PHYSICAL SCIENCES

GRADE 12: REVISION STUDY GUIDE

EASTER CLASSES

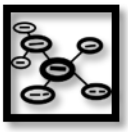
Topic 1

Electrostatics

Topic 2

Organic Molecules.

ICON DESCRIPTION

	 Mind Map	
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 Methodology	 Activities	 Bibliography

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TOPIC 2: Organic Molecules **Structure of Organic molecules (Nomenclature):** ➢ Examination guidelines ➢ Important terms and definition ➢ Worked examples and typical exam questions **Physical Properties:** ➢ Examination guidelines ➢ Important terms and definition ➢ Brief notes on physical properties ➢ Worked examples and typical exam questions **Reactions of organic compounds:** ➢ Examination guidelines ➢ Important terms and definition ➢ Brief notes on organic reactions ➢ Worked examples and typical exam questions	 **17-21** **20** **22-28** **29** **29** **30-33** **34-40** **41** **42** **43-44** **45-50**
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EASTER CLASSES		
DAY	**ACTIVITY**	**TIME**
1	Pre-test	55 Min
	Electrostatics	1 Hour 5 Min
2	Electrostatics	2 Hours
3	Organic Molecules	2 Hours
4	Organic Molecules	2 Hours
5	Organic Molecules	1 Hour
	Post-Test	1 Hour

EXAMINATION GUIDELINES:

Topic 14: Electrostatics (Grade 11)

Coulomb's law

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

Electric field

- Describe an *electric field* as a region of space in which an electric charge experiences a force. The direction of the electric field at a point is the direction that a positive test charge would move if placed at that point.
- Draw electric field patterns for the following configurations:
  - A single point charge
  - Two point charges (one negative, one positive OR both positive OR both negative)
  - A charged sphere
- Define the ***electric field at a point***: **The electric field at a point is the electrostatic force experienced per unit positive charge placed at that point**. In symbols: $E = \frac{F}{q}$.
- Solve problems using the equation $E = \frac{F}{q}$.
- Calculate the electric field at a point due to a number of point charges, using the equation $E = \frac{kQ}{r^2}$ to determine the contribution to the field due to each charge. Restrict to three charges in a straight line.

IMPORTANT TERMS & DEFINITIONS:

Coulomb's law	The magnitude of the electrostatic force exerted by one point charge on another point charge is directly proportional to the product of the magnitudes of the charges and inversely proportional to the square of the distance (r) between them. In symbols: $F = \frac{kQ_1Q_2}{r^2}$
Electric field	A region of space in which an electric charge experiences a force.
Electric field at a point	The electric field at a point is the electrostatic force experienced per unit positive charge placed at that point. In symbols: $E = \frac{F}{q}$ Unit: $N \cdot C^{-1}$
Direction of electric field	The direction of the electric field at a point is the direction that a positive test charge would move if placed at that point.

IMPORTANT UNITS:

coulomb (C)	Unit of electric charge – the charge is 1 coulomb when a current of 1 ampere passes a point in a conductor in one second. (1 C = 1 A·s)
volt (V)	Unit of potential difference – 1 volt is 1 joule per coulomb. ($1\ V = 1\ J·C^{-1}$)
$N·C^{-1}$	Unit of electric field
Newton (N)	Unit of force

PHYSICAL CONSTANTS TABLE:

NAME/*NAAM*	SYMBOL/*SIMBOOL*	VALUE/*WAARDE*
Acceleration due to gravity	g	$9,8\ m·s^{-2}$
Universal gravitational constant	G	$6,67 \times 10^{-11}\ N·m^2·kg^{-2}$
Speed of light in a vacuum	c	$3,0 \times 10^8\ m·s^{-1}$
Planck's constant	h	$6,63 \times 10^{-34}\ J·s$
Coulomb's constant	k	$9,0 \times 10^9\ N·m^2·C^{-2}$
Charge on electron	e^-	$-1,6 \times 10^{-19}\ C$
Electron mass	m_e	$9,11 \times 10^{-31}\ kg$
Mass of Earth	M	$5,98 \times 10^{24}\ kg$
Radius of Earth	R_E	$6,38 \times 10^3\ km$

FORMULAE TABLE:

$F = \frac{kQ_1Q_2}{r^2}$	$E = \frac{kQ}{r^2}$
$E = \frac{F}{q}$	$n = \frac{Q}{e}$ or / *of* $n = \frac{Q}{q_e}$

ELECTROSTATICS

Study of charges at rest

Two kinds of charge

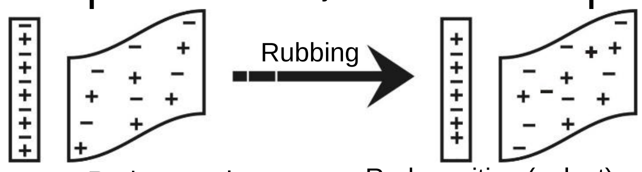
Positive: electron deficient
Negative: excess of electrons

Neutral (uncharged):
Number of protons = number of electrons

Quantisation of charge
All charges are multiples of the smallest charge i.e. the charge on one electron: $1,6 \times 10^{-19}$ C

Conservation of charge
Charge cannot be created or destroyed. It can only be transferred from one object to another.

Charging of objects
By contact: Electrons transferred from one object to another.



Rod: neutral
Cloth: neutral

Rod: positive (e^- lost)
Cloth: negative (e^- gained)

Electrostatic force

Like charges repel
Unlike charges attract

Coulomb's law

$F \propto Q_1Q_2$ and $F \propto \frac{1}{r^2}$

$\therefore \quad F = \frac{kQ_1Q_2}{r^2} \quad k = 9 \times 10^9$

Electric field

Region in space where an electric charge experiences a force. Represented with field lines.

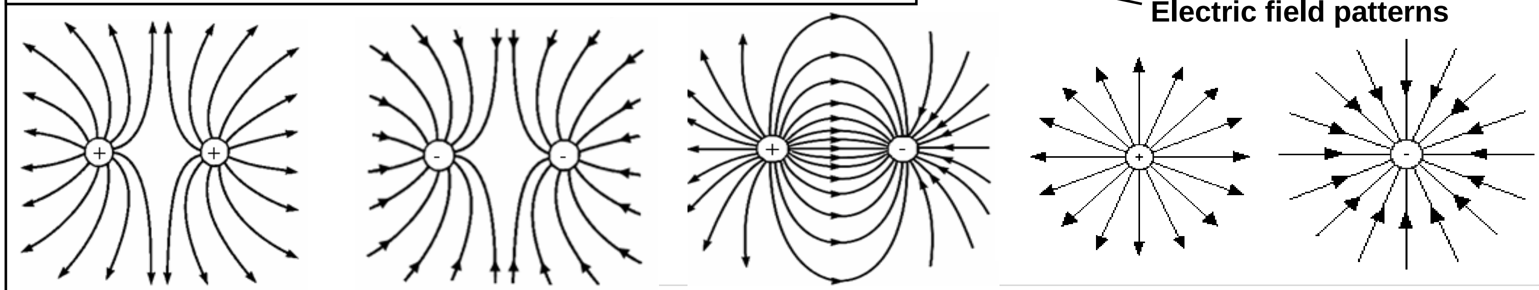
Definition of electric field: $E = \frac{F}{q}$

:

-

Electric field at a certain distance from a point charge: E =
kQ

Electric field patterns



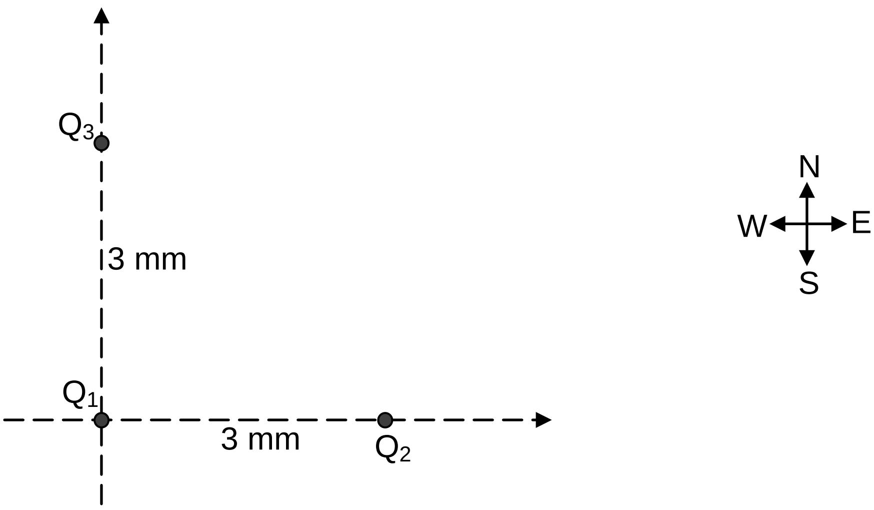
LEARNER & TEACHER MANUAL	
TOPIC: Electrostatics	**Duration:** 2 HOURS

Key Concepts:

1. Coulomb's law
2. Free-body diagram
3. Solving problems for charges in 1D and 2D using Coulomb's law equation.
4. Electric field
5. Electric field patterns
6. Electric field calculations (1D)

EXAMPLE

Three small, identical metal spheres, Q_1, Q_2 and Q_3, are placed in a vacuum. Each sphere carries a charge of – 4 μC. The spheres are arranged such that Q_2 and Q_3 are each 3 mm from Q_1 as shown in the diagram below.

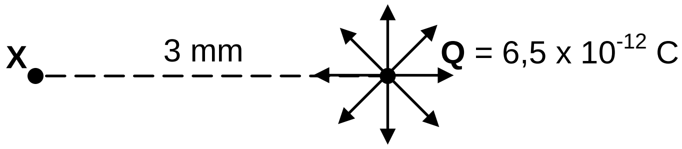


1.1 State Coulomb's law in words. (2)

1.2 Draw a force diagram showing the electrostatic forces exerted on Q_1 by Q_2 and Q_3. (2)

1.3 Calculate the net force exerted on Q_1 by Q_2 and Q_3. (8)
[12]

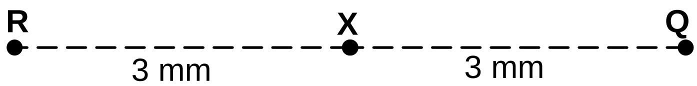
An isolated point charge **Q** is located in space as shown in the diagram below. Point charge **Q** contributes to an electric field as shown. Point **X** is located 3 mm away from point charge **Q**.

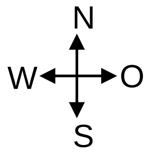


2.1 Define the term *electric field* at a point. (2)

2.2 Calculate the magnitude of the electric field at point **X**. (3)

2.3 Point charge **R** carrying a charge of + 6,5 x 10^{-12} C is placed 3 mm away from point **X** as shown in the diagram below.





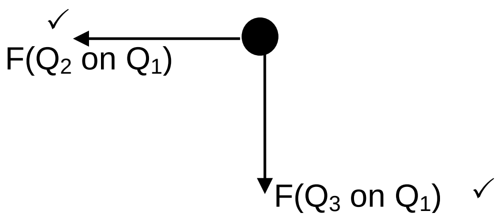
Calculate the net electric field at point **X**. (4)

[9]

SOLUTIONS

1.1 The (magnitude) of the electrostatic force exerted by one charge on another is directly proportional to the (magnitudes of the) charges ✓ and inversely proportional to the square of the distance between their centres. ✓
Die (grootte) van die elektrostatiese krag wat een lading op 'n ander uitoefen, is direk eweredig aan die (groottes van die) ladings en omgekeerd eweredig aan die kwadraat van die afstand tussen hul middelpunte. (2)

1.2



(2)

1.3 $F = k\frac{Q_1Q_2}{r^2}$ ✓

$F(Q_2 \text{ on } Q_1) = (9 \times 10^9)\frac{(4\times10^{-6})(4\times10^{-6})}{(3\times10^{-3})^2}$ ✓ ✓ $= 1{,}6 \times 10^4$ N (to left/*na links*)

$F(Q_3 \text{ on } Q_1) = (9 \times 10^9)\frac{(4\times10^{-6})(4\times10^{-6})}{(3\times10^{-3})^2}$ ✓ $= 1{,}6 \times 10^4$ N

(downwards/*afwaarts*)

$$F_{net} = \sqrt{(F_{Q2\ on\ Q1})^2 + (F_{Q3\ on\ Q1})^2}$$
$$= \sqrt{(1{,}6 \times 10^4)^2 + (1{,}6 \times 10^4)^2} \checkmark$$
$$= 2{,}26 \times 10^4\ N$$

$$\tan\theta = \left(\frac{F_{Q3\ on\ Q1}}{F_{Q2\ on\ Q1}}\right)$$
$$\tan\theta = \left(\frac{1{,}6 \times 10^4}{1{,}6 \times 10^4}\right) \checkmark$$

$\therefore \theta = 45°$

$F_{net} =$ 2,26 x 10^3 N ✓ SW / 225° / 45° south of west / *suid van wes* ✓ (8)

[12]

.1 The force ✓per unit charge ✓ at that point.
Die krag per eenheidslading by daardie punt. (2)

.2
$$E = \frac{kQ}{r^2} \checkmark$$
$$= \frac{(9 \times 10^9)(6{,}5 \times 10^{-12})}{(0{,}003)^2} \checkmark$$
$= 6{,}5 \times 10^3\ N{\cdot}C^{-1}$ ✓ (3)

.3 **At point X/*By punt X***

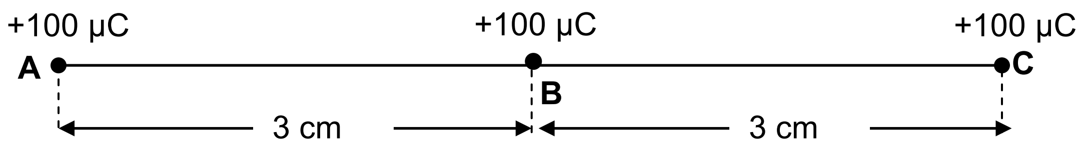
$E_Q = 6{,}5 \times 10^3\ N{\cdot}C^{-1}$ west/*wes* ✓
$$E_R = \frac{kQ}{r^2}$$
$$= \frac{(9 \times 10^9)(6{,}5 \times 10^{-12})}{(0{,}003)^2}$$
$= 6{,}5 \times 10^3\ N{\cdot}C^{-1}$ east/*oos* ✓

$E_{net} = E_Q + E_R$ ✓
$= 6{,}5 \times 10^3 + (-6{,}5 \times 10^3)$
$= 0\ N{\cdot}C^{-1}$ ✓ (4)

[9]

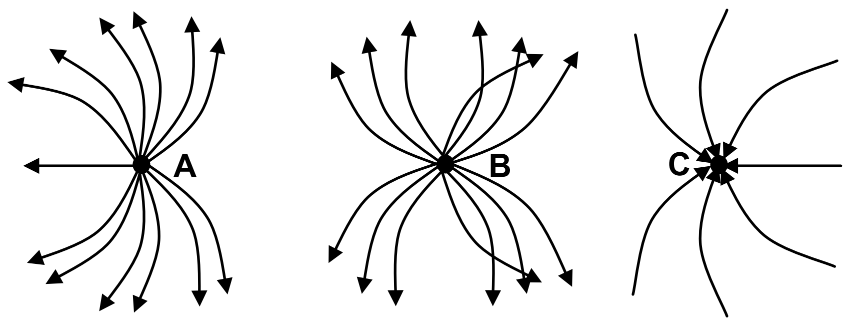
ACTIVITY 1

Three +100 μC point charges, **A**, **B** and **C**, are equally spaced on a straight line in a vacuum. The charges are a distance of 3 cm from each other as shown in the sketch below.



1.1 Name the law that describes the electrostatic force exerted by one point charge on another. (1)

1.2 A learner sketches the electric field pattern produced by the three charges as shown below.



Write down THREE mistakes the learner made. (3)

1.3 Calculate the net electrostatic force experienced by point charge **C**. (6)

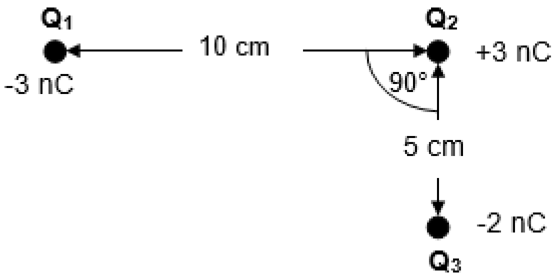
1.4 Write down the net electrostatic force experienced by point charge **B**. Give a reason for the answer. (2)

[12]

A -3 nC charge Q_1 is placed 10 cm away from a +3 nC Q_2 charge as shown in the diagram below.

1.1 Draw the electric field pattern formed between the two charges. (3)

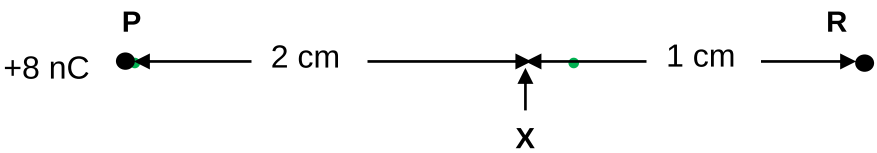
1.2 A -2 nC charge Q_3 is placed 5 cm away from Q_2 as indicated in the diagram below.



Draw a force diagram showing the electrostatic forces exerted on Q_2 by Q_1 and Q_3 respectively. (2)

1.3 Calculate the net force exerted on Q_2 by Q_1 and Q_3 respectively. (8)

1.4 An unknown point charge **R** is placed 3 cm away from point **P** as shown in the sketch below.



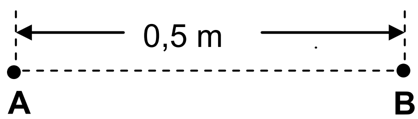
Calculate the charge on **R** if the net electric field strength at point **X** is zero. (5)

[18]

ADDITIONAL ACTIVITIES

ACTIVITY 3

Two identical negatively charged spheres, **A** and **B**, having charges of the **same magnitude**, are placed 0,5 m apart in vacuum. The magnitude of the electrostatic force that one sphere exerts on the other is $1,44 \times 10^{-1}$ N.



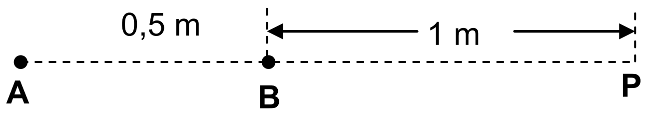
1.1 State Coulomb's law in words. (2)

1.2 Calculate the:

1.2.1 Magnitude of the charge on each sphere (4)

1.2.2 Excess number of electrons on sphere **B** (3)

1.3 **P** is a point at a distance of 1 m from sphere **B**.



1.3.1 What is the direction of the net electric field at point **P**?

1.3.2 Calculate the number of electrons that should be removed from sphere **B** so that the net electric field at point **P** is 3×10^4 N·C^{-1} to the right. (8)

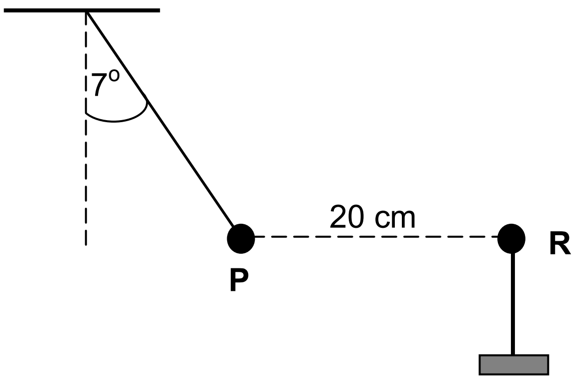
[18]

ACTIVITY 4

A very small graphite-coated sphere **P** is rubbed with a cloth. It is found that the sphere acquires a charge of + 0,5 μC.

1.1 Calculate the number of electrons removed from sphere **P** during the charging process. (3)

Now the charged sphere **P** is suspended from a light, inextensible string. Another sphere, **R**, with a charge of – 0,9 μC, on an insulated stand, is brought close to sphere **P**. As a result sphere **P** moves to a position where it is 20 cm from sphere **R**, as shown below. The system is in equilibrium and the angle between the string and the vertical is 7°.



1.2 Draw a labelled free-body diagram showing ALL the forces acting on sphere **P**. (3)

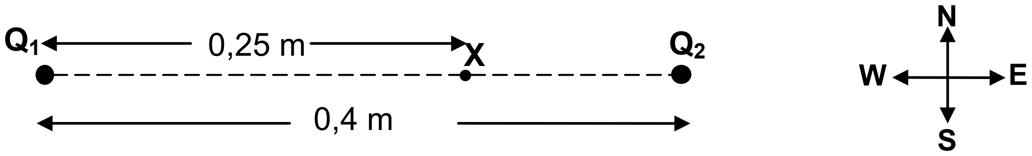
1.3 State Coulomb's law in words. (2)

1.4 Calculate the magnitude of the tension in the string. (5)

[13]

ACTIVITY 5

Two charged particles, **Q_1** and **Q_2**, are placed 0,4 m apart along a straight line. The charge on **Q_1** is + 2 x 10^{-5} C, and the charge on **Q_2** is – 8 x 10^{-6} C. Point **X** is 0,25 m **east** of **Q_1**, as shown in the diagram below.



Calculate the:

1.1 Net electric field at point **X** due to the two charges (6)

1.2 Electrostatic force that a – 2 x 10^{-9} C charge will experience at point **X** (4)

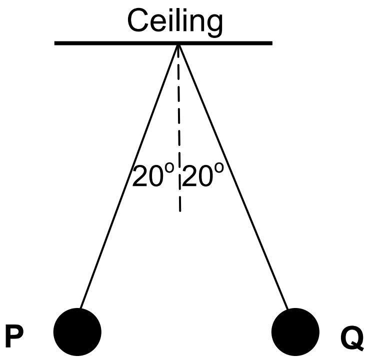
The – 2 x 10^{-9} C charge is replaced with a charge of – 4 x 10^{-9} C at point **X**.

1.3 **Without any further calculation**, determine the magnitude of the force that the – 4 x 10^{-9} C charge will experience at point **X**. (1)

[11]

ACTIVITY 6

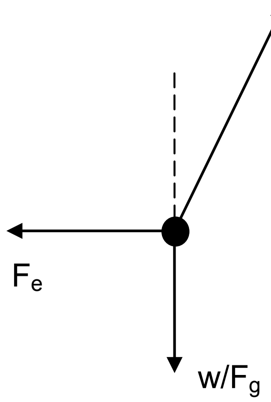
Two identical spherical balls, **P** and **Q**, each of mass 100 g, are suspended at the same point from a ceiling by means of identical light, inextensible insulating strings. Each ball carries a charge of +250 nC. The balls come to rest in the positions shown in the diagram below.



1.1 In the diagram, the angles between each string and the vertical are the same. Give a reason why the angles are the same. (1)

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

1.3 The free-body diagram, not drawn to scale, of the forces acting on ball **P** is shown below.



Calculate the:

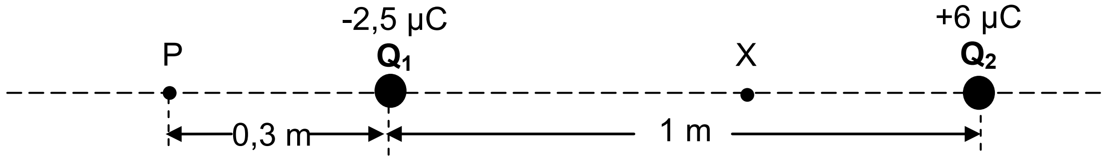
1.3.1 Magnitude of the tension (T) in the string (3)

1.3.2 Distance between balls **P** and **Q** (5)

[11]

ACTIVITY 7

A sphere $\mathbf{Q_1}$, with a charge of -2,5 μC, is placed 1 m away from a second sphere $\mathbf{Q_2}$, with a charge +6 μC. The spheres lie along a straight line, as shown in the diagram below. Point **P** is located a distance of 0,3 m to the left of sphere $\mathbf{Q_1}$, while point **X** is located between $\mathbf{Q_1}$ and $\mathbf{Q_2}$. The diagram is not drawn to scale.



1.1 Show, with the aid of a VECTOR DIAGRAM, why the net electric field at point **X** *cannot be zero.* (4)

1.2 Calculate the net electric field at point **P**, due to the two charged spheres $\mathbf{Q_1}$ and $\mathbf{Q_2}$. (6)

[10]

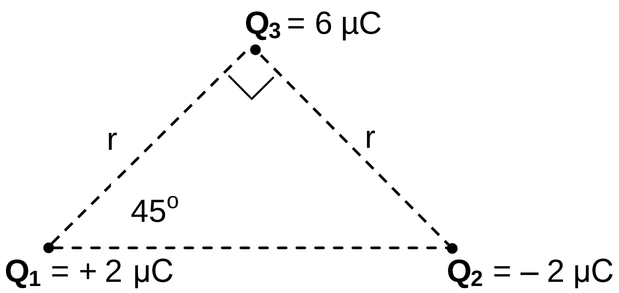
ACTIVITY 7 (CHALLENGE***)

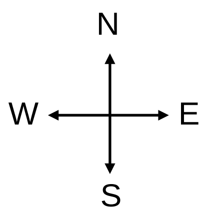
1.1 A metal sphere A, suspended from a wooden beam by means of a non-conducting string, has a charge of +6 µC.

1.1.1 Were electrons ADDED TO or REMOVED FROM the sphere to obtain this charge? Assume that the sphere was initially neutral. (1)

1.1.2 Calculate the number of electrons added to or removed from the sphere. (3)

1.2 Point charges $\mathbf{Q_1}$, $\mathbf{Q_2}$ and $\mathbf{Q_3}$ are arranged at the corners of a right-angled triangle, as shown in the diagram below.





The charges on $\mathbf{Q_1}$ and $\mathbf{Q_2}$ are + 2 µC and – 2 µC respectively and the magnitude of the charge on $\mathbf{Q_3}$ is 6 µC.

The distance between $\mathbf{Q_1}$ and $\mathbf{Q_3}$ is r. The distance between $\mathbf{Q_2}$ and $\mathbf{Q_3}$ is also r.

The charge $\mathbf{Q_3}$ experiences a resultant electrostatic force of 0,12 N to the west.

1.2.1 Without calculation, identify the sign (positive or negative) on the charge $\mathbf{Q_3}$. (1)

1.2.2 Draw a vector diagram to show the electrostatic forces acting on $\mathbf{Q_3}$ due to charges $\mathbf{Q_1}$ and $\mathbf{Q_2}$ respectively. (2)

1.2.3 Write down an expression, in terms of r, for the horizontal component of the electrostatic force exerted on $\mathbf{Q_3}$ by $\mathbf{Q_1}$. (3)

1.2.4 Calculate the distance r. (4)

1.3 The magnitude of the electric field is 100 $N{\cdot}C^{-1}$ at a point which is 0,6 m away from a point charge Q.

1.3.1 Define the term *electric field at a point* in words. (2)

1.3.2 Calculate the distance from point charge Q at which the magnitude of the electric field is 50 $N{\cdot}C^{-1}$. (5)

[21]

STRUCTURE OF ORGANIC MOLECULES

EXAMINATION GUIDELINES:

Organic Molecules (This section must be read in conjunction with the CAPS, p. 104–116.)

- Define *organic molecules* as molecules containing carbon atoms.

Organic molecular structures – functional groups, saturated and unsaturated structures, isomers

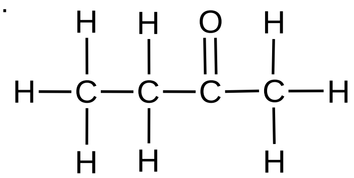
- Write down condensed structural formulae, structural formulae and molecular formulae (up to 8 carbon atoms, one functional group per molecule) for:
  - Alkanes (no ring structures)
  - Alkenes (no ring structures)
  - Alkynes
  - Halo-alkanes (primary, secondary and tertiary haloalkanes; no ring structures)
  - Alcohols (primary, secondary and tertiary alcohols)
  - Carboxylic acids
  - Esters
  - Aldehydes
  - Ketones
- Know the following definitions/terms:

  Molecular formula: A chemical formula that indicates the type of atoms and the correct number of each in a molecule.

  Example: C_4H_8O

  Structural formula: A structural formula of a compound shows which atoms are attached to which within the molecule. Atoms are represented by their chemical symbols and lines are used to represent ALL the bonds that hold the atoms together.

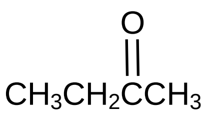
  Example:



  Condensed structural formula: This notation shows the way in which atoms are bonded together in the molecule, but DOES NOT SHOW ALL bond lines.

  Example:

  $CH_3CH_2COCH_3$ OR



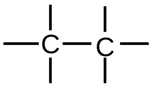
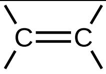
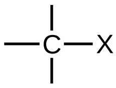
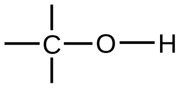
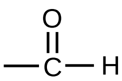
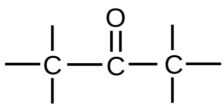
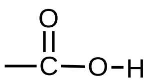
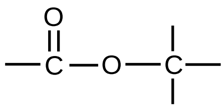
  Hydrocarbon: Organic compounds that consist of hydrogen and carbon only.

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

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

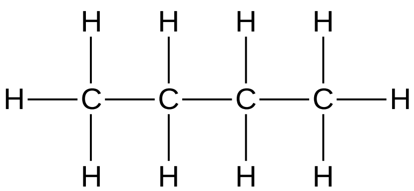
  Unsaturated compounds: Compounds with one or more multiple bonds between C atoms in their hydrocarbon chains.

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

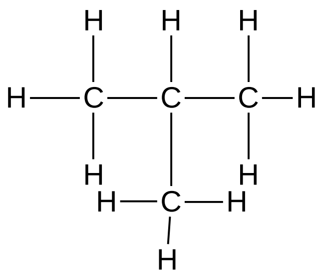
Homologous series	Structure of functional group	
	Structure	**Name/Description**
Alkanes		Only C-H and C-C single bonds
Alkenes		Carbon-carbon double bond
Alkynes		Carbon-carbon triple bond
Haloalkanes	 (X = F, Cℓ, Br, I)	Halogen atom bonded to a saturated C atom
Icohols		Hydroxyl group bonded to a saturated C atom
Aldehydes		Formyl group
Ketones		Carbonyl group bonded to two C atoms
Carboxylic acids		Carboxyl group
Esters		-

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

- Identify compounds (up to 8 carbon atoms) that are saturated, unsaturated and are structural isomers.
- Restrict structural isomers to chain isomers, positional isomers and functional isomers.
  - Chain isomers: Same molecular formula, but different types of chains, e.g. butane and 2-methylpropane.



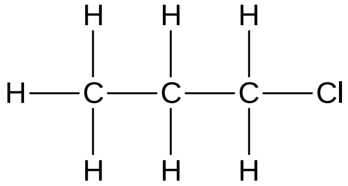
Butane



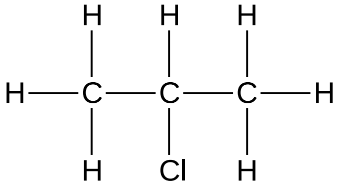
2-methylpropane

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

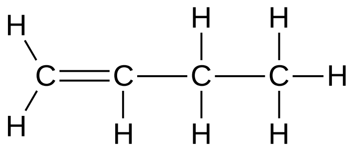
EXAMINATION GUIDELINES:



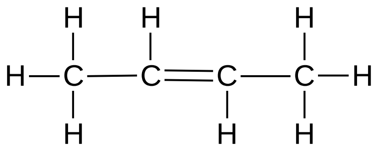
1-chloropropane



2-choropropane

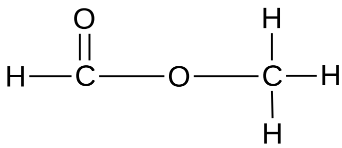


but-1-ene

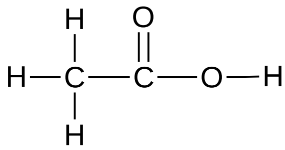


but-2-ene

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



methyl methanoate



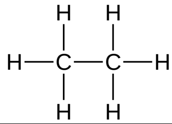
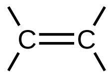
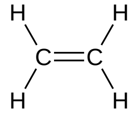
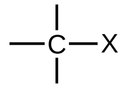
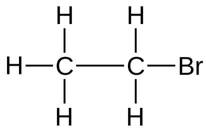
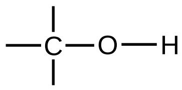
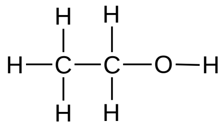
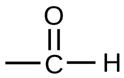
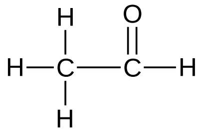
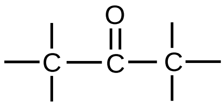
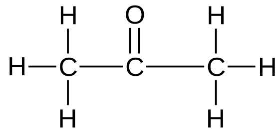
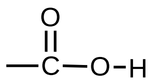
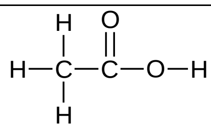
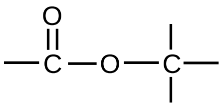
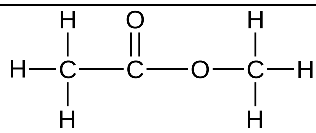
ethanoic acid

IUPAC naming and formulae

- Write down the IUPAC name when given the structural formula or condensed structural formula for compounds from the homologous series above, restricted to one functional group per compound, except for haloalkanes. For haloalkanes, maximum two functional groups per molecule.
- Write down the structural formula when given the IUPAC name for the above homologous series.
- Identify alkyl substituents (methyl- and ethyl-) in a chain to a maximum of THREE alkyl substituents on the parent chain.
- When naming haloalkanes, the halogen atoms do not get preference over alkyl groups – numbering should start from the end nearest to the first substituent, either the alkyl group or the halogen. In haloalkanes, where e.g. a Br and a Cℓ have the same number when numbered from different ends of chain, Br gets alphabetical preference.
- When writing IUPAC names, substituents appear as prefixes written alphabetically (bromo, chloro, ethyl, methyl), ignoring the prefixes di- and tri.

IMPORTANT TERMS AND DEFINITIONS	
Organic molecules	Molecules containing carbon atoms.
Molecular formula	A chemical formula that indicates the type of atoms and the correct number of each in a molecule.
Structural formula	A structural formula of a compound shows which atoms are attached to which within the molecule. Atoms are represented by their chemical symbols and lines are used to represent ALL the bonds that hold the atoms together.
Condensed structural formula	This notation shows the way in which atoms are bonded together in the molecule, but DOES NOT SHOW ALL bond lines.
Hydrocarbon	Organic compounds that consist of hydrogen and carbon only.
Homologous series	A series of organic compounds that can be described by the same general formula OR in which one member differs from the next with a CH_2 group.
Saturated compounds	Compounds in which there are no multiple bonds between C atoms in their hydrocarbon chains.
Unsaturated compounds	Compounds with one or more multiple bonds between C atoms in their hydrocarbon chains.
Functional group	A bond or an atom or a group of atoms that determine(s) the physical and chemical properties of a group of organic compounds.
Alkanes	Only C-H and C-C single bonds.
Alkenes	Carbon-carbon double bond.
Alkynes	Carbon-carbon triple bond.
Haloalkanes	(X = F, Cℓ, Br, I) Halogen atom bonded to a saturated C atom.
Alcohols	Hydroxyl group bonded to a saturated C atom.
Aldehydes	Formyl group.
Ketones	Carbonyl group bonded to two C atoms.
Carboxylic acids	Carboxyl group.
Esters	
Structural isomer	Organic molecules with the same molecular formula, but different structural formulae.
Chain isomers	Same molecular formula, but different types of chains, e.g. butane and 2-methylpropane.
Positional isomers	Same molecular formula, but different positions of the side chain, substituents or functional groups on the parent chain, e.g. 1-choropropane and 2-chloropropane or but-2-ene and but-1-ene.
Functional isomers	Same molecular formula, but different functional groups, e.g. methyl methanoate and ethanoic acid.

FUNCTIONAL GROUPS OF ORGANIC COMPOUNDS

Homologous series	Structure of functional group	Example of a compound	
		Name	Structural formula
alkanes	Only C-H and C-C single bonds	ethane	
alkenes		ethene	
alkynes	—C≡C—	ethyne	H—C≡C—H
haloalkanes (alkyl halides)	 (X = F, Cl, Br, I)	bromoethane	
alcohols (alkanols)		ethanol	
aldehydes		ethanal	
ketones		propan-2-one	
carboxylic acids		ethanoic acid	
esters		methyl ethanoate	

NAMING OF ORGANIC COMPOUNDS

The name of every organic molecule has three parts:

- The **parent name** indicates the number of C atoms in the longest carbon chain in the molecule.
- The **suffix** indicates what functional group is present.
- The **prefix** reveals the identity, location and number of substituents attached to the carbon chain.

prefix	parent	suffix
What and where are the substituents?	How many carbons?	What is the functional group/homologous series?

Number of carbon atoms	Parent name	Number of carbon atoms	Parent name
1	meth	5	pent
2	eth	6	hex
3	prop	7	hept
4	but	8	oct

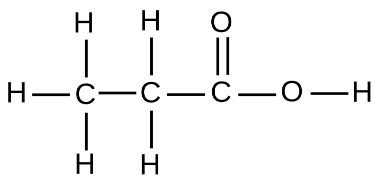
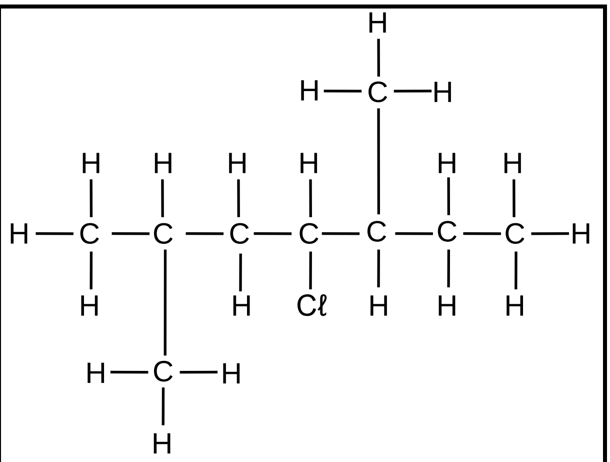
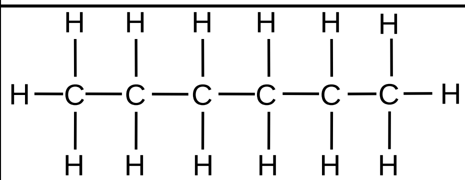
LEARNER & TEACHER MANUAL	
TOPIC: Organic Molecules: Nomenclature	**Duration: 1** HOUR: 40 MIN

Key Concepts:

1. Functional groups, saturated and unsaturated structures
2. Isomers
3. IUPAC naming and formulae

EXAMPLE 1

The letters **A** to **F** in the table below represent six organic compounds.

A		**B**	
C	C_4H_8	**D**	$CH_3CH_2COCH_3$
E	$CH_3CH(CH_3)CH_2OH$	**F**	

Use the information in the table (where applicable) to answer the questions that follow.

1.1 Write down the LETTER that represents a compound that:
(A compound may be used more than once.)

1.1.1 Is a haloalkane (1)

1.1.2 Has a hydroxyl group as functional group (1)

1.1.3 Belongs to the same homologous series as ethanoic acid (1)

1.2 Write down the:

1.2.1 IUPAC name of compound **B** (3)

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

1.2.3 Structural formula of the functional group of compound **D** (1)

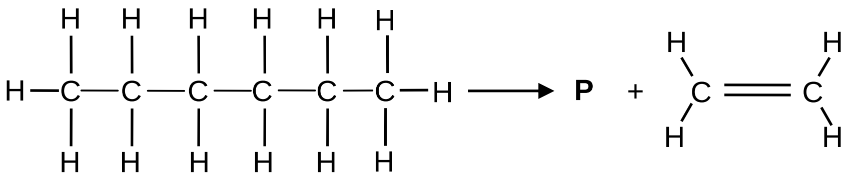
1.3 Compound **C** has CHAIN and POSITIONAL isomers.

1.3.1 Define the term *positional isomer*. (2)

1.3.2 Write down the IUPAC name of each of the TWO positional isomers of compound **C**. (4)

1.3.3 Write down the structural formula of a chain isomer of compound **C**. (2)

1.4 Compound **F** reacts at high pressure and high temperature to form compounds **P** and **Q** as given below.



Compound **F** Compound **Q**

Write down the:

1.4.1 Type of reaction that takes place (1)

1.4.2 IUPAC name of compound **Q** (1)

1.4.3 Molecular formula of compound **P** (1)

Compound **Q** is the monomer of a polymer used to make plastic bags.

1.4.4 Write down the NAME and CONDENSED FORMULA of this polymer. (3)
[23]

SOLUTION 1

1.1

1.1.1 B ✓ (1)

1.1.2 E ✓ (1)

1.1.3 A ✓ (1)

1.2

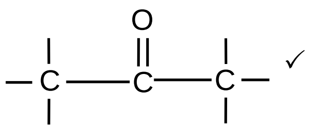
1.2.1 4-chloro-2,5-dimethylheptane

Marking criteria*:*

- Correct stem i.e. heptane. ✓
- All substituents (chloro and dimethyl) correctly identified. ✓Substituents correctly numbered, in alphabetical order, hyphens and commas correctly used. ✓

(3)

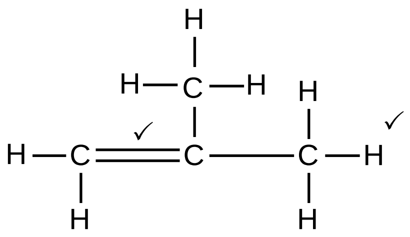
1.2.2 2-methyl✓propan-1-ol ✓ (2)

1.2.3  (1)

1.3

1.3.1 Compounds with the <u>same molecular formula</u>✓ but <u>different POSITIONS of the functional group</u> / side chain / substituents on parent chain. ✓ (2)

1.3.2 <u>But</u>-1-<u>ene</u> ✓✓ **AND** <u>But</u>-2-<u>ene</u> ✓✓ (4)

1.3.3 

<u>Marking criteria:</u>
- Whole structure correct: ✓✓
- Only functional group correct: ✓

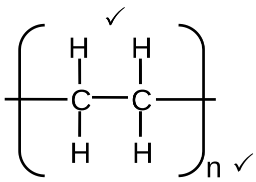
(2)

1.4

1.4.1 Cracking / elimination ✓ (1)

1.4.2 Ethene ✓ (1)

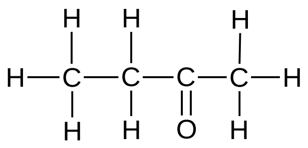
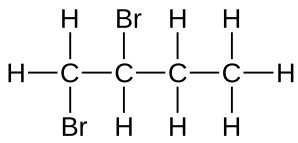
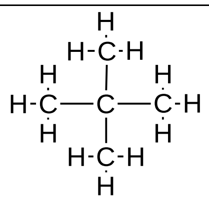
1.4.3 C_4H_{10} ✓ (1)

1.4.4 Polyethene ✓  (3)

[23]

ACTIVITY 1

The letters **A** to **F** in the table below represent six organic compounds.

A	Butanal	**B**	$CH_3CH_2CCCH_3$
C		**D**	
E		**F**	Ethyl ethanoate

Use the information in the table to answer the questions that follow.

1.1 Write down the letter(s) representing:

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

1.1.2 A ketone (1)

1.1.3 An aldehyde (1)

1.1.4 An unsaturated hydrocarbon (1)

1.2 For compound **F**, write down the:

1.2.1 Structure of the functional group to which it belongs (2)

1.2.2 IUPAC name of the acid and an alcohol needed to prepare **F** (2)

1.3 Write down the IUPAC name of:

1.3.1 Compound **C** (2)

1.3.2 Compound **D** (2)

1.4 Write down the condensed structural formula for **C**. (2)

1.5 Write down the structural formula of:

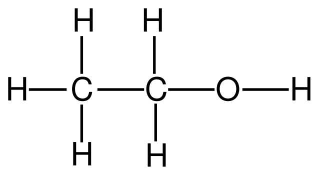
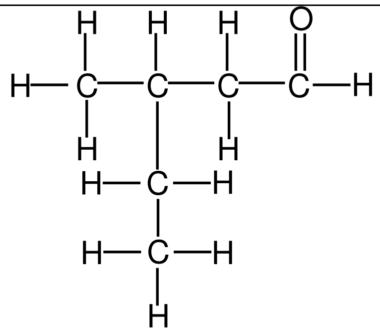
1.5.1 A chain isomer of compound **E** (2)

1.5.2 Compound **F** (2)

[18]

ACTIVITY 2

The letters **A** to **H** in the table below represent eight organic compounds.

A		**B**	
C	$(CH_3)_2CHCHC(CH_3)CH_2CH_3$	**D**	1,2-dibromo-3-methylbutane
E	Propanoic acid	**F**	$CH_3CCCH(C_2H_5)CH_2CH_3$
G	$(CH_3)_2CHCH_2CH(CH_3)CH_2CH_3$	**H**	4-methylpentan-2-one

2.1 Write down the letter(s) that represent(s):

2.1.1 A compound with a carboxyl group as functional group (1)

2.1.2 An alkene (1)

2.1.3 An aldehyde (1)

2.1.4 A saturated hydrocarbon (1)

2.1.5 Two compounds that are functional isomers (1)

2.2 Write down the IUPAC name of:

2.2.1 Compound **B** (2)

2.2.2 Compound **F** (2)

2.2.3 Compound **G** (2)

2.3 Write down the structural formula of:

2.3.1 Compound **D** (2)

2.3.2 Compound **H** (2)

2.4 Compound **A** and compound **E** is heated in the presence of a few drops of concentrated sulphuric acid. Write down the:

2.4.1 Type of reaction that takes place (1)

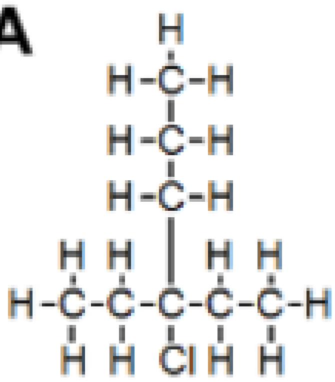
2.4.2 Structural formula of the organic product (2)

[18]

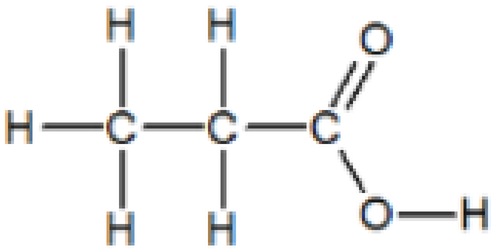
ACTIVITY 3

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

A



B



C

CH_3CH_2CHO

D

Methylpropanoate

3.1.1 Explain why compound **A** is a saturated compound. (1)

3.1.2 Write down the IUPAC name of compound **A**. (3)

3.1.3 Write down the IUPAC name of compound **C**. (1)

3.1.4 Name the homologous series to which compound **B** belongs. (1)

3.1.5 Write down the IUPAC name of the alcohol needed to prepare compound **D**. (1)

3.1.6 Write down the structural formula for a functional isomer of compound **D.** (2)

3.2 An ester contains 9,81% hydrogen (H), 58,85% carbon (C) and 31,34 % oxygen (O). The molecular mass of the ester is 102 $g\cdot mol^{-1}$.

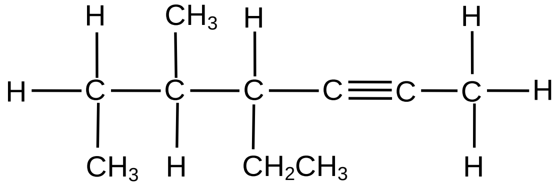
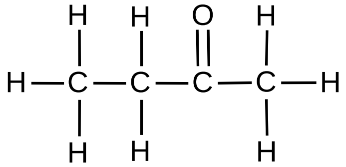
3.2.1 The alcohol used to prepare this ester is ethanol. What is the name of the other reagent used to prepare the ester? (1)

3.2.2 Calculate the molecular formula of the ester. (6)

[16]

ACTIVITY 4

The letters **A** to **D** in the table below represent four organic compounds.

A		**B**	
C	CH_3CH_2CHO	**D**	Butane

4.1 Write down the:

4.1.1 Letter that represents a ketone (1)

4.1.2 Structural formula of the functional group of compound **C** (1)

4.1.3 General formula of the homologous series to which compound **A** belongs (1)

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

4.1.5 IUPAC name of compound **B** (2)

4.2 Compound **D** is a gas used in cigarette lighters.

4.2.1 To which homologous series does compound **D** belong? (1)

4.2.2 Write down the STRUCTURAL FORMULA and IUPAC NAME of a structural isomer of compound **D**. (4)

4.2.3 Is the isomer in QUESTION 4.2.2 a CHAIN, POSITIONAL or FUNCTIONAL isomer? (1)

4.3 Compound **D** reacts with bromine (Br_2) to form 2-bromobutane.
Write down the name of the:

4.3.1 Homologous series to which 2-bromobutane belongs (1)

4.3.2 Type of reaction that takes place (1)

[16]

PHYSICAL PROPERTIES

EXAMINATION GUIDELINES:

Structure and physical properties (boiling point, melting point, vapour pressure) relationships

- For a given example (from the above functional groups), explain the relationship between physical properties and:
  - Strength of intermolecular forces (Van der Waal's forces), i.e. hydrogen bonds, dipole-dipole forces, induced dipole forces
  - Type of functional groups
  - Chain length

IMPORTANT TERMS AND DEFINITIONS	
Dipole-dipole forces	Forces between two polar molecules
Induced dipole forces or London forces	Forces between non-polar molecules
Hydrogen bonding	Forces between molecules in which hydrogen is covalently bonded to nitrogen, oxygen or fluorine – a special case of dipole-dipole forces
Intermolecular forces	An attraction between molecules
Interatomic (intramolecular) forces	An electrostatic force of attraction between atoms due to the sharing or transfer of electrons
Boiling point	The temperature at which the vapour pressure of a substance equals atmospheric pressure. The stronger the intermolecular forces, the higher the boiling point.
Melting point	The temperature at which the solid and liquid phases of a substance are at equilibrium. The stronger the intermolecular forces, the higher the melting point.
Vapour pressure	The pressure exerted by a vapour at equilibrium with its liquid in a closed system. The stronger the intermolecular forces, the lower the vapour pressure.

2.1 Types of physical properties

The physical properties of organic compounds that will be studied in this section are defined in the table below.

Physical property	Definition
Boiling point	The temperature at which the vapour pressure of a liquid equals atmospheric pressure.
Melting point	The temperature at which the solid and liquid phases of a substance are at equilibrium.
Vapour pressure	The pressure exerted by a vapour at equilibrium with its liquid in a closed system.

Physical properties of organic compounds are **mainly determined by the strength of intermolecular forces.**

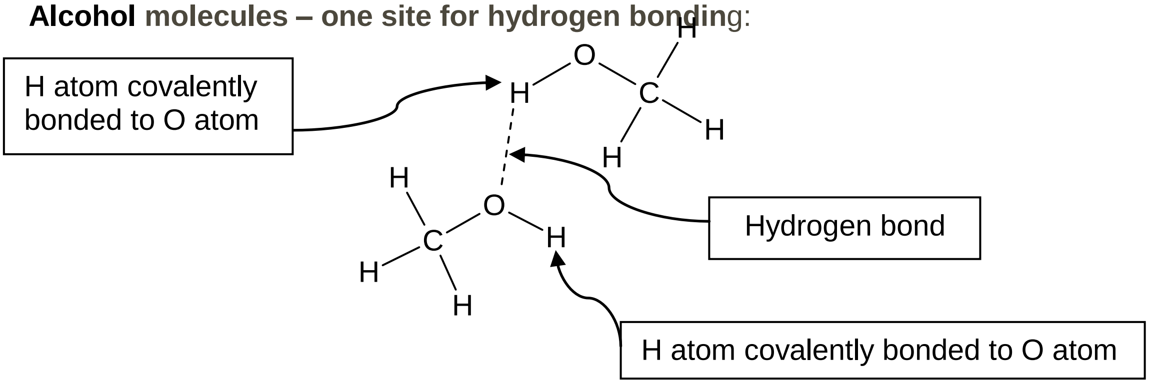
2.2 Types of intermolecular forces

Intermolecular forces are the interactions that exist between molecules. The three different types of intermolecular forces that can exist between organic molecules are, in order of increasing strength:

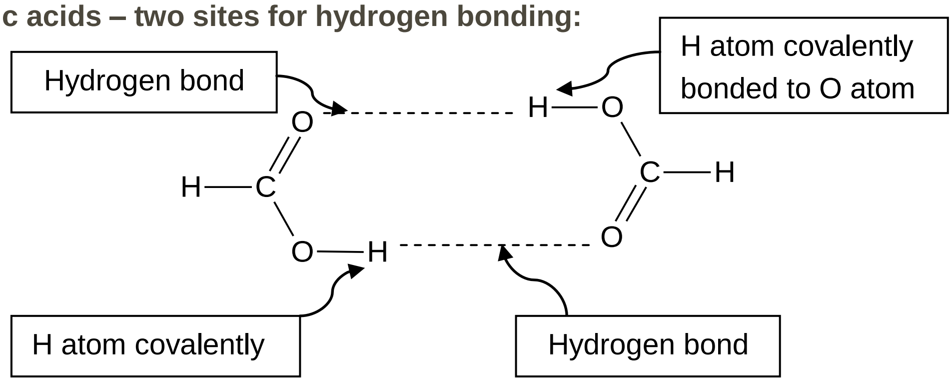
- **London (or dispersion) forces –** weakest intermolecular force. These forces are present between all molecules.
- **Dipole-dipole forces** – present between polar molecules
- **Hydrogen bonding -** strongest intermolecular force. Only between molecules in which an H atom is covalently bonded to a N, O or F atom.
  For our purposes: Only between molecules of alcohols and molecules of carboxylic acids.

Examples:

Alcohol molecules – one site for hydrogen bonding:



Carboxylic acids – two sites for hydrogen bonding:



The table below links the homologous series discussed in this manual to the type of intermolecular forces that can be found between molecules in each.

Homologous series	Alkanes Alkenes Alkynes	Aldehydes Ketones Esters Haloalkanes	Alcohols Carboxylic acids
Type of intermolecular forces	London forces	London forces Dipole-dipole forces	London forces Dipole-dipole forces Hydrogen bonding

1.3 Physical properties and intermolecular forces

- Physical properties of compounds depend on the **strength of intermolecular forces** (forces between molecules).
- **Stronger intermolecular forces** results in:
  - **Higher** boiling points
  - **Higher** melting points
  - **Lower** vapour pressures
- Compounds with **high boiling points** have **low vapour pressures**.

1.3.1 Boiling point

Boiling point of organic compounds **increase with increase in strength of intermolecular forces** - more energy needed to overcome the intermolecular forces.

The boiling point of substances depends on:

(a) Type of functional group

Molecules have **different degrees of polarity as determined by the type of functional group** present. The polarity ranking of functional groups discussed in this document is as follows:

Polarity ranking of functional groups:
Carboxylic acid > Alcohol > Ketone ~ Aldehyde > Ester > Alkane

Principle: The greater the polarity of molecules, the greater the forces of attraction between molecules, and the higher the boiling point.

(b) Surface area – chain length

For compounds with the **same functional group**, the **longer the carbon chain, the larger the surface area and the higher the boiling point.**

(c) Surface area – branching

For compounds with the **same functional group and comparable molecular mass, increase in branching results in a decrease in surface area, weaker intermolecular forces and thus a decrease in boiling point.**

1.3.2 Vapour pressure

Compounds with **HIGH BOILING POINTS** have **LOW VAPOUR PRESSURES**. **Vapour pressure decreases** with **increase in strength of intermolecular forces.**

Vapour pressure is affected by:

(a) Type of functional group
For compounds of **comparable molecular mass, the more polar the functional group, the stronger the intermolecular forces and the LOWER the vapour pressure.**

(b) Surface area – chain length
For compounds with the **same functional group**, the **longer the carbon chain, the larger the surface area and the lower the vapour pressure.** A larger surface area has more sites where London forces can form, resulting in stronger intermolecular forces, and thus a lower vapour pressure.

(c) Surface area – branching
For compounds with the **same functional group and of comparable molecular mass, increase in branching** results in a **decrease in surface area, weaker intermolecular forces** and thus **an increase in vapour pressure.**

1.3.3 Melting points

Melting points are affected by:

(a) Type of functional group
The polarity of molecules determines the forces of attraction between the molecules in the solid state. For compounds of **comparable molecular mass, the more polar the functional group, the stronger the intermolecular forces, and the higher the melting point.**

(b) Surface area – chain length
For compounds with the **same functional group**, the **longer the carbon chain, the larger the surface area and the higher the melting point.** A larger surface area has more sites where London forces can form. The combined effect of all the London forces result in stronger intermolecular forces and a higher melting point.

LEARNER & TEACHER MANUAL	
TOPIC: Organic Molecules: Physical properties	**Duration: 1** HOUR: 40 MIN

Key Concepts:

1. Structure and physical properties relationships.
   - Boiling point
   - Melting point
   - Vapour pressure

EXAMPLE 1

Learners use compounds **A** to **C**, shown in the table below, to investigate a factor which influences the boiling point of organic compounds.

A	$CH_3CH_2CH_2CH_3$
B	$CH_3CH_2CH_2CH_2CH_3$
C	$CH_3CH_2CH_2CH_2CH_2CH_3$

1.1 Which ONE of the compounds (**A**, **B** or **C**) has the highest boiling point? (1)

1.2 For this investigation, write down the:

1.2.1 Independent variable (1)

1.2.2 Dependent variable (1)

1.3 Write down the name of the type of Van der Waals force that occurs between the molecules of compound **B**. (1)

1.4 How will the vapour pressure of 2-methylpentane compare to that of compound **C**? Write down only HIGHER THAN, LOWER THAN or EQUAL TO. (1)

The learners now compare the boiling points of compounds **D** and **E**, shown in the table below.

D	$CH_3CH_2CH_2CH_2CH_2OH$
E	$CH_3CH_2CH_2COOH$

1.5 How does the boiling point of compound **D** compare to that of compound **E**? Write down HIGHER THAN, LOWER THAN or EQUAL TO. Fully explain the answer. (4)

[9]

SOLUTION 1

1.1 C ✓ (1)

1.2

1.2.1 Chain length ✓ (1)

1.2.2 Boiling point ✓ (1)

1.3 London forces ✓ (1)

1.4 Higher than ✓ (1)

1.5 Lower than ✓

- Both compounds **D** and **E** have hydrogen bonding between molecules. ✓
- Compound **D** has one site for hydrogen bonding whilst compound **E** has two sites for hydrogen bonding OR can form dimers. ✓
- More energy needed to overcome intermolecular forces in compound **E.** ✓ (4)

[9]

ACTIVITY 1

The relationship between strength of intermolecular forces and boiling point is investigated using four organic compounds. The compounds and their boiling points are given in the table below.

Compound	Boiling point (^oC)
butane	-1
2-methylbutane	27,7
pentane	36,1
2-methylpropan-2-ol	82

1.1 Write down the definition of the term "*boiling point*." (2)

1.2 Which substance(s) will be a liquid at 50 ^oC? (1)

1.3 Name the type of intermolecular force(s) found between butane molecules. (1)

1.4 Refer to the strength of intermolecular forces, the type of intermolecular forces and/or structure of the molecules and energy in order to explain the difference between the boiling points of the following substances:

1.4.1 pentane and 2-methylbutane (4)

1.4.2 pentane and 2-methylpropan-2-ol (4)

1.5 Which substance will have the lowest vapour pressure at 50 ^oC? (1)

1.6 A sample of butane (C_4H_{10}) of mass 26 g burns in excess oxygen. 34 g of CO_2 forms. The balanced equation for this reaction is given below:

$$2C_4H_{10}\,(g) + 13O_2\,(g) \rightarrow 8CO_2(g) + 10H_2O(g)$$

Calculate the percentage by mass of pure butane gas in the sample. (5)

[18]

ACTIVITY 2

The table below shows the vapour pressures of various organic compounds at 25 °C.

Compound	Molar mass ($g \cdot mol^{-1}$)	Vapour Pressure ($x10^2$ Pa)
pentane	72	573,0
hexane	86	160,0
heptane	100	48,0
propan-1-ol	60	21,0
propan-2-ol	60	44,0
butan-1-ol	74	6,2
butan-2-ol	74	18,3
pentan-1-ol	88	2,2
pentan-2-ol	88	8,04
ethanoic acid	60	15,3
propanone	58	240,0

2.1 Write down

2.1.1 the general formula of the homologous series of which heptane is a

2.1.2 the IUPAC name and structural formula of an isomer of pentane. (2)

2.1.3 the structural formula of propanone. (2)

2.2 State and explain the relationship between vapour pressure and the strength of intermolecular forces. (3)

2.3 Explain the difference in vapour pressure between pentane, hexane and heptane. Refer to strength of intermolecular forces in your answer. (2)

2.4 Explain why:

2.4.1 The vapour pressure of butan-1-ol is so much lower than that of pentane. (2)

2.4.2 The vapour pressure of secondary alcohols are higher than the primary alcohols that has the same structural formula. (2)

2.5 Which compound will have the higher boiling point: ethanoic acid or propan-1-ol? (1)

2.6 Refer to vapour pressure, intermolecular forces and energy and give a

[18]

ACTIVITY 3

The table below shows five organic compounds represented by the letters **A** to **E**.

A	CH_4
B	CH_3CH_3
C	$CH_3CH_2CH_3$
D	$CH_3CH_2CH_2CH_3$
E	CH_3CH_2OH

3.1 Is compound **B** SATURATED or UNSATURATED? Give a reason for the answer. (2)

Consider the boiling points of compounds **A** to **E** given in random order below and use them, where applicable, to answer the questions that follow.

0 °C	- 162 °C	- 42 °C	- 89 °C	78 °C

3.2 Write down the boiling point of:

3.2.1 Compound **C** (1)

3.2.2 Compound **E** (1)

3.3 Explain the difference in boiling points of compounds **C** and **E** by referring to the TYPE of intermolecular forces present in EACH of these compounds. (3)

3.4 Does vapour pressure INCREASE or DECREASE from compounds **A** to **D**? Fully explain the answer. (4)

3.5 How will the vapour pressure of 2-methylpropane compare to the vapour pressure of compound **D**? Write down only HIGHER THAN, LOWER THAN or EQUAL TO. (1)
[12]

ACTIVITY 4

Four compounds of comparable molecular mass are used to investigate the effect of functional groups on vapour pressure. The results obtained are shown in the table below.

COMPOUND		VAPOUR PRESSURE (kPa at 20 °C)
A	Butane	204
B	Propan-2-one	24,6
C	Propan-1-ol	2
D	Ethanoic acid	1,6

4.1 Define the term *functional group* of an organic compound. (2)

4.2 Which ONE of the compounds (**A**, **B**, **C** or **D**) in the table has the:

4.2.1 Highest boiling point
(Refer to the vapour pressures in the table to give a reason for the answer.) (2)

4.2.2 Weakest intermolecular forces (1)

4.3 Refer to the type of intermolecular forces to explain the difference between the vapour pressure of compound **A** and compound **B**. (3)

4.4 The vapour pressures of compounds **C** and **D** are much lower than those of compounds **A** and **B**. Name the type of intermolecular force in **A** and **B** that is responsible for this difference. (1)

4.5 Briefly explain the difference in vapour pressure between compound **C** and compound **D**. (2)

4.6 During a combustion reaction in a closed container of adjustable volume, 8 cm^3 of compound **A** (butane) reacts in excess oxygen according to the following balanced equation:

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

If the initial volume of the oxygen in the container was 60 cm^3, calculate the TOTAL volume of the gases that are present in the container at the end of the reaction. All the gases in the container are at the same temperature and pressure. (5)

[16]

ACTIVITY 5

The boiling points of three isomers are given in the table below.

	ISOMERS	BOILING POINT (°C)
A	2,2-dimethylpropane	9
B	2-methylbutane	28
C	pentane	36

7.1 Define the term *structural isomer*. (2)

7.2 What type of isomers (POSITIONAL, CHAIN or FUNCTIONAL) are these three compounds? (1)

7.3 Explain the trend in the boiling points from compound **A** to compound **C**. (3)

7.4 Which ONE of the three compounds (**A**, **B** or **C**) has the highest vapour pressure? Refer to the data in the table to give a reason for the answer. (2)

7.5 Use MOLECULAR FORMULAE and write down a balanced equation for the complete combustion of compound **B**. (3)

[11]

REACTIONS OF ORGANIC COMPOUNDS

EXAMINATION GUIDELINES:

Esterification

- Write down an equation, using structural formulae, for the formation of an ester.
- Name the alcohol and carboxylic acid used and the ester formed.
- Write down reaction conditions for esterification.

Substitution, addition and elimination reactions

- Identify reactions as elimination, substitution or addition.
- Write down, using structural formulae, equations and reaction conditions for the following addition reactions of alkenes:
  - Hydrohalogenation:
    The addition of a hydrogen halide to an alkene
  - Halogenation:
    The reaction of a halogen (Br_2, $C\ell_2$) with a compound
  - Hydration:
    The addition of water to a compound
  - Hydrogenation:
    The addition of hydrogen to an alkene
- Write down, using structural formulae, equations and reaction conditions for the following elimination reactions:
  - Dehydrohalogenation of haloalkanes:
    The elimination of hydrogen and a halogen from a haloalkane
  - Dehydration of alcohols:
    Elimination of water from an alcohol
  - Cracking of alkanes:
    The chemical process in which longer chain hydrocarbon molecules are broken down to shorter more useful molecules.
- Write down, using structural formulae, equations and reaction conditions for the following substitution reactions:
  - Hydrolysis of haloalkanes
    Hydrolysis: The reaction of a compound with water
  - Reactions of HX (X = Cℓ, Br) with alcohols to produce haloalkanes
  - Halogenation of alkanes
    The reaction of a halogen (Br_2, $C\ell_2$) with a compound
- Distinguish between *saturated* and *unsaturated hydrocarbons* using bromine water.

Plastics and polymers (ONLY BASIC POLYMERISATION as application of organic chemistry)

- Describe the following terms:
  Macromolecule: A molecule that consists of a large number of atoms
  Polymer: A large molecule composed of smaller monomer units covalently bonded to each other in a repeating pattern
  Monomer: Small organic molecules that can be covalently bonded to each other in a repeating pattern
  Polymerisation: A chemical reaction in which monomer molecules join to form a polymer
- Distinguish between *addition polymerisation* and *condensation polymerisation*:
  Addition polymerisation: A reaction in which small molecules join to form very large molecules by adding on double bonds
  Addition polymer: A polymer formed when monomers (usually containing a double bond) combine through an addition reaction
  Condensation polymerisation: Molecules of two monomers with different functional groups undergo condensation reactions with the loss of small molecules, usually water

EXAMINATION GUIDELINES:

Condensation polymer: A polymer formed by two monomers with different functional groups that are linked together in a condensation reaction in which a small molecule, usually water, is lost

- Identify monomers from given addition polymers.
- Write down an equation for the polymerisation of ethene to produce polythene.
- State the industrial uses of polythene.

Oxidation of alkanes

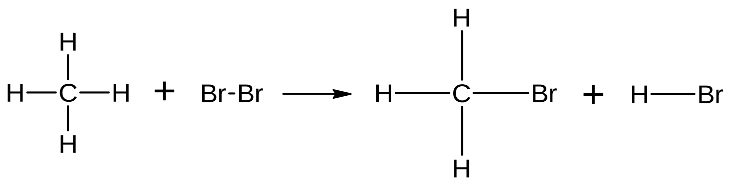
- State the use of alkanes as fuels.
- Write down an equation for the combustion of an alkane in excess oxygen.

IMPORTANT TERMS AND DEFINITIONS	
Hydrohalogenation	The addition of a hydrogen halide to an alkene.
Halogenation	The reaction of a halogen (Br_2, $C\ell_2$) with a compound.
Hydration	The addition of water to a compound.
Hydrogenation	The addition of hydrogen to an alkene.
Dehydrohalogenation of haloalkanes	The elimination of hydrogen and a halogen from a haloalkane.
Dehydration of alcohols	Elimination of water from an alcohol.
Cracking of alkanes	The chemical process in which longer chain hydrocarbon molecules are broken down to shorter more useful molecules.
Hydrolysis	The reaction of a compound with water.
Macromolecule	A molecule that consists of a large number of atoms.
Polymer	A large molecule composed of smaller monomer units covalently bonded to each other in a repeating pattern.
Monomer	Small organic molecules that can be covalently bonded to each other in a repeating pattern.
Polymerisation	A chemical reaction in which monomer molecules join to form a polymer.
Addition polymerisation	A reaction in which small molecules join to form very large molecules by adding on double bonds.
Addition polymer	A polymer formed when monomers (usually containing a double bond) combine through an addition reaction.
Condensation polymerisation	Molecules of two monomers with different functional groups undergo condensation reactions with the loss of small molecules, usually water.
Condensation polymer	A polymer formed by two monomers with different functional groups that are linked together in a condensation reaction in which a small molecule, usually water, is lost.

APPENDIX B: Organic reactions

REACTIONS OF ALKANES

SUBSTITUTION
Alkane → haloalkane

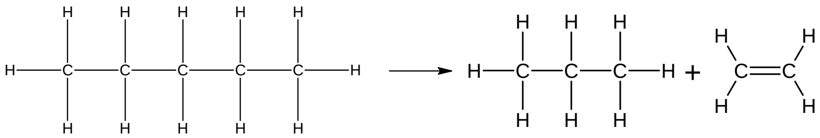


Conditions: heat OR sunlight **Reactants:** alkane + X_2 (F, Cl, Br, I)
Type of substitution: halogenation **Products**: haloalkane + HX

OXIDATION (COMBUSTION)

$2C_6H_{14} + 19O_2 \rightarrow 12CO_2 + 14H_2O$
Alkane + oxygen → carbon dioxide + water + **energy**

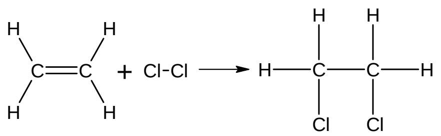
ELIMINATION
Alkane → alkene(s) + alkane with shorter chain



Type of elimination: (thermal) cracking
Conditions: heat + high pressure
Reactant: alkane
Products: alkene(s) + alkane / alkene + H_2

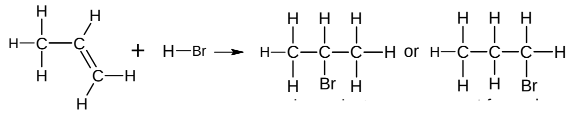
REACTIONS OF ALKENES

ADDITION



Conditions: unreactive solvent
Type of addition: halogenation
Reactants: alkene + X_2 (X = Cl, Br)
Product: haloalkane

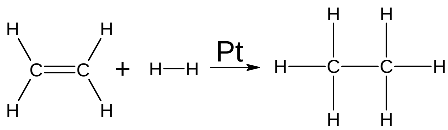
ADDITION



Major product

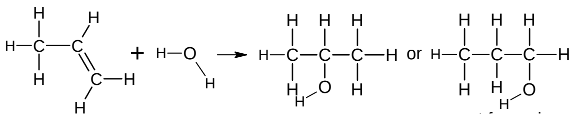
Conditions: no water; unreactive solvent
Type of addition: hydrohalogenation
Reactants: alkene + HX (X = I, Br, Cl)
Product(s): haloalkane(s)
Major product: H atom bonds to the C atom already having the greater number of H atoms.

ADDITION



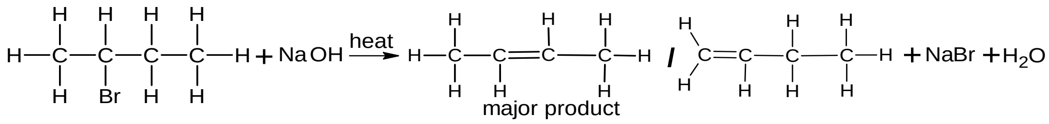
Conditions: Pt, Pd or Ni as catalyst
Type of addition: hydrogenation
Reactants: alkene + H_2
Product: alkane

ADDITION



Major product

Conditions: excess H_2O; small amount of acid (H_2SO_4/H_3PO_4) as catalyst
Type of addition: hydration
Reactants: alkene + H_2O
Product: alcohol(s)
Major product: H atom bonds to the C atom already having the greater number of H atoms.

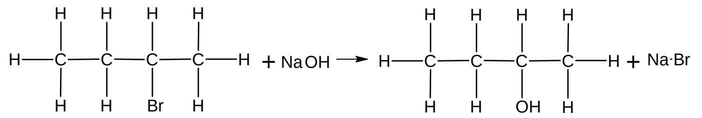


Conditions: concentrated strong base (NaOH, KOH, LiOH) in ethanol + heat
Type of elimination: dehydrohalogenation
Reactants: haloalkane + concentrated strong base **Products:** alkene + NaBr + H_2O
Major product: The one where the H atom is removed from the C atom with the least number of H atoms (most substituted double bond forms i.e. double bond with most alkyl groups)

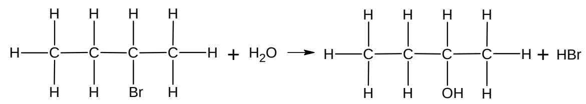
ELIMINATION

REACTIONS OF HALOALKANES

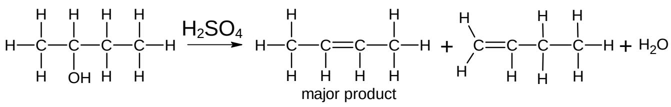
SUBSTITUTION



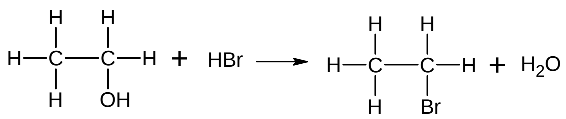
Conditions: dilute strong base (NaOH/KOH/LiOH) + mild heat
Type of substitution: hydrolysis
Reactants: haloalkane + dilute strong base
Products: alcohol + NaBr/KBr/LiBr



Conditions: excess H_2O + mild heat
Type of substitution: hydrolysis
Reactants: haloalkane + H_2O
Products: alcohol + HBr



Conditions: dehydrating agent (H_2SO_4/H_3PO_4) + heat
Type of elimination: dehydration
Reactants: alcohol + H_2SO_4
Products: alkene(s) + H_2O
Major product: The one where the H atom is removed from the C atom with the least number of H atoms



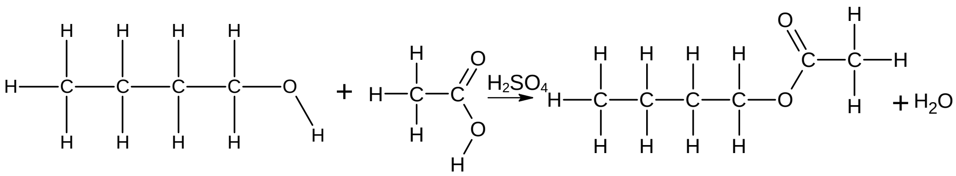
Conditions: heat
Reactants needed: alcohol + HX
Primary & secondary alcohols:
NaBr + H_2SO_4 used to make HBr in reaction flask
Tertiary alcohols: water free HBr (or HCl)
Products: haloalkane + H_2O

ELIMINATION
Alcohol → alkene

SUBSTITUTION

REACTIONS OF ALCOHOLS

ESTERIFICATION



Conditions: concentrated sulphuric acid as catalyst + heat **Type:** esterification
Reactants: alcohol + carboxylic acid **Products:** ester + water

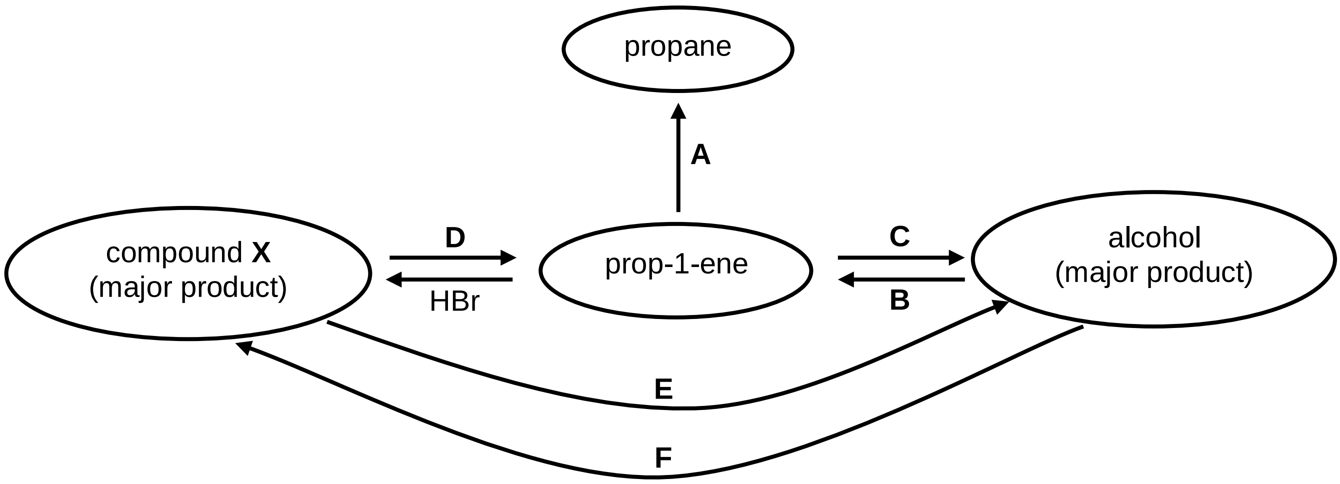
TOPIC: Organic Molecules: Reactions of organic compounds	**Duration: 1** HOUR: 40 MIN

Key Concepts:

1. Oxidation of alkanes.
2. Esterification.
3. Substitution, addition and elimination reactions.
4. Plastics and polymers

EXAMPLE 1

The flow diagram below shows how prop-1-ene can be used to prepare other organic compounds.



1.1 Write down the type of reaction represented by:

1.1.1 **A** (1)

1.1.2 **D** (1)

1.1.3 **F** (1)

1.2 Write down the:

1.2.1 NAME or FORMULA of the catalyst needed for reaction **A** (1)

1.2.2 NAME or FORMULA of the inorganic reagent needed for reaction **B** (1)

1.2.3 Type of addition reaction represented by reaction **C** (1)

1.2.4 IUPAC name of compound **X** (2)

1.3 Use structural formulae to write down a balanced equation for reaction **B**. (5)

1.4 Both reactions **D** and **E** take place in the presence of a strong base. State TWO conditions that will favour reaction **D** over reaction **E**. (2)

[15]

SOLUTION 1

1.1

1.1.1 Addition / Hydrogenation ✓ (1)

1.1.2 Elimination / Dehydrohalogenation / Dehydrobromination ✓ (1)

1.1.3 Substitution / Halogenation / Bromination ✓ (1)

1.2

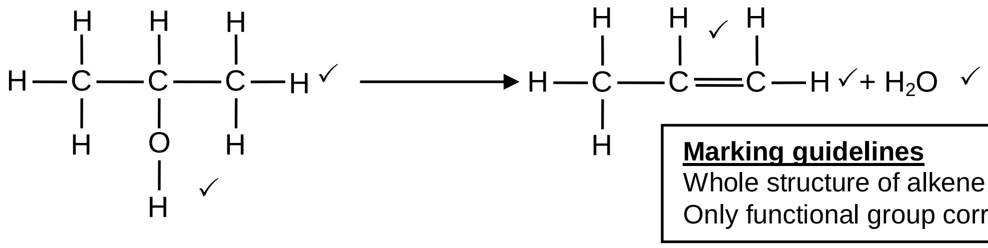
1.2.1 Pt / platinum ✓ (1)

1.2.2 H_2SO_4 / sulphuric acid ✓ (1)

1.2.3 Hydration ✓ (1)

1.2.4 2✓-bromopropane ✓ (2)

1.3



Marking guidelines
Whole structure of alkene correct: ✓✓
Only functional group correct: ✓

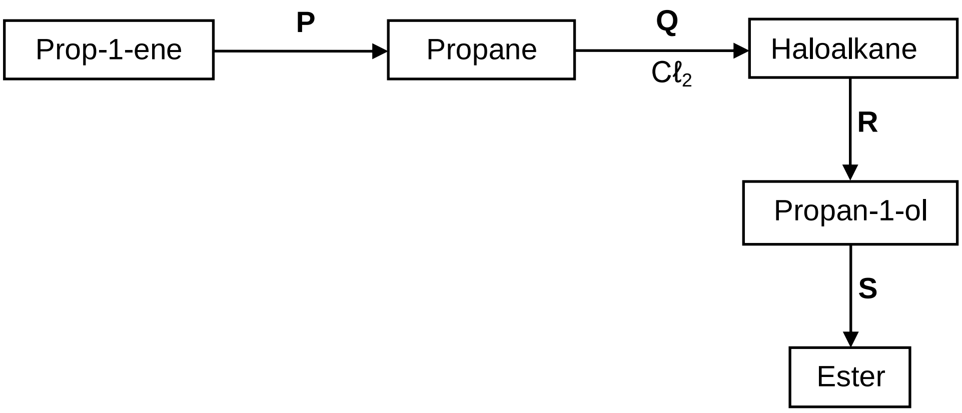
(5)

1.4 <u>Higher temperature</u> ✓
<u>Concentrated base</u> ✓ (2)

[15]

ACTIVITY 1

The flow diagram below shows the preparation of an ester using prop-1-ene as a starting reagent. **P**, **Q**, **R** and **S** represent different organic reactions.



1.1 Write down the type of reaction represented by:

1.1.1 **Q** (1)

1.1.2 **R** (1)

1.2 For reaction **P** write down the:

1.2.1 Type of addition reaction (1)

1.2.2 Balanced equation using structural formulae (3)

1.3 Write down the structural formula of the haloalkane formed in reaction **Q**. (2)

1.4 In reaction **S** propan-1-ol reacts with ethanoic acid to form the ester.

For this reaction write down the:

1.4.1 Name of the reaction that takes place (1)

1.4.2 FORMULA or NAME of the catalyst needed (1)

1.4.3 Structural formula of the ester formed (2)

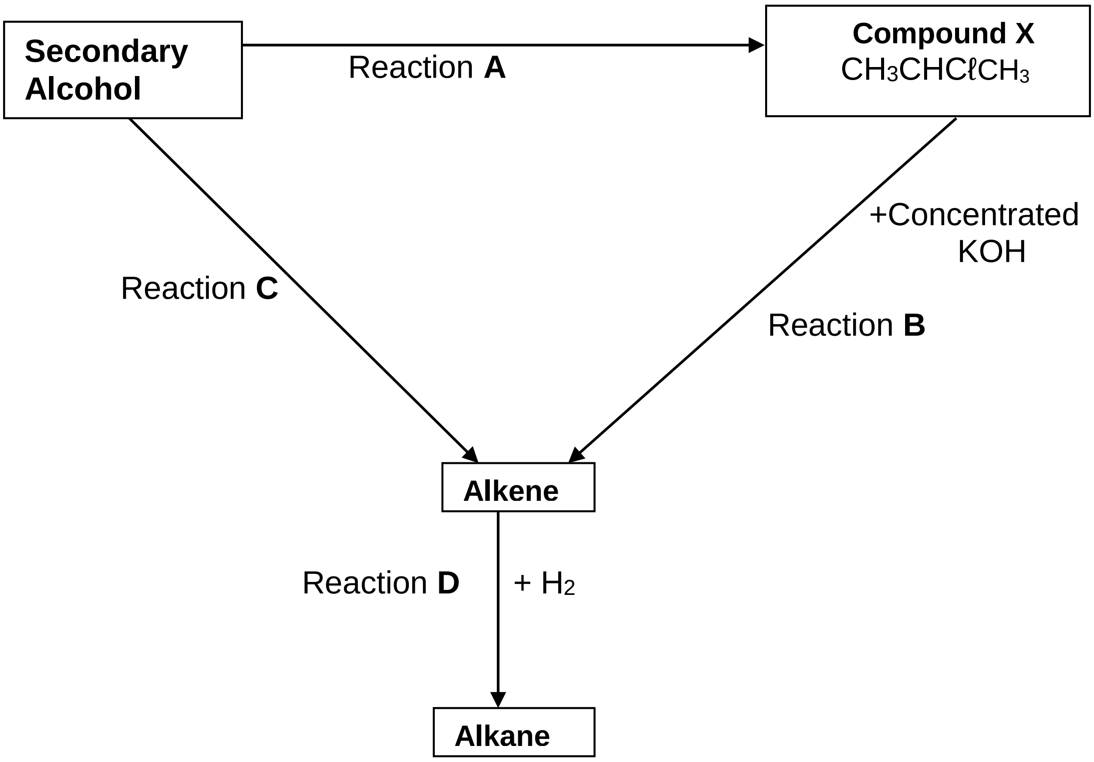
1.4.4 IUPAC name of the ester formed (2)

1.5 The propan-1-ol formed in reaction **R** can be converted to prop-1-ene. Write down the FORMULA or NAME of the inorganic reagent needed. (1)

[15]

ACTIVITY 2

The flow diagram below shows how alcohols can react to form other organic compounds.



2.1 Write down the type of reaction represented by reaction:

2.1.1 **A** (1)

2.1.2 **B** (1)

2.1.3 **D** (1)

2.2 In reaction **B**, compound **X** is converted to an alkene. Write down the:

2.2.1 IUPAC name of compound **X** (2)

2.2.2 Balanced equation for the reaction **B**, using structural formulae (4)

2.3 Reaction **C** takes place in the presence of a strong acid.

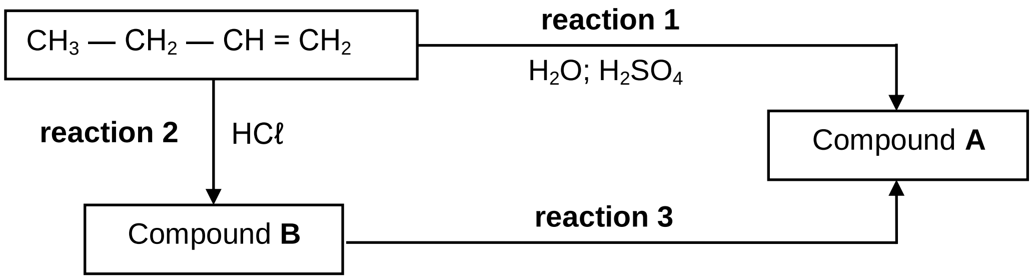
2.3.1 Explain the term *secondary alcohol* (2)

2.3.2 Write down the IUPAC name of the alcohol used (2)

[13]

ACTIVITY 3

In the flow diagram below, but-1-ene is used as starting material in the preparation of compound **A**.



3.1 Is but-1-ene a SATURATED or UNSATURATED compound? Give a reason for the answer. (2)

3.2 Compound **A** is the major product formed in **reaction 1**.

Write down the:

3.2.1 Structural formula of compound **A** (2)

3.2.2 Type of reaction that takes place (1)

3.3 For compound **B**, write down the:

3.3.1 IUPAC name (2)

3.3.2 Structural formula of the positional isomer (2)

3.4 For **reaction 3**, write down:

3.4.1 TWO reaction conditions needed (2)

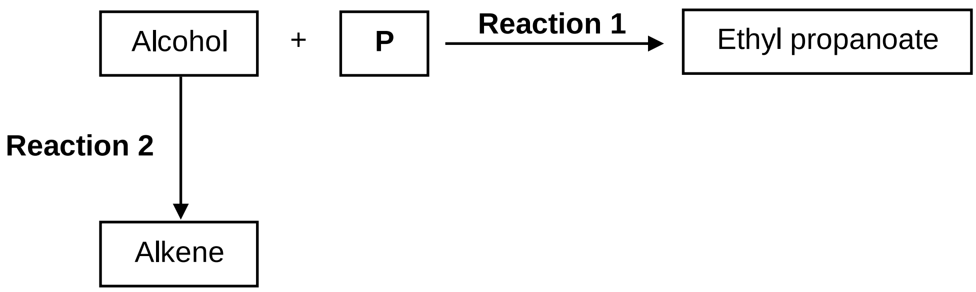
3.4.2 The type of reaction that occurs (1)

3.4.3 A balanced equation, using molecular formulae (3)

[15]

ACTIVITY 4

4.1 The flow diagram below shows two organic reactions. The letter **P** represents an organic compound.



Use the information in the flow diagram to answer the questions that follow.

Write down the:

4.1.1 Type of reaction of which **Reaction 1** is an example (1)

4.1.2 STRUCTURAL FORMULA of the functional group of ethyl propanoate (1)

4.1.3 IUPAC name of compound **P** (1)

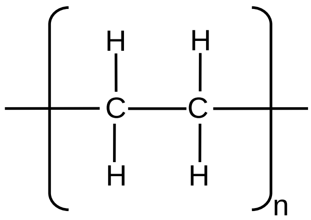
Reaction 2 takes place in the presence of an acid catalyst and heat.
Write down the:

4.1.4 Type of reaction of which **Reaction 2** is an example (1)

4.1.5 NAME or FORMULA of the acid catalyst (1)

4.1.6 STRUCTURAL FORMULA of the alkene (2)

4.2 The condensed formula of a polymer is shown below.



Write down the:

4.2.1 STRUCTURAL FORMULA of the monomer that is used to prepare the above polymer (2)

4.2.2 Type of polymerisation reaction (ADDITION or CONDENSATION) that is used to prepare this polymer (1)

[10]

TABLE 3: THE PERIODIC TABLE OF ELEMENTS
TABEL 3: DIE PERIODIEKE TABEL VAN ELEMENTE

KEY/*SLEUTEL*

Electronegativity / *Elektronegatiwiteit*	Atomic number / *Atoomgetal*	Symbol / *Simbool*	Approximate relative atomic mass / *Benaderde relatiewe atoommassa*
1,9	29	Cu	63,5

1 (I)	2 (II)	3	4	5	6	7	8	9	10	11	12	13 (III)	14 (IV)	15 (V)	16 (VI)	17 (VII)	18 (VIII)
1 H 1 (2,1)																	2 He 4
3 Li 7 (1,0)	4 Be 9 (1,5)											5 B 11 (2,0)	6 C 12 (2,5)	7 N 14 (3,0)	8 O 16 (3,5)	9 F 19 (4,0)	10 Ne 20
11 Na 23 (0,9)	12 Mg 24 (1,2)											13 Aℓ 27 (1,5)	14 Si 28 (1,8)	15 P 31 (2,1)	16 S 32 (2,5)	17 Cℓ 35,5 (3,0)	18 Ar 40
19 K 39 (0,8)	20 Ca 40 (1,0)	21 Sc 45 (1,3)	22 Ti 48 (1,5)	23 V 51 (1,6)	24 Cr 52 (1,6)	25 Mn 55 (1,5)	26 Fe 56 (1,8)	27 Co 59 (1,8)	28 Ni 59 (1,8)	29 Cu 63,5 (1,9)	30 Zn 65 (1,6)	31 Ga 70 (1,6)	32 Ge 73 (1,8)	33 As 75 (2,0)	34 Se 79 (2,4)	35 Br 80 (2,8)	36 Kr 84
37 Rb 86 (0,8)	38 Sr 88 (1,0)	39 Y 89 (1,2)	40 Zr 91 (1,4)	41 Nb 92	42 Mo 96 (1,8)	43 Tc (1,9)	44 Ru 101 (2,2)	45 Rh 103 (2,2)	46 Pd 106 (2,2)	47 Ag 108 (1,9)	48 Cd 112 (1,7)	49 In 115 (1,7)	50 Sn 119 (1,8)	51 Sb 122 (1,9)	52 Te 128 (2,1)	53 I 127 (2,5)	54 Xe 131
55 Cs 133 (0,7)	56 Ba 137 (0,9)	57 La 139	72 Hf 179 (1,6)	73 Ta 181	74 W 184	75 Re 186	76 Os 190	77 Ir 192	78 Pt 195	79 Au 197	80 Hg 201	81 Tℓ 204 (1,8)	82 Pb 207 (1,8)	83 Bi 209 (1,9)	84 Po (2,0)	85 At (2,5)	86 Rn
87 Fr (0,7)	88 Ra 226 (0,9)	89 Ac															

58 Ce 140	59 Pr 141	60 Nd 144	61 Pm	62 Sm 150	63 Eu 152	64 Gd 157	65 Tb 159	66 Dy 163	67 Ho 165	68 Er 167	69 Tm 169	70 Yb 173	71 Lu 175
90 Th 232	91 Pa	92 U 238	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr