and **B**
- Time taken to hit the ground (4)

[13]

QUESTION 4

A man throws ball **A** downwards with a speed of 2 $m \cdot s^{-1}$ from the edge of a window, 45 m above a dam of water. One second later he throws a second ball, ball **B**, downwards and observes that both balls strike the surface of the water in the dam at the same time. Ignore air friction.

4.1 Calculate the:

4.1.1 Speed with which ball **A** hits the surface of the water (3)

4.1.2 Time it takes for ball **B** to hit the surface of the water (3)

4.1.3 Initial velocity of ball **B** (5)

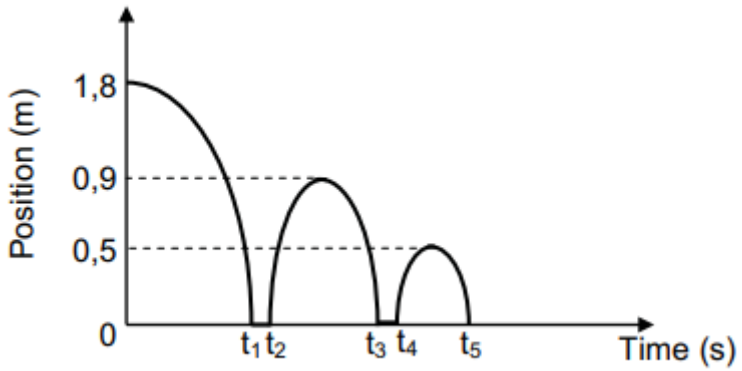
4.3 On the same set of axes, sketch a velocity versus time graph for the motion of balls **A** and **B**. Clearly indicate the following on your graph:

- Initial velocities of both balls **A** and **B**
- The time of release of ball **B**
- The time taken by both balls to hit the surface of the water (5)

[16]

QUESTION 5

A ball of mass 0,5 kg is projected vertically downwards towards the ground from a height of 1.8 m at a velocity of 2 $m.s^{-1}$. The position-time graph for the motion of the ball is shown below.



5.1 What is the maximum vertical height reached by the ball after the second bounce? (1)

Calculate the:

5.2 Magnitude of the time t1 indicated on the graph (5)

5.3 Velocity with which the ball rebounds from the ground during the first bounce (4)

The ball is in contact with the ground for 0,2 s during the first bounce.

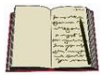
5.4 Calculate the magnitude of the force exerted by the ground on the ball during the first bounce if the ball strikes the ground at 6.27 $m.s^{-1}$. (4)

5.5 Draw a velocity-time graph for the motion of the ball from the time that it is projected to the time when it rebounds to a height of 0,9 m.

Clearly show the following on your graph:

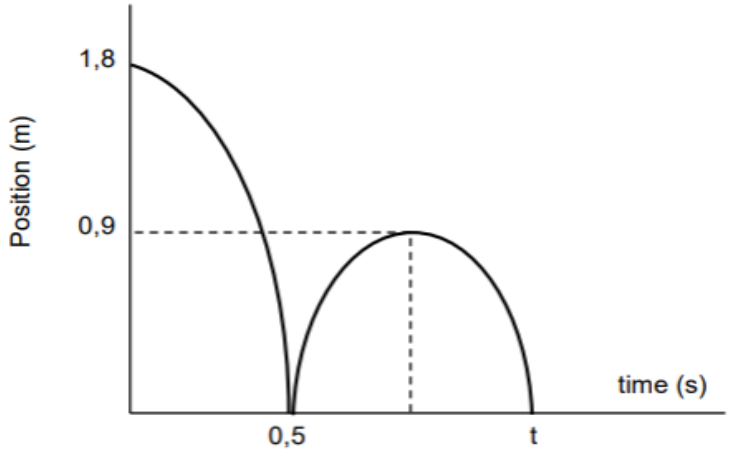
- The time when the ball hits the ground
- The velocity of the ball when it hits the ground
- The velocity of the ball when it rebounds from the ground (3)

[15]



QUESTION 6

The position-time graph is given for a ball which is thrown down from a vertical height of 1,8 m and bounces once on reaching the ground. The contact time between the ball and the floor can be ignored.



6.1 Calculate the initial velocity with which the ball was thrown. (3)

6.2 At what speed does the ball strike the ground? (3)

6.3 At what speed did the ball leave the ground after bouncing? (3)

6.4 Calculate the value of time t. (4)

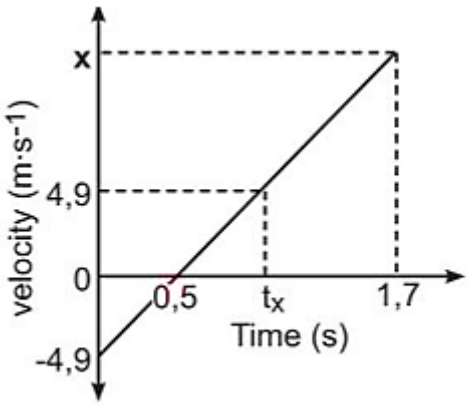
6.5 Sketch a velocity-time graph to represent the motion of the ball. Indicate the following values on the graph:

- The initial velocity at which the object was thrown.
- The velocity at which the ball strikes the ground.
- The velocity at which the ball bounces off the ground.
- The time at which the ball strikes the ground for the first time.
- The time, t, when the ball strikes the ground after the first bounce. (6)

[19]

QUESTION 7

The velocity-time graph below indicates the motion of the ball that is thrown upwards from a balcony of a building. It takes 0,5 s for the ball to reach its highest point above the balcony, after which it falls past the balcony and hits the ground. Ignore the effects of friction.



7.1 State the numerical value of:

7.1.1 The gradient of the velocity-time graph. Give a reason for your answer. (2)

7.1.2 Time, t_x, as shown on the graph. (1)

7.2 Use ONLY the graph (NO equations of motion) to determine, the maximum height the ball reaches at the top of the balcony. (3)

7.3 By using equations of motion and data from the graph, calculate the:

7.3.1 Velocity, x, with which the ball hits the ground. (3)

7.3.2 Height of the balcony above the ground (3)

7.4 Sketch an acceleration versus time graph for the motion of the ball. (2)

[14]

JENN

Training and Consultancy

The path to enlightened education

SUBJECT: PHYSICAL SCIENCES

GRADE 12

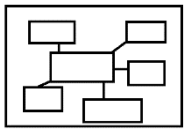
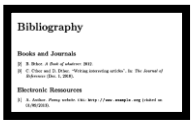
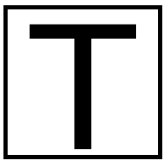
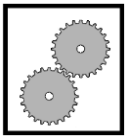
TERM 1

TEACHER AND LEARNER CONTENT MANUAL

Topic(s)

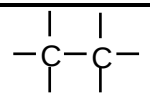
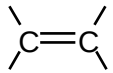
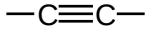
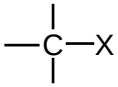
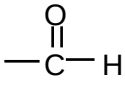
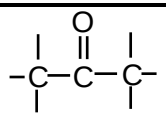
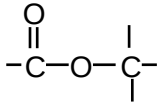
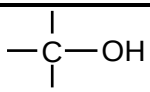
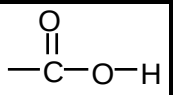
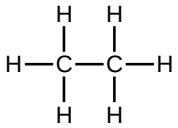
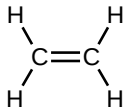
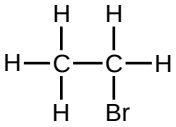
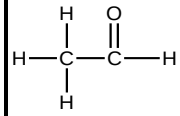
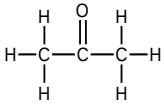
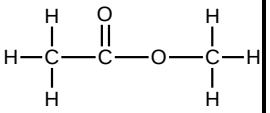
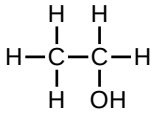
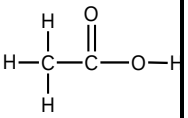
3. Nomenclature
4. Chemical Reactions

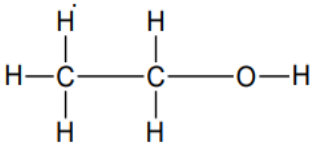
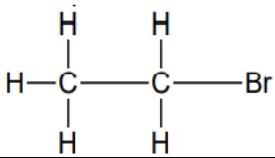
ICON DESCRIPTION

 MIND MAP	 EXAMINATION GUIDELINE	 CONTENTS	 ACTIVITIES
 BIBLIOGRAPHY	 TERMINOLOGY	 WORKED EXAMPLES	 STEPS

CONTENTS **PAGE**

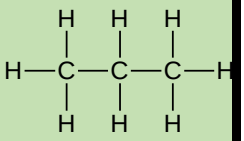
TOPIC 1: Nomenclature ○ Examination guideline and outcomes ○ Important terms and definitions ○ Worked examples. ○ Activities	47 - 58
TOPIC 2: Physical Properties ○ Examination guideline and outcomes ○ Important terms and definitions ○ Worked examples. ○ Activities	59 - 68

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

MATTER AND MATERIALS: ORGANIC MOLECULES	
Boiling point	The temperature at which the vapour pressure of a liquid equals atmospheric pressure.
Chain isomers	Compounds with the same molecular formula, but different types of chains.
Condensed structural formula	A formula that shows the way in which atoms are bonded together in the molecule but DOES NOT SHOW ALL bond lines.
Elimination reaction	A reaction in which elements of the starting material are “lost” and a double bond is formed.
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.
Functional isomers	Compounds with the same molecular formula, but different functional groups.
Homologous series	A series of organic compounds that can be described by the same general formula and that have the same functional group. OR A series of organic compounds in which one member differs from the next with a CH_2 group.
Hydrocarbon	Organic compounds that consist of hydrogen and carbon only.
Intermolecular force	Forces between molecules that determine physical properties of compounds.
London force	A weak intermolecular force between non-polar molecules.
Melting point	The temperature at which the solid and liquid phases of a substance are at equilibrium.
Molecular formula	A chemical formula that indicates the type of atoms and the correct number of each in a molecule, e.g., CH_4.
Organic chemistry	Chemistry of carbon compounds.
Positional isomer	Compounds with the same molecular formula, but different positions of the side chain, substituents or functional groups on the parent chain.
Primary alcohol	The C atom bonded to the hydroxyl group is bonded to ONE other C atom. Example: 
Primary haloalkane	The C atom bonded to the halogen is bonded to ONE other C atom. Example: 

NOMENCLATURE AND STRUCTURE

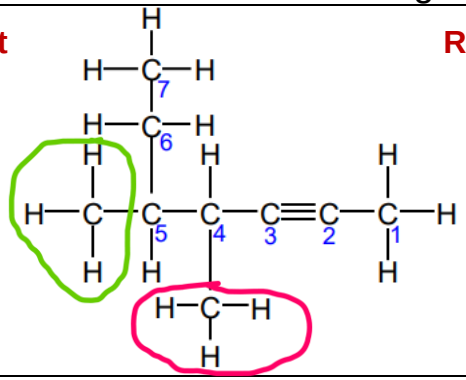
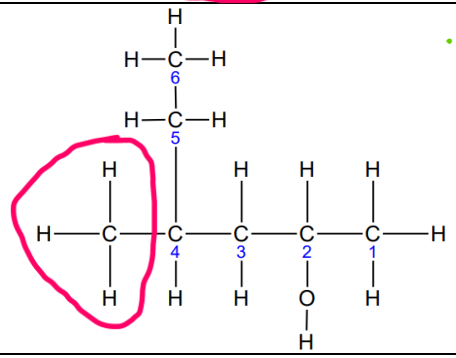
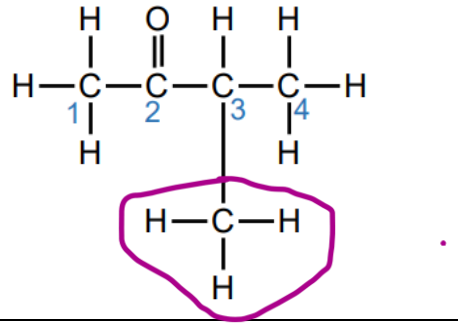
FORMULAE FOR REPRESENTING MOLECULES

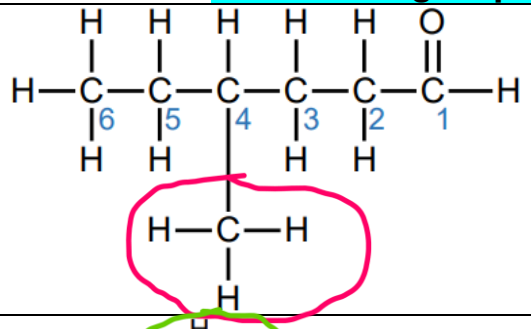
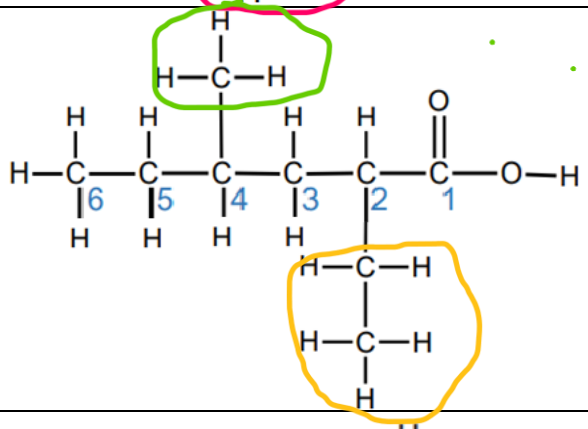
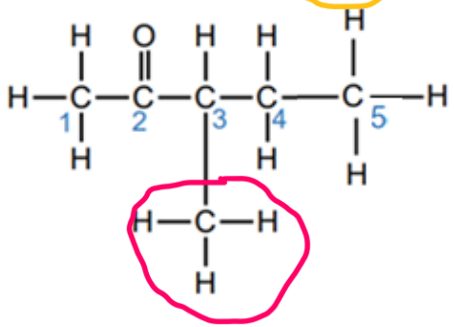
Type of formula	Definition	Example	
		Name	Formula
Molecular formula	A chemical formula that indicates the type of atoms and the correct number of each in a molecule.	propane	C_3H_8
Condensed structural formula	Shows the way in which atoms are bonded together in a molecule but DOES NOT SHOW ALL bond lines.	propane	$CH_3CH_2CH_3$
Structural formula	Shows which atoms are attached to which within the molecule. Atoms are represented by chemical symbols and lines are used to represent ALL the bonds that hold atoms together. Structural formulae usually do NOT depict the actual geometry/shape of molecules.	propane	

IUPAC Naming

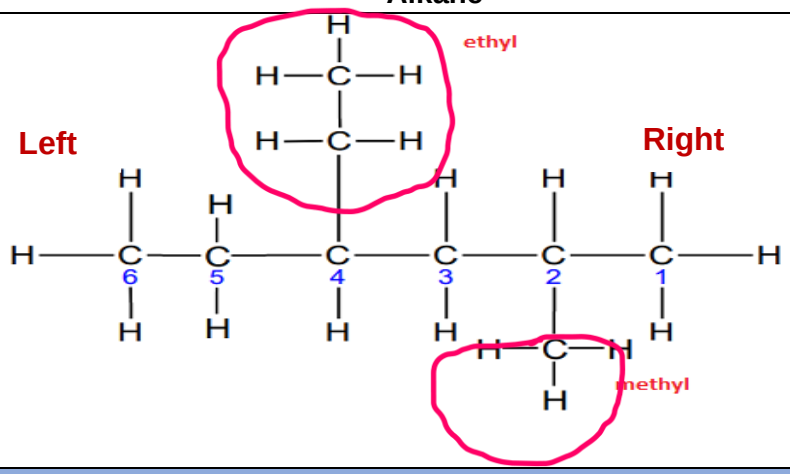
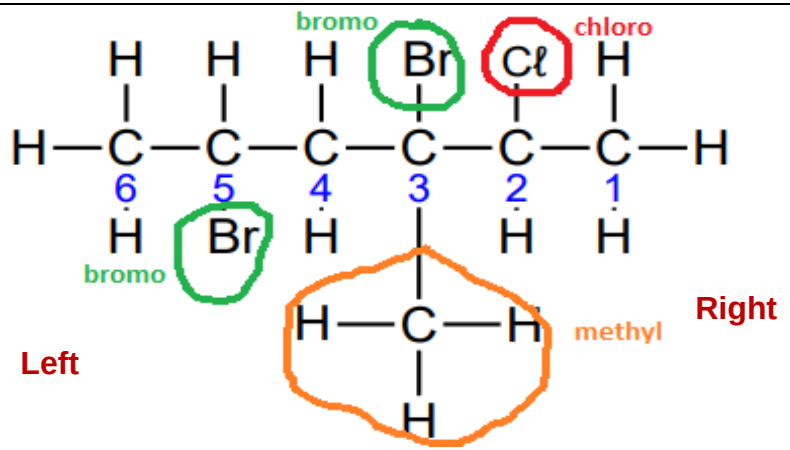
- Determine the **functional group** in the structure of the given compound or the homologous series to which the compound belongs.
- The number of C atoms in the longest carbon chain that contains the functional group determines the **parent name**.
- Number the C atoms in the longest chain, starting with C nearer to the functional group.
- **Identify substituents** on the parent chain. Substituents can be methyl (*one C atom i.e.* $-CH_3$) or *ethyl* (*2 C atoms i.e.* $-CH_2CH_3$).
- **Use numbers on the parent chain to indicate the position of the substituents** on the parent chain.
- **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-**trimethylhexan-3-one

Alkenes, alkynes, alcohols, ketones: Number from the side that will give the functional group the smallest number. The functional group receives a number that is written between parent name and suffix.

Left Right 	• The compound is an unsaturated hydrocarbon with a carbon-carbon triple bond. The Homologous Series is **Alkyne**. The name ends on –**ene.** • The longest chain containing the triple bond has 7 C atoms - the parent name is **hept-**. • Number from the side that will give the functional group the lowest number. Therefore, number from right: **hept-2-yne.** • The substituents are two methyl groups on C4 and C5. Use di- in front of the name of the substituent. • IUPAC Name: **4,5-dimethylhept-2-yne.**
	• The compound contains a hydroxyl group. Homologous series is **Alcohol.** The name ends on **–ol.** • The longest chain containing the hydroxyl group has 6 C atoms - the parent name is **hex-.** • Number from the side that will give the functional group the lowest number. Therefore, number from right: **hexan-2-ol.** • The substituent is a methyl group on C4. • IUPAC Name: **4-methylhexan-2-ol**
	• A compound contains a carbonyl group. A homologous series is a ketone. The name ends on –**one** • The longest chain containing the carbonyl group has 4 C atoms - the parent name is but-. • Number from the side that will give the functional group the lowest number. Therefore, number from left: **butan -2-one.** • Substituent is methyl group on C3. • IUPAC Name**:** **3-methylbutan-2-one**

Aldehydes and carboxylic acids: Number from the C atom that forms part of the functional group. **Functional groups of aldehydes, carboxylic acids and esters are not numbered.**	
	• The compound contains a formyl (–CHO) group. The Homologous series is **Aldehyde**. The name ends on –**al.** • The longest chain containing the formyl group has 7 C atoms - the parent name is **hex-**. • Number from the C atom that forms part of the functional group. Therefore, number from right: **hexanal.** • The substituents is a methyl groups on C4. • IUPAC Name: **4-methylhexanal**
	• The compound contains a carboxyl group (-COOH). Homologous series is Carboxylic acid**.** The name ends on **–oic acid.** • The longest chain containing the carboxyl group has 6 C atoms - the parent name is **hex-.** • Number from the C atom that forms part of the functional group. Therefore, number from right: **hexanoic acid** • The substituents are ethyl group on C2 and methyl group on C4. • IUPAC Name: **2-ethyl-4-methylhexanoic acid.**
	• A compound contains a carbonyl group. A homologous series is a ketone. The name ends on –**one** • The longest chain containing the carbonyl group has 5 C atoms - the parent name is pent-. • Number from the side that will give the functional group the lowest number. Therefore, number from left: penta**n -2-one.** • Substituent is methyl group on C3. • IUPAC Name**:** **3-methylpentan-2-one**

Branched Alkanes and haloalkanes:

Alkane	Haloalkane
	
Suffix What is the functional group/homologous series?	
• Homologous series is an **alkane**. • The name ends on – **ane.**	• Homologous series is an **Haloalkane**. • The name ends on – **ane.**
Parent name Number of C atoms in the longest continues carbon chain	
• The longest chain contains 6 C atoms - the parent name is **hex**-.	• The longest chain contains 6 C atoms - the parent name is **hex**-.
Prefix What, where and how many are the substituents attached to the longest carbon chain?	
• ethyl on carbon 4 (**4-ethyl**) • methyl on carbon 2 (**2-methyl**) Numbering should be such that **the substituents have the lowest numbers** • numbering from right to left **2+4 =6** • from left to right **3+5=8** • we number from right with lowest possible numbers for the substituents (**2+4 =6**).	• methyl on carbon 3 (**3-methyl**) • 2 Bromine on carbon 3 and 5 (**3,5-dibromo**) • Chlorine on carbon 2 (**2-chloro**) Numbering should be such that **the substituents have the lowest numbers** • numbering from left to right **3+3+4 =10** • from right to left **3+4 +4 = 11** we number from right with lowest possible numbers for the substituents (**3+3+4 =10**).
2-methyl-3-ethylhexane	**3,5-dibromo-3-chloro-3-methylhexane**

Writing Structural formulae from IUPAC Names

- **Identify the parent name in the IUPAC name. Draw a carbon skeleton with the number of C atoms indicated by the parent name.**
- **Identify the functional group (suffix) or homologous series to which this compound belongs. Use the number in front of the functional group (suffix) to place the functional on the correct C atom.**
- **Identify the substituents (prefix). Use the number in front of each substituent to place the substituents on the correct C atoms.**
- **Ensure that each C atom is surrounded by 4 bonds (lines indicating bonds).**
- **Include H atoms at all open bonds after ensuring that each C atom is surrounded by 4 bonds.**
- **All bonds should be shown. Do not draw any part of the molecule condensed e.g. $-CH_3$.**
- **As a final check ensure all C atoms form 4 bonds, all O atoms 2 bonds and all H atoms, Br atoms and Cℓ atoms 1 bond.**

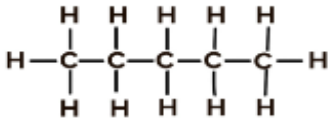
STRUCTURAL ISOMERS

Same molecular formula, different structural formulae.

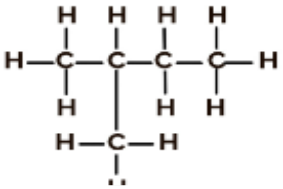
CHAIN ISOMERS

Same molecular formula, different chains

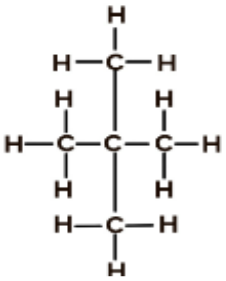
C_5H_{12}



Pentane



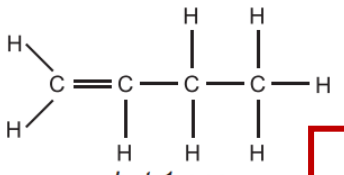
2-Methylbutane



2,2 dimethylpropane

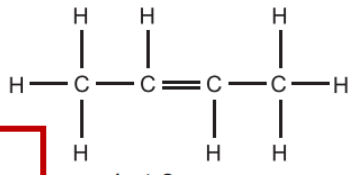
POSITIONAL ISOMERS

Same molecular formula, different positions of functional group or side chain.

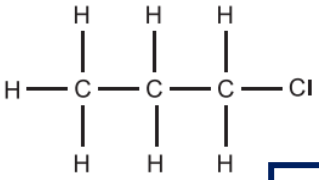


but-1-ene

C_4H_8

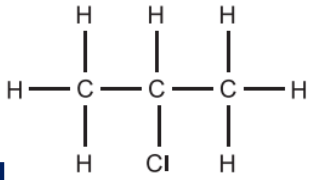


but-2-ene



1-chloropropane

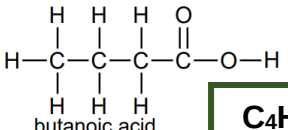
C_3H_7Cl



2-chloropropane

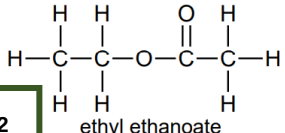
FUNCTIONAL ISOMERS

Same molecular formula, different functional groups.



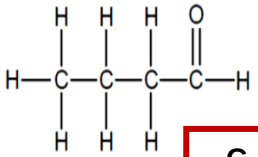
butanoic acid

$C_4H_8O_2$

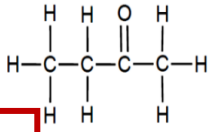


ethyl ethanoate

Butanal



Butan-2-one



C_4H_8O

QUESTION 1: MULTIPLE CHOICE QUESTIONS

Nomenclature

Four possible responses are provided as answers to the following questions.

Each question has only ONE correct answer. Choose the answer and write only the letter (A – D) next to the question number (1.1 – 1.6) in the ANSWER BOOK

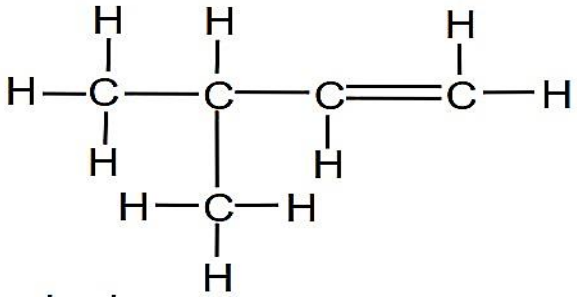
1.1 Which ONE of the following is the name of the functional group of aldehydes?

A Carbonyl
B Carboxyl
C Hydroxyl
D Formyl (2)

1.2 The ratio of the number of carbon atoms to the number of hydrogen atoms in an alkene is …

A 6:14
B 4:8
C 3:8
D 2:2 (2)

1.3 Consider the organic compound represented below



A saturated and branched.
B unsaturated and branched.
C saturated and straight chained.
D unsaturated and straight chained. (2)

1.4 The alcohols form a homologous series. This means that alcohols have ...

A similar chemical property.
B similar physical properties.
C the same molecular formula.
D the same structural formula. (2)

1.5 The reaction of propane with bromine can be classified as …

A elimination reaction
B an addition reaction
C a redox reaction
D a substitution reaction (2)

1.6 Which ONE of the following reactions will take place when exposed to light?

A $CH_2CH_2 + H_2 \rightarrow CH_3CH_3$

B $CH_3CH_3 \rightarrow CH_2CH_2 + H_2$

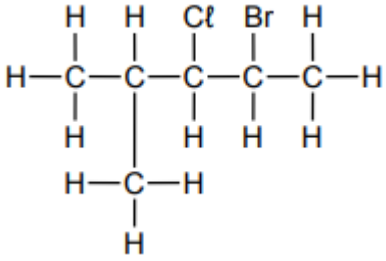
C $CH_2CH_2 + Cl_2 \rightarrow CH_2ClCH_2Cl$

D $CH_3CH_3 + Cl_2 \rightarrow CH_3CH_2Cl + HCl$ (2)

[12]

QUESTION 2

Consider the organic compounds represented by the letters A to D in the table below.

A	2,2,4-trimethylhexane	C	$CH_3CH_2CH_2CH_2CHO$
B		D	Pentan-2-one

2.1 Write down the LETTER that represents the following:

2.1.1 An aldehyde (1)

2.1.2 A compound which has a carbonyl group bonded to two carbon atoms as its functional group (1)

2.2 Write down the IUPAC name of compound C. (3)

2.3 Write down the structural formula of:

2.3.1 Compound A (2)

2.3.2 Compound D (2)

2.4 The table contains compounds which are functional isomers.

2.4.1 Define the term *functional isomer*. (2)

2.4.2 Write down the LETTERS that represent two compounds that are functional isomers. (1)

[12]

QUESTION 3

3.1 Define the term *functional group* of organic compounds. (2)

3.2 Write down the:

3.2.1 Structural formula of the functional group of aldehydes (1)

3.2.2 Name of the functional group of carboxylic acids (1)

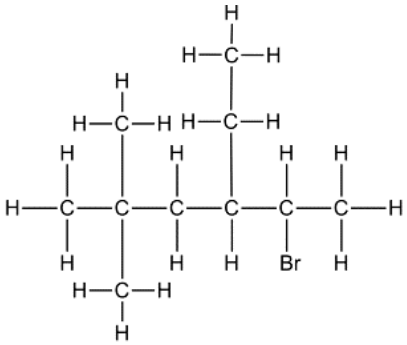
3.3 The IUPAC name of an organic compound is 2,4-dimethylhexan-3-one. For this compound, write down the:

3.3.1 Homologous series to which it belongs (1)

3.3.2 Structural formula (1)

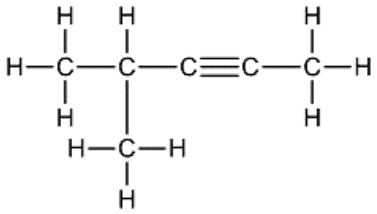
3.4 Write down the IUPAC names of the following compounds:

3.4.1



(3)

2.4.2

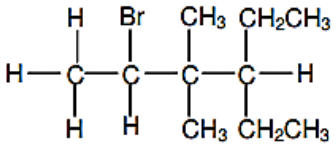
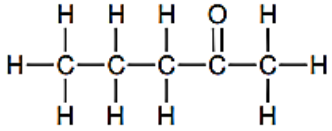


(2)

[8]

QUESTION 4

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	$CH_3CH_2CH_2CH_2CH_2CH_2CHCH_2$		

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

4.1.1 A ketone (1)

4.1.2 A hydrocarbon (1)

4.1.3 An alkene (1)

4.2 Write down the:

4.2.1 IUPAC name of compound **A** (3)

4.2.2 STRUCTURAL FORMULA of compound **D** (2)

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

4.3 Compound **B** is a straight chain compound that undergoes the following exothermic reaction:

$$2C_xH_y + 25O_2(g) \rightarrow 16CO_2(g) + 18H_2O(g)$$

4.3.1 Besides being exothermic, what type of reaction is represented above? (1)

4.3.2 Determine the MOLECULAR FORMULA of compound **B**. (2)

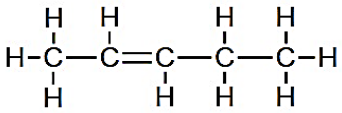
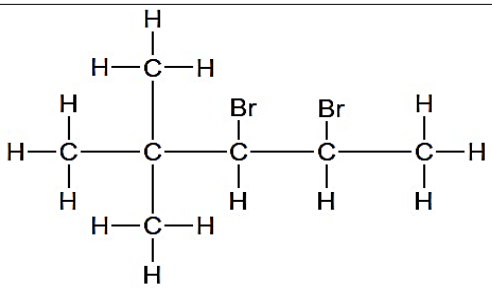
The reaction above takes place in a closed container at a constant temperature higher than 100 °C and at constant pressure.

4.3.3 Calculate the TOTAL VOLUME of gas formed in the container when 50 cm^3 of C_xH_y reacts completely with oxygen. (3)

[16]

QUESTION 5

The letters P to U in the table below represent six organic compounds.

P		**Q**	Methylpropanoate
R	3-Methylbutan-2-ol	**S**	$CH_3CH_2CH_2CO_2H$
T		**U**	$CH_3CH_2CH_2COCH_2CH_3$

5.1 Write down the LETTER(S) that represent(s) the following:

5.1.1 A ketone. (1)

5.1.2 A carboxylic acid (1)

5.1.3 A compound with the general formula C_nH_{2n} (1)

5.1.4 Two compounds that are FUNCTIONAL ISOMERS. (1)

5.2 Write down the IUPAC name of compound:

5.2.1 T (3)

5.2.2 U (2)

5.3 Write down the STRUCTURAL FORMULA of compound:

5.3.1 Q (2)

5.3.2 R (2)

5.4 Compound R is a secondary alcohol. Explain the validity of this statement. (1)

[14]

ORGANIC REACTIONS

Organic compounds take part in different types of reactions which can be grouped into:

- Oxidation (Combustion)
- Esterification
- Substitution
- Addition and
- Elimination reactions

Oxidation (Combustion)

Oxidation of alkanes is also called the combustion of alkanes. In the complete combustion reaction of alkanes, carbon dioxide (CO2) and water (H2O) are released along with energy.

An equation for the combustion of an alkane in excess oxygen:

$$Alkane + Oxygen \rightarrow Carbon\ dioxide + water$$

$$Alkane + O_2 \rightarrow CO_2 + H_2O$$

The balanced equation for the complete combustion of methane is:

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

How to write a balanced equation for the combustion of alkanes:

Step 1: Balance the carbon atoms

Step 2: Balance the hydrogen atoms

Step 3: Balance the oxygen atoms

Step 4: Make sure all numbers are whole numbers

Worked Example 1

Balance the equation for the combustion of butane:

$$C_4H_{10} + O_2 \rightarrow CO_2 + H_2O$$

Step 1: Balance the carbon atoms

$$C_4H_{10} + O_2 \rightarrow 4CO_2 + H_2O$$

Step 2: Balance the hydrogen atoms

$$C_4H_{10} + O_2 \rightarrow 4CO_2 + 5H_2O$$

Step 3: Balance the oxygen atoms

$$C_4H_{10} + \frac{13}{2}O_2 \rightarrow 4CO_2 + 5H_2O$$

Step 4: Make sure all numbers are whole numbers

$$2C_4H_{10} + 13O_2 \rightarrow 8CO_2 + 10H_2O$$

Step 1: Balance the carbon atoms

4 C atoms on reactants, 1 C atom on products balance C atoms by placing 4 in front of CO_2

Step 2: Balance the hydrogen atoms

10 H atoms on reactants, 2 H atom on products: balance H atoms by placing 5 in front of H_2O

Step 3: Balance the oxygen atoms

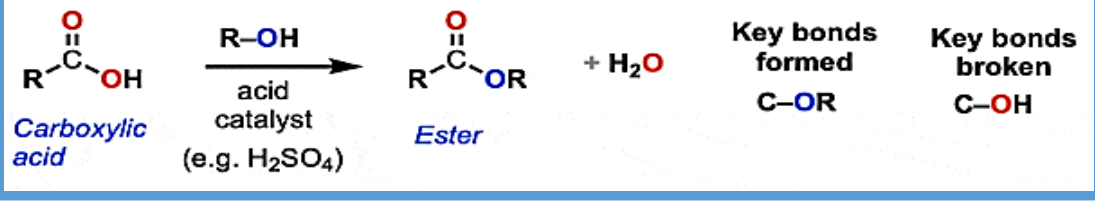
1 O atoms on reactants, 8+5 =13 O atom on products: balance O atoms by placing $^{13}/_{2}$ in front ofO_2

Step 4: Make sure all numbers are whole numbers

Multiply every coefficient by 2 to eliminate fraction

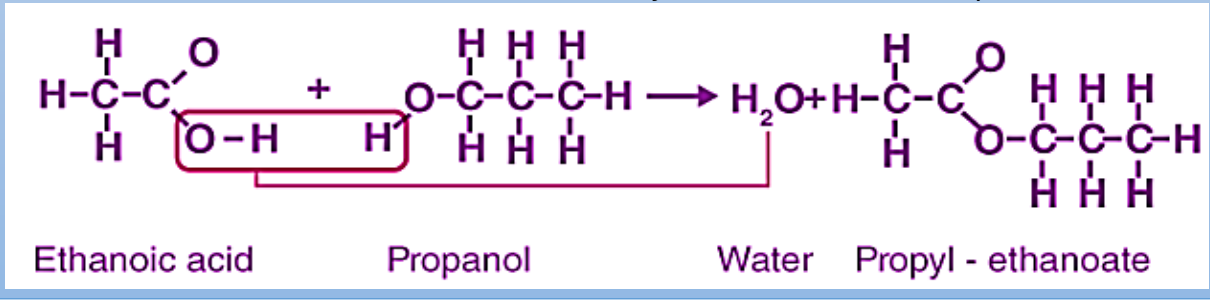
ESTERIFICATION REACTIONS

- One way to form an ester is through the reaction of an alcohol and a carboxylic acid. This process is called an **esterification or condensation**.
- The reaction conditions for esterification: an alcohol and a carboxylic acid must be **heated in** the presence of **concentrated H_2SO_4**. The reaction is an acid catalysed condensation reaction. An ester (organic compound) and water (inorganic compound) are produced during an esterification reaction.



The equation, using structural formulae, for the formation of the ester propyl ethanoate:

You must be able to name the alcohol and carboxylic acid used to form a specific ester.



Worked Example

1. Which two compounds need to be heated in the presence of concentrated sulphuric acid in order to form butyl methanoate?
2. What ester will form during the acid catalysed reaction of ethanol and propanoic acid?

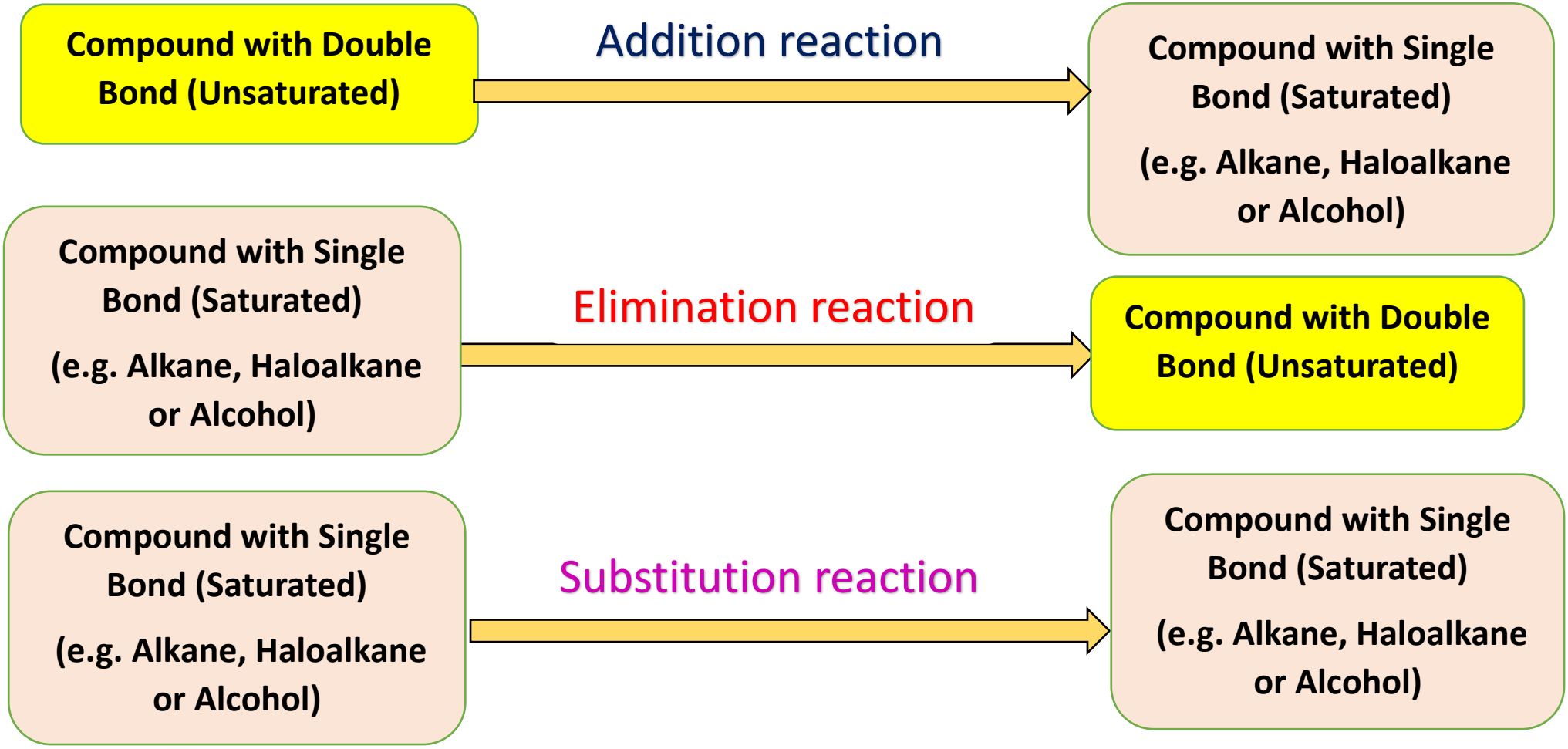
Solutions

1. butanol + methanoic acid
2. Ethyl propanoate

Esters are used in the manufacture of:
• *perfumes (pleasant smell)*
• *solvents*
• *artificial fruit flavours*

Substitution, Addition and Elimination reactions

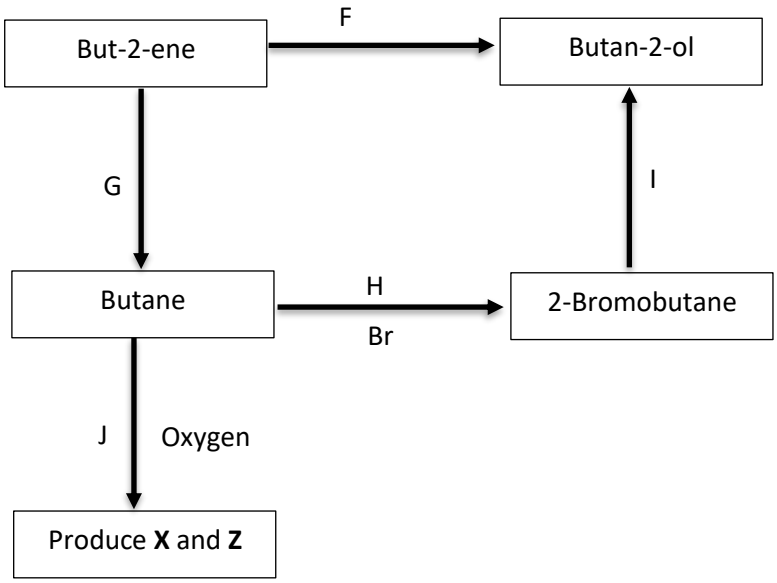
Flow diagram to show the difference between Substitution Addition and Elimination reactions



Type of organic reaction	Name of reaction	Reactants	Reaction conditions	Products
Substitution	Halogenation	alkane + halogen	hf/Δ	haloalkane + hydrogen halide
	Hydrolysis	haloalkane + base (NaOH/ KOH/LiOH)	• dilute strong base • mild heat	alcohol + halide salt
		haloalkane + water	• add water • mild heat	alcohol + hydrogen halide
	Substitution	alcohol + hydrogen halide	no water	haloalkane + water
Addition	Hydration	alkene + water	concentrated H_2SO_4	alcohol
	Hydrogenation	alkene + hydrogen	Pt, Pd, Ni; dissolved in non-polar solvent	alkane
	Halogenation	alkene + halogen		haloalkane
	Hydrohalogenation	alkene + hydrogen halide	no water	haloalkane
Elimination	Cracking	alkanes	high temperature and high pressure OR catalyst	alkene + hydrogen OR alkane + alkene(s)
	Dehydrohalogenation	haloalkane + base (NaOH/KOH)	• concentrated strong base • heat	alkene + salt + water
	Dehydration	alcohol	• concentrated H_2SO_4 • heat	alkane + water

Worked Example

Study the diagram below.

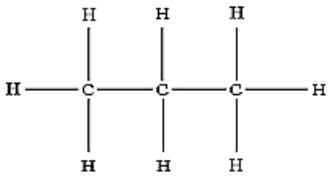


1.1 In which phase does butane occur at room temperature? (1)
1.2 Draw the structural formula of propane (2)
1.3 Give one important use of Alkanes (1)
1.4 Write down the type of reactions represented by:
1.4.1 **F** (1)
1.4.2 **H** (1)
1.4.3 **G** (1)
1.5 During reaction, **I**, the Haloalkane reacts in the presence of a base to form an alcohol.
Write down: (1)
1.5.1 the **Name** of the suitable base used in the reaction. (1)
1.5.2 the reaction conditions required in required in the reaction. (2)
1.6 With the use of molecular formulae write down a balance chemical reaction for reaction **J.** (3)

[14]

SOLUTIONS

1.1 Gas ✓ (1)
1.2 ✓✓



(2)
1.3 Used as fossil fuel✓ (1)
1.4.1 Addition-Hydration✓ (1)

1.4.2 Addition- hydrogenation ✓ (1)

1.4.3 Substitution - halogenation✓ (1)

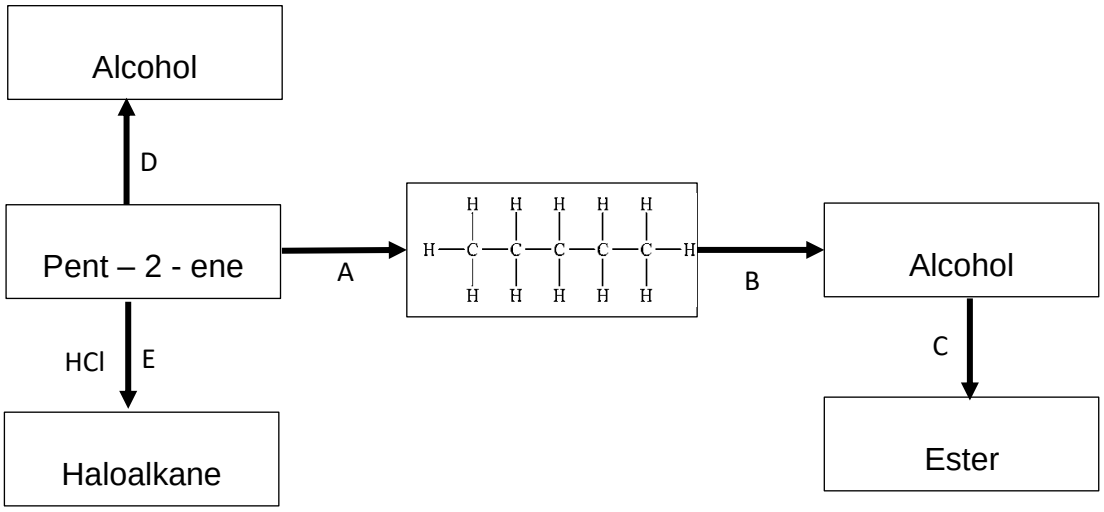
1.5.1 Sodium hydroxide✓ (1)

1.5.2 A dilute strong base and **mild** heat ✓ (2)

1.6 $2C_4H_{10} + 13O_2 \rightarrow 8CO_2 + 10H_2O$ ✓✓✓ (3)

QUESTION 1

Consider the flow diagram below and answer questions that follows:



1.1 What type of reaction is represented by each of the following:

1.1.1 **A** (1)

1.1.2 **B** (1)

1.1.3 **C** (1)

1.1.4 **D** (1)

1.2 Give the IUPAC name of the alcohol(s) formed in reaction.

1.2.1 **D** (1)

1.2.2 **B** (1)

1.3 Draw the structural formula of halo-alkane formed in reaction **E**. (2)

1.4 Is the Haloalkane formed a major or a minor product?

1.5 What type of alcohol is formed in reaction **D**? **Write only primary/secondary/tertiary** and give the reason to your answer. (1)

1.6 Write down the formula for the inorganic product formed in reaction **C.** (2)

1.7 What type of reaction is reaction **C**? (1)

[13]

QUESTION 2

Consider the incomplete equations of two reactions below.
X represents the organic product formed in **reaction** 1, which is a SUBSTITUTION REACTION. In **reaction 2**, X reacts with reactant Y as shown

Reaction 1: $C_2H_5Br \xrightarrow{\text{strong base}} NaBr + \mathbf{X}$

Reaction 2: $\mathbf{X} + \mathbf{Y} \xrightarrow{\text{Concentrated } H_2SO_4} C_3H_6O_2 + H_2O$

2.1 Consider **reaction 1**. Write down the:

2.1.1 Type of substitution reaction that takes place (1)

2.1.2 TWO reaction conditions (2)

2.1.3 IUPAC name of compound **X** (1)

2.2 Consider **reaction 2**. Write down the:

2.2.1 Type of reaction that takes place (1)

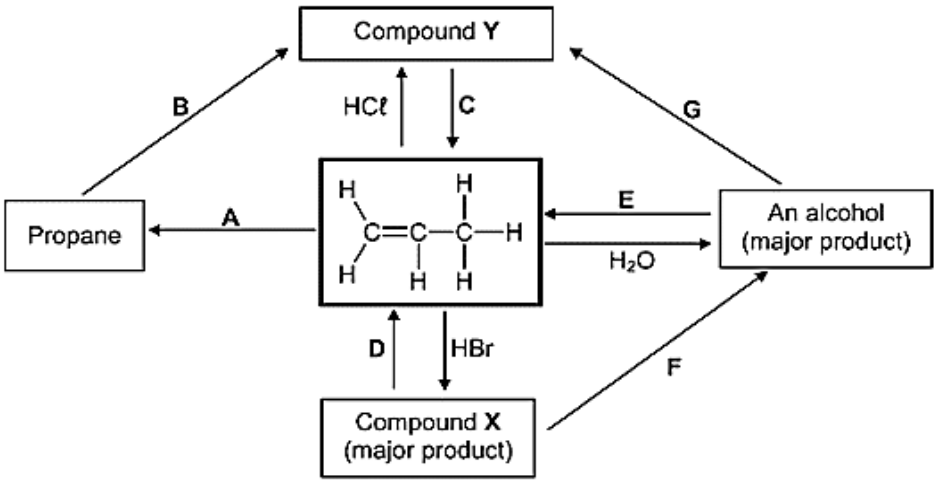
2.2.2 Structural formula of compound **Y** (2)

2.2.3 IUPAC name of the organic product (2)

[9]

QUESTION 3

The flow diagram below shows how an alkene can be used to prepare other organic compounds. The letters **A** to **G** represent different organic reactions.



3.1 Write down the type of reaction represented by:

3.1.1 **A** (1)

3.1.2 **B** (1)
3.1.3 **E** (1)

3.2 Write down the IUPAC name of compound **X**.

3.3 For reaction **D**, write down:

3.3.1 The type of elimination reaction (1)
3.3.2 TWO reaction conditions (2)

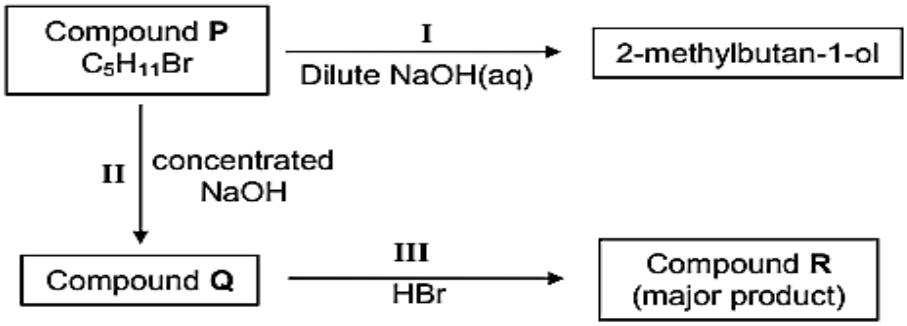
3.4 Write down the:

3.4.1 FORMULA of an inorganic reactant needed for reaction **F** (1)
3.4.2 Balanced equation, using structural formulae, for reaction **G** (4)

[13]

QUESTION 4

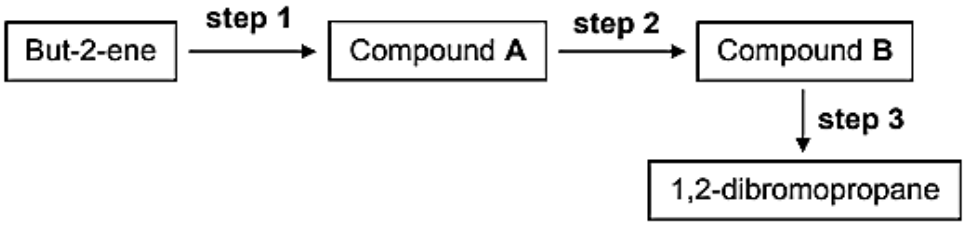
4.1 Compound P is used as a starting reactant in each of two reactions as shown in the flow diagram below.



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

4.1.1 Name the type of reaction represented by **I**. (2)
4.1.2 Is 2-methylbutan-1-ol a PRIMARY, SECONDARY or TERTIARY alcohol?
Give a reason for the answer. (3)
4.1.3 Write down the STRUCTURAL FORMULA of compound P. (1)
4.1.4 Name the type of reaction represented by **II**. (1)
4.1.5 To which homologous series does compound Q belong? (1)
4.1.6 Name the type of reaction represented by **III**.
Choose from ADDITION, ELIMINATION or SUBSTITUTION. (1)
4.1.7 Write down the IUPAC name of compound **R**. (2)

4.2 1,2-dibromopropane can be prepared from but-2-ene by a three-step process as shown in the flow diagram below.



4.2.1 Using CONDENSED STRUCTURAL FORMULAE, write down a balanced equation for **step 1**. Indicate the reaction conditions on the arrow. (4)

4.2.2 Write down the type of reaction in **step 2.** (1)

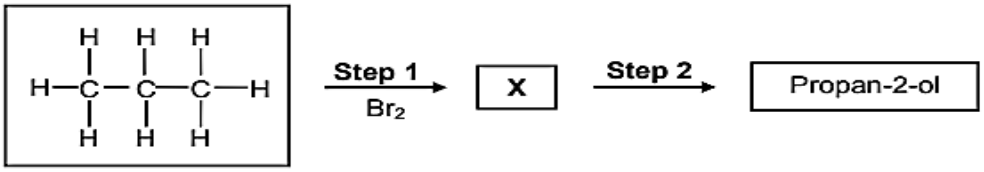
4.2.3 Write down the IUPAC name of compound **B.** (2)

4.2.4 Using CONDENSED STRUCTURAL FORMULAE, write down a balanced equation for **step 3.** (3)

[21]

QUESTION 5

5.1 The flow diagram below shows the conversion of propane to propan-2-ol.



5.1.1 State ONE reaction condition for **Step 1**. (1)

5.1.2 Write down the NAME or FORMULA of the INORGANIC product formed in **Step 1**. (1)

5.1.3 Name the TYPE of substitution reaction represented by **Step 2**. (1)

5.1.4 Write down the NAME or FORMULA of the INORGANIC reagent needed in **Step 2**. (1)

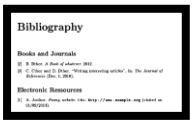
5.1.5 Write down the IUPAC name of compound **X**. (2)

5.2 Ethane can be prepared from chloroethane (CH_3CH_2Cl) by a TWO-STEP process. You are supplied with the following chemicals:

H_2	$HC\ell$	$C\ell_2$	H_2O	Pt	Ethanol	concentrated H_2SO_4	concentrated NaOH

Select chemicals in the table above that can be used for this preparation.
Using CONDENSED structural formulae, write down a balanced equation for
EACH reaction. Indicate the reaction conditions for EACH reaction. (8)

[14]



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