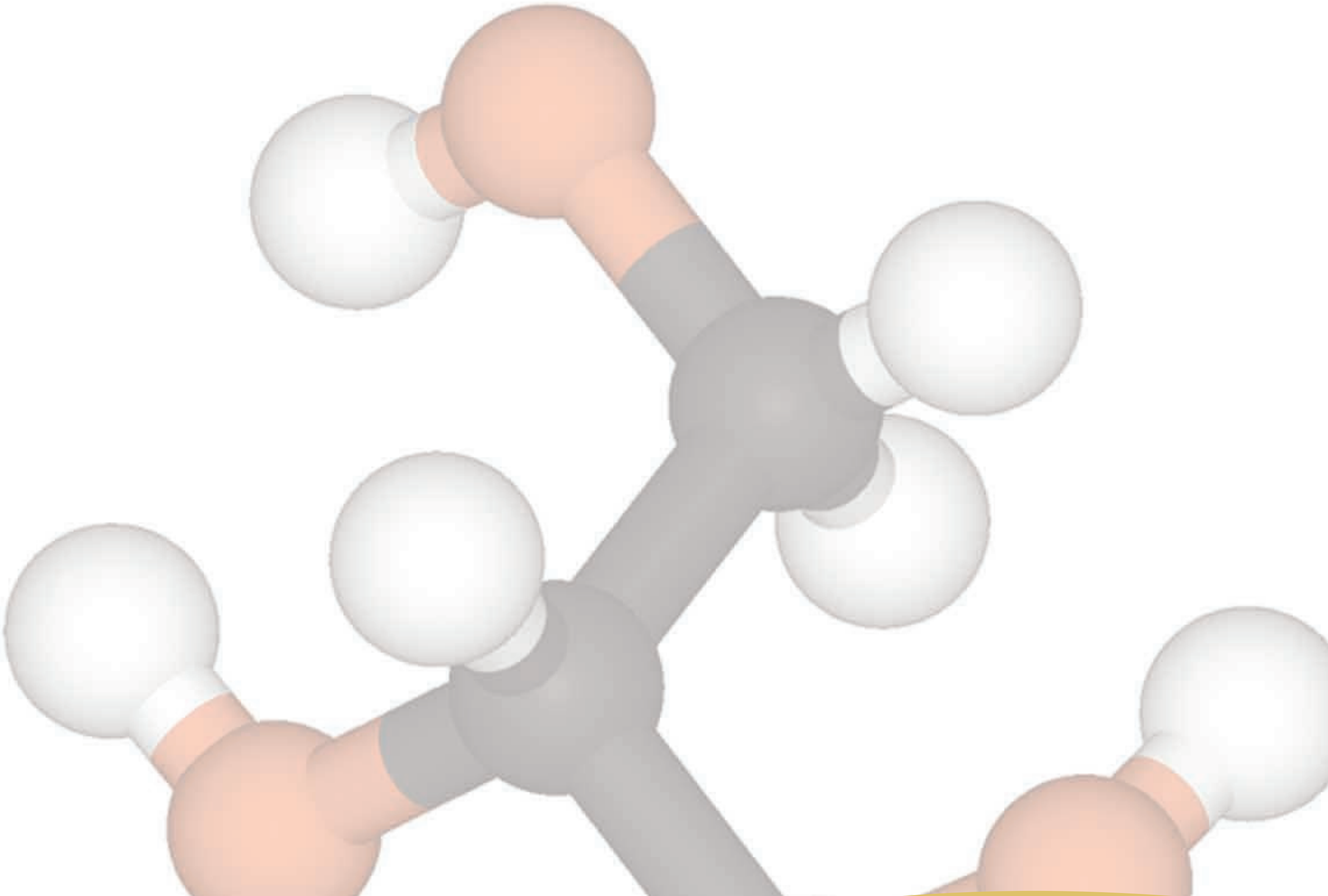


PHYSICAL SCIENCE PAPER 2

ORGANIC MOLECULE CHEMISTRY

GRADE 12

basic education
Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

Read to Lead
A Reading Nation is a Leading Nation

2030
NDP

Foreword

In order to improve learning outcomes the Department of Basic Education conducted research to determine the specific areas that learners struggle with in Grade 12 examinations. The research included a trend analysis by subject experts of learner performance over a period of five years as well as learner examination scripts in order to diagnose deficiencies or misconceptions in particular content areas. In addition, expert teachers were interviewed to determine the best practicesto ensure mastery of thetopic by learners and improve outcomes in terms of quality and quantity.

The results of the research formed the foundation and guiding principles for the development of the booklets. In each identified subject, key content areas were identified for the development of material that will significantly improve learner's conceptual understanding whilst leading to improved performance in the subject.

The booklets are developed as part of a series of booklets, with each bookletfocussing onlyon one specific challenging topic. The selected content is explained in detail and include relevant concepts from Grades 10 - 12 to ensure conceptual understanding.

The main purpose of these booklets is to assist learners to master the content starting from a basic conceptual level of understanding to the more advanced level. The content in each booklets is presented in an easy to understand manner including the use of mind maps, summaries and exercises to support understanding and conceptual progression. These booklets should ideally be used as part of a focussed revision or enrichment program by learners after the topics have been taught in class. The booklets encourage learners to take ownership of their own learning and focus on developing and mastery critical content and skills such as reading and higher order thinking skills.

Teachers are also encouraged to infuse the content into existing lesson preparation to ensure in-depth curriculum coverage of a particular topic. Due to the nature of the booklets covering only one topic, teachers are encouraged to ensure learners access to the booklets in either print or digital form if a particular topic is taught.

Table of contents

1. How to use this Study Guide

This book serves as a guide to understanding the Grade 12 Physical Sciences content. However, it does not replace your textbook. The authors have used their experience and focused their attention on the areas that learners generally seem to struggle with. The book focuses on the challenges that have been observed over the past few years with learners' responses in the Grade 12 National Examinations.

This guide aims to further explain the concepts dealt with in your regular textbook. It also offers more exercises and examples, which serve as building blocks to your own understanding of what is expected of you in this subject area. The book draws on basic knowledge acquired in the lower grades and demonstrates how this knowledge fits in with the new chapters in Grade 12, starting with atomic theory. Figure 1 shows how your study of chemistry is related to the atomic theory. The atomic theory is a framework for the whole chemistry curriculum! It is therefore important to remember this theory, as well as the properties of the parts of an atom and the role they play, generally, in chemistry.

The chemistry in your textbook is presented in chapters and sections, but remember to integrate these chapters when you answer questions, because everything is interrelated. Science is an expression of nature, as it draws from nature. Therefore, DO NOT THINK OF CONCEPTS IN ISOLATION TO THE REST OF THE CHEMISTRY subject! Use the information learnt in other sections to solve the problem at hand!

All the questions in this booklet have solutions. Some questions were sourced from past papers, while others were sourced elsewhere. Study each question carefully and make sure you understand the steps taken to solve the question. Then try the rest of the questions, without looking at the solutions. After completion of an exercise, check your solutions against the answers provided. Move on to the rest of the questions and try to understand why you were wrong when your answer was wrong. Solutions to all exercises are provided in last section of this book.

Do not hesitate to ask your teacher for help if you struggle with any of the exercises.

2. Study and Examination Tips

1. Pay attention to your health:
2. Eat wholesome food - grains, fruit and vegetables - and drink enough water.
3. Engage in light exercise like walking.
4. Get enough sleep and rest.
5. Develop a study timetable and try to be disciplined in terms of the times allocated to studying!

3.1 Subject specific

As you prepare to write your examination, it is important that you understand the rules governing certain aspects of your work: definitions, rules, laws and concepts. Understand these definitions/ rules/ laws/ concepts well. Understand **what they mean, where they apply and when they apply and also when and where they do not** apply. Also, always:

1. Start with the questions that you know you are able to answer.
2. Read the question that you are working on carefully.
3. Understand what it says and what is required of you.
4. Write down the information that you have.

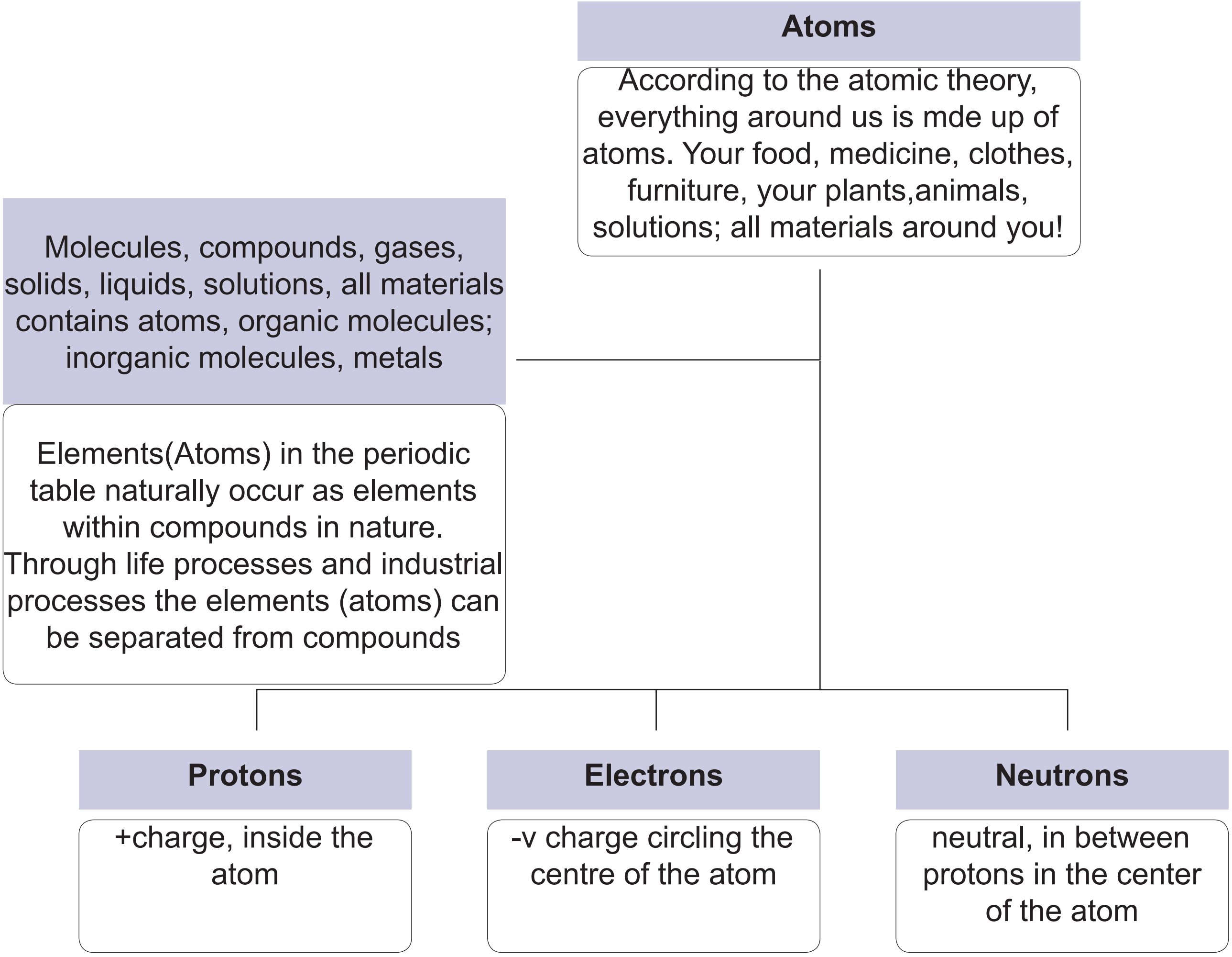
5. Write down the information that you do not have.
6. Use existing information to derive what you need to solve the question.
7. All questions have hints that point to the answer.
8. Check your work by going through these steps again.

3.2 Topic specific

About a third of the Physical Sciences Grade 12 Examination Paper 2 comprises Organic Chemistry questions. This booklet provides a few tips that will help you achieve marks in organic chemistry.

This topic requires that you know how to: 1) Name the organic molecules and learn the rules of naming molecules; 2) The second part requires understanding the reaction of organic molecules. Pay attention to the names of the reactions, as they provide some explanation about the reactions, e.g. e.g.: hydration means a water (hydro) molecule is added to the molecule in question; dehydration means the water molecule is removed.

4. Atomic Theory: its Place in Organic Chemistry



Atoms

According to the atomic theory, everything around us is mde up of atoms. Your food, medicine, clothes, furniture, your plants,animals, solutions; all materials around you!

Molecules, compounds, gases, solids, liquids, solutions, all materials contains atoms, organic molecules; inorganic molecules, metals

Elements(Atoms) in the periodic table naturally occur as elements within compounds in nature. Through life processes and industrial processes the elements (atoms) can be separated from compounds

Protons

+charge, inside the atom

Electrons

-v charge circling the centre of the atom

Neutrons

neutral, in between protons in the center of the atom

Figure 1: The atomic theory in chemistry©

Organic compounds comprise the largest group of compounds on earth. Many things around you have carbon as the most abundant atom in them, including food, clothes, paper, coal, fuel, diamonds … the list is endless.

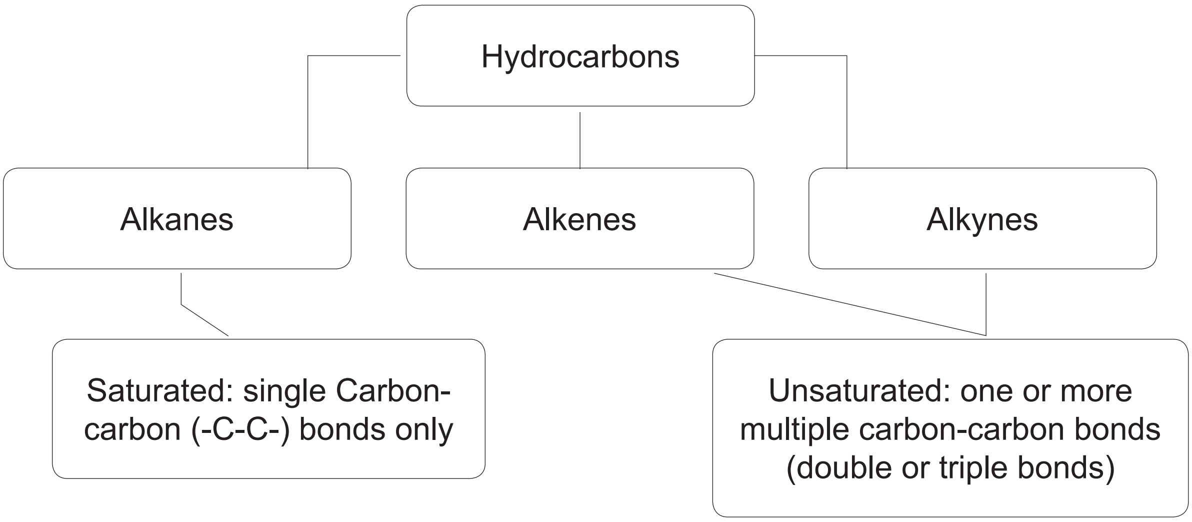
The carbon atom has wonderful properties that make it bond easily with other carbon atoms and with other atoms to form short chains and long chains. From methane, a dominant constituent of marsh gas to polymers …

A long time ago, clothes were made from cotton only, which is made up of carbon atoms. The second industrial revolution brought about the process of synthesis, when people realised that they can make new products from existing materials and turn the material into something completely new through a range of reactions that usually mimic something that already exists naturally. Polymers are such an example. To a large extent, they have replaced cotton through reactions that produce synthetic materials such as polyester, polyamides, etc. These play an important role in the clothing industry, and in many other industrial and home products.

In South Africa, SASOL produced petrol out of coal. That is the beauty of synthesis: petrol from coal and not from oil!

4.1 Organic Chemistry

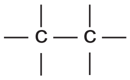
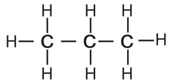
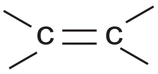
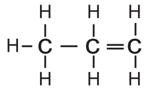
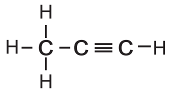
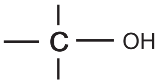
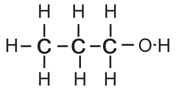
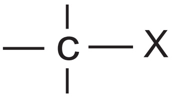
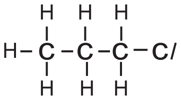
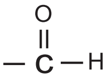
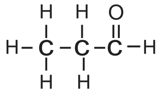
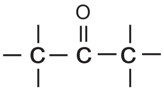
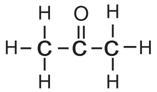
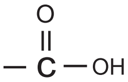
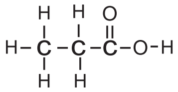
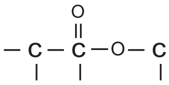
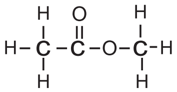
4.1.1 Classification of hydrocarbons



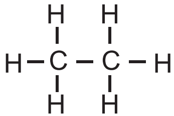
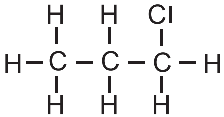
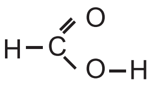
4.1.2 Root names or prefixes and examples of side chain alkyls

Number	Root name	Name	Alkyl Group	
1	Meth-	methane	Methyl	$-CH_3$
2	Eth-	ethane	Ethyl	$-CH_2CH^3$
3	Prop-	propane	Propyl	$-CH_2CH_2CH^3$
4	But-	butane	Butyl	$-CH_2CH_2CH_2CH^3$
5	Pent-			
6	Hex-			
7	Hept-			
8	Oct-			

4.1.3 Summary of homologous series

Homologous series	General formula	Functional group	Example	Structural formula of a given example	Name ending (suffix)
Alkanes	C_nH_{2n+2}		Propane		-ane
Alkenes	C_nH_{2n}		Propene		-ene
Alkynes	C_nH_{2n-2}	$-C\equiv C-$	Propyne		-yne
Alcohols	$C_nH_{2n+1}OH$		Propan-1-ol 1-propanol		-ol
Haloalkanes (Alkylhalides)	$C_nH_{2n+1}X$ X = F, Cl, Br or I		1-chloro-propane		-ane
Aldehydes	$C_nH_{2n}O$		Propanal		-al
Ketones	$C_nH_{2n}O$		Propanone		-one
Carboxylic acids	$C_nH_{2n}O_2$		Propanoic acid		-anoic (acid)
Esters			Methyl ethanoate		-noate

4.1.4 Examples of organic molecules

Examples of organic molecules: ethane, propane and methanoic acid			
Ethane (C2H6)	1-Chloropropane (C3H7Cl)	Methanoic acid (CH2O2)	**Molecular Formula:** a chemical formula that indicates the types of atoms and the correct number of each (atom) in a molecule. Examples: C2H6 (ethane), CH2O2 (methanoic acid), C3H7Cl (1-chloropropane).
			**Structural formula:** It shows how atoms are attached/ bonded to one another within the molecule.
CH3CH3	CH3CH2CH2Cl	HCOOH	**Condensed structural formula:** a notation that shows how atoms are bonded together in a molecule, but it DOES NOT SHOW ALL bond lines.
			**Molecular model:** shows a 3-D representation of organic molecules.

4.1.5 Chain length, and boiling point and melting point of hydrocarbons

(Molecules from nonane to eicosane are not examinable.)

Saturated Hydrocarbons or Alkanes				
Name	**Molecular Formula**	**Melting Point (^{o}C)**	**Boiling Point (^{o}C)**	**State at 25 ^{o}C**
methane	CH_4	-183	-164	gas
ethane	C_2H_6	-183	-89	
propane	C_3H_8	-190	-42	
butane	C_4H_{10}	-138	-0.5	
pentane	$C5H_{12}$	-130	36	
hexane	C_6H_{14}	-95	69	
heptane	C_7H_{16}	-91	98	
octane	C_8H_{18}	-57	125	
nonane	C_9H_{20}	-51	151	liquid
decane	$C_{10}H_{22}$	-30	174	
undecane	$C_{11}H_{24}$	-25	196	
dodecane	$C_{12}H_{26}$	-10	216	
eicosane	$C_{20}H_{42}$	37	343	solid

4.2 Bonding in Organic Chemistry

4.2.1 Types of bonds in organic molecules: Van der Waals forces

Homologous series	Alkanes, Alkenes, Alkynes	Aldehydes, Ketones, Haloalkanes	Alcohols, Carboxylic acids
Intermolecular forces acting on the homologous series	London forces	London forces Dipole-dipole forces	London forces Dipole-dipole forces Hydrogen bonds
Types of intermolecular forces and their relative strengths	London forces (dispersion forces/ induced dipole forces)	Dipole-dipole forces	Hydrogen bonds
	The weakest intermolecular forces. The least amount of energy is required to break these intermolecular forces.	Stronger than London forces, but weaker than H-bond. More energy is needed H-bond is required to break these intermolecular forces than with London forces, but less than with H-bond.	The strongest intermolecular forces. The most amount of energy is required to break these intermolecular forces.

4.2.2 Van der Waals forces explained

	Formed by the attraction between …	Examples
Ion-dipole	an ion and a polar molecule Interaction between a charged ion and a molecule that has a dipole. It is an attractive force that is commonly found in solutions, especially ionic compounds dissolved in polar liquids.	Na^+ and H_2O
Hydrogen bond	molecules which have H on N, O, or F atoms a weak bond between two molecules resulting from an electrostatic attraction between a proton in one molecule and an electronegative atom in the other	H_2O and H_2O; H_2O and CH_3CH_2OH
Dipole–Dipole	Two polar molecules with their negative and positive ends experiencing dipole-dipole attraction. $H{-}Cl\cdots H{-}Cl$	CH_3Br and ICl; CH_3Br and H_2O, hydrogen chloride (HCl): the relatively positive end of a polar molecule will attract the relatively negative end of another HCl molecule
Ion-induced dipole	Intermolecular Forces	Fe_2^+ and O_2
London (dispersion) forces	The London dispersion force is the weakest intermolecular force. The London dispersion force is a temporary attractive force that results when the electrons in two adjacent atoms occupy positions that make the atoms form temporary dipoles. This force is sometimes called an induced dipole attraction.	CH_4 and CH_4; F_2 and F_2; CH_4 and F_2

Activity

Consider the kinds of intermolecular forces present in the following substances:

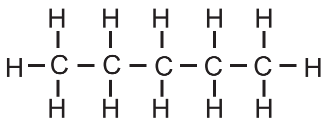
a) CH_3Br;
b) CH_3OH in H_2O;
c) $CH_3CH_2CH_3$ in CCl_4;
d) O_2 and Fe^{2+};
e) CH_3Br in H_2O;
f) $CH_3CH_2CH_3$ in CH_3Cl.

4.3 Isomers

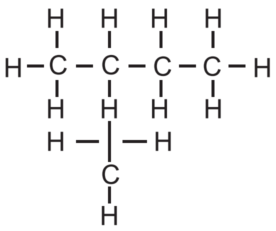
Isomers means two or more compounds with the same formula, but a different arrangement of atoms in the molecule (structure) and different properties.

4.3.1 Types of Isomers

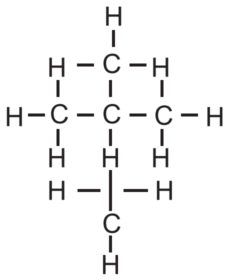
Structural isomer is an organic molecule with the same molecular formula, but a different structure



Pentane

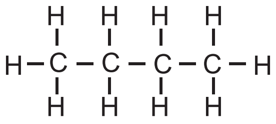


2-Methylbutane

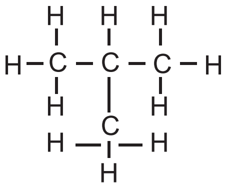


2,2-dimethylpropane

Chain isomers: Same molecular formula, but different chains, (e.g. molecular formula C_4H_{10}):

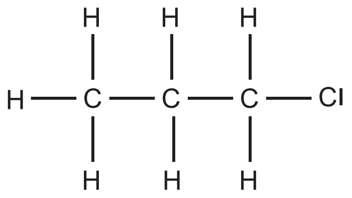


Butane

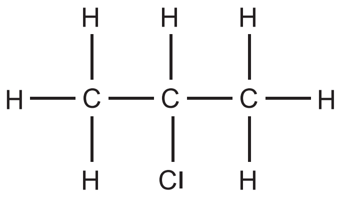


2-methylpropane

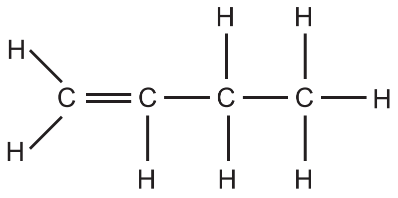
Positional isomers are compounds with the same molecular formula, but different positions of the side chain, substituents or functional groups on the parent chain, e.g. molecular formula: C_3H_7Cl and C_4H_8.



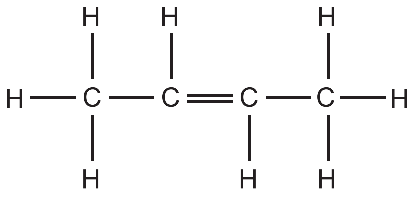
1-chloropropane



2-chloropropane



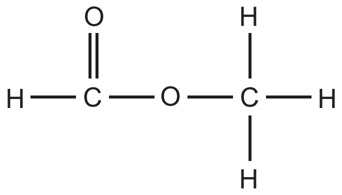
but-1-ene



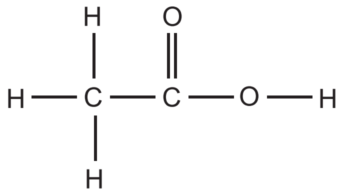
but-2-ene

See the position of chlorine in the first molecule and the second molecule.

See the position of double bonds in but-1-ene and but-2-ene.
Functional isomers are compounds with the same molecular formula, but different functional groups, e.g. molecular formula: C2H4O2 for both molecules that have different structures and therefore different functional groups.



methyl methanoate



ethanoic acid

Boiling point is 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 is 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 is 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.)

The vapour pressure decreases with an increase in molecular mass/ carbon chain length/ number of carbons.
Increase in boiling point results in a decrease in vapour pressure (from methane to octane). Therefore, compounds with a lower boiling point will have high vapour pressure, e.g. petrol, which has a lower boiling point than water, will have a higher vapour pressure.

Vapour pressure will increase from octane heaviest alkane to methane lightest alkane.

Boiling/ melting point and viscosity increase from methane to octane.

The same will be true for all other homologous series.

4.4 Boiling point, melting point and vapour pressure

Methane, ethane, propane, butane, pentane, hexane, heptane and octane

- Carbon chain length and therefore molecular mass increases from methane to octane.
- Intermolecular forces increase with an increase in molecular mass/ carbon chain length.
- The stronger the intermolecular forces the more energy will be required to break them (London/ dispersion/ induced dipole force).

Vapour pressure	Increases with an increase in branching (of the carbon chain). OR Increases with a decrease in the exposed surface area. ***Vapour pressure decreases from 2,2-dimethylpropane to pentane*** The converse is also true the vapour pressure of a straight chain isomer is lower than that of its branched isomer.

Methane, ethane, propane, butane, pentane, hexane, heptane and octane

→

- Carbon chain length and therefore molecular mass increases when moving from left of arrow above to right along the from methane to octane.
- Intermolecular forces increase with an increase in molecular mass/ carbon chain length.
- The stronger the intermolecular forces, the more energy will be required to break the intermolecular forces (London/ dispersion/ induced dipole force).
  Boiling/melting point and viscosity increase from methane to octane.
  The same will be true for all other homologous series.

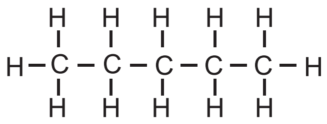
Vapour pressure	It decreases with an increase in molecular mass/ carbon chain length/ number of carbons.

An increase in boiling point results in a decrease in vapour pressure (from methane to octane). Therefore, compounds with a lower boiling point will have high vapour pressure (e.g. petrol, which has a lower boiling point than water, will have a higher vapour).

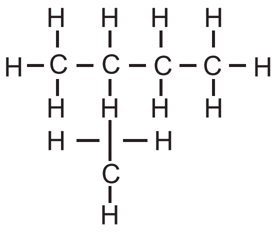
Methane, ethane, propane, butane, pentane, hexane, heptane and octane.

Vapour pressure will increase from octane to methane.

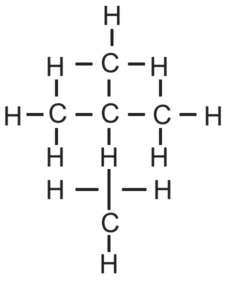
Consider the structural isomers of C_5H_{12}.



Pentane



2-Methylbutane



2,2-dimethylpropane

Vapour pressure	These will decrease with an increase in branching (of carbon chain). OR These will decrease with a decrease in exposed surface area. The converse is also true the boiling point of a straight chain is higher than that of its branched isomer.

Pentane, 2-Methylbutane and 2,2-dimethylpropane

Boiling point increases from 2,2-dimethylpropane to pentane

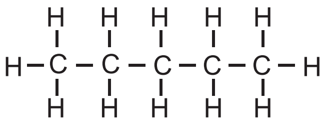
- Branching increases from Pentane to 2,2-dimethylpropane.
- The intermolecular forces decrease from pentane to 2,2-dimethylpropane.
- Intermolecular forces decrease with an increase in branching.
- The weaker the intermolecular forces, the less the amount of energy required to break the intermolecular forces (London / dispersion/ induced dipole force).

Boiling/ melting point and viscosity decrease from pentane to 2,2-dimethylpropane.
The same will be true for all other homologous series.

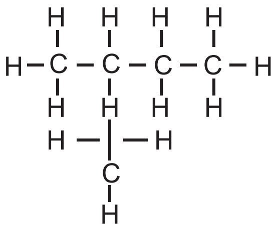
Vapour pressure	It will increase with an increase in branching (of carbon chain). OR It will increase with a decrease in the exposed surface area. **Vapour pressure decreases from 2,2-dimethylpropane to pentane** The converse is also true the vapour pressure of straight chain isomer is lower than that of its branched isomer.

4.5 Boiling point, melting point and viscosity in branched hydrocarbons

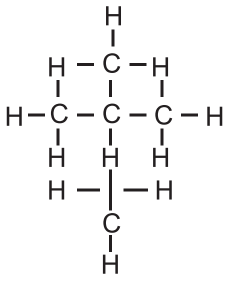
Consider the structural isomers of C5H12.



Pentane



2-Methylbutane



2,2-dimethylpropane

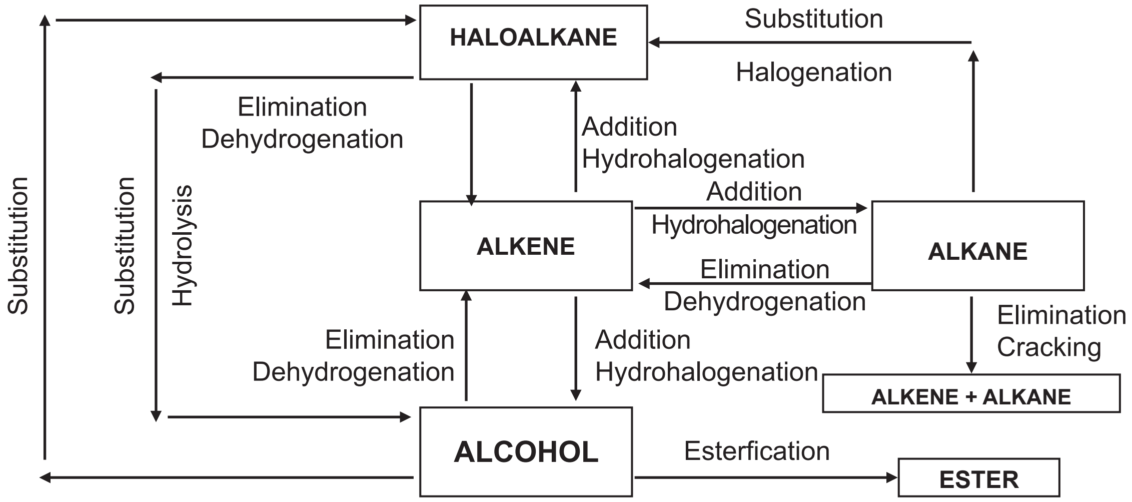
Boiling point increases from 2,2-dimethylpropane to pentane

Pentane, 2-Methylbutane and 2,2-dimethylpropane
Branching increases from Pentane to 2,2-dimethylpropane.

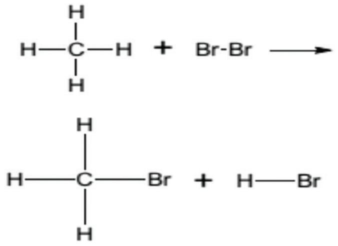
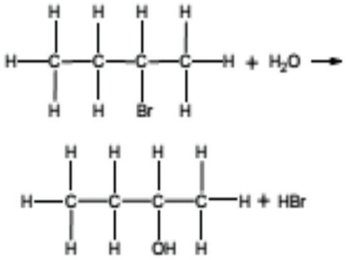
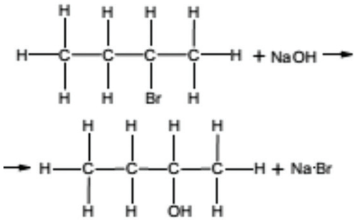
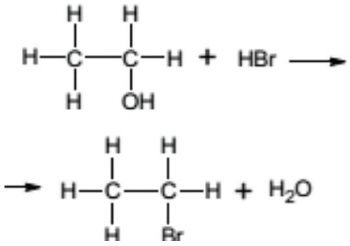
- The intermolecular forces decrease from pentane to 2,2-dimethylpropane.
- Intermolecular forces decrease with an increase in branching.
- The weaker the intermolecular forces, the less the amount of energy required to break the intermolecular forces (London / dispersion/ induced dipole force).

Boiling/ melting point and viscosity decrease from pentane to 2,2-dimethylpropane.
The same will be true for all other homologous series.

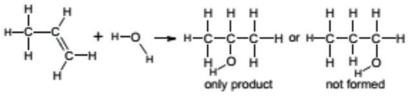
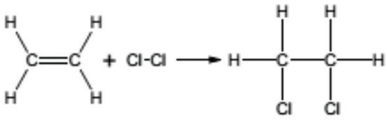
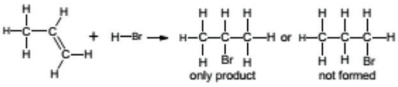
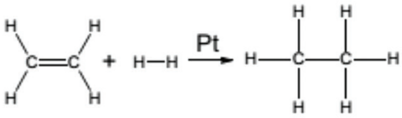
4.6 Organic reactions

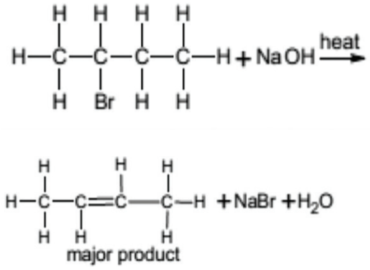
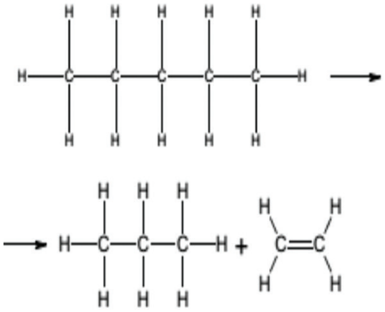
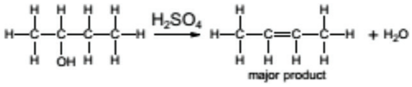


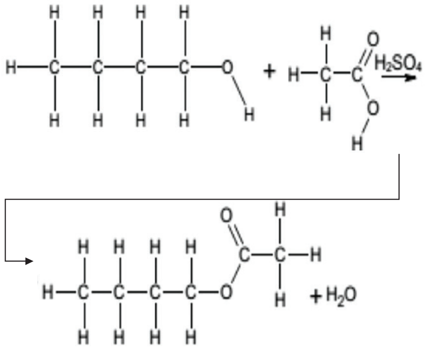
4.6.1 Examples of organic reactions

1. Substitution reactions: Compounds with SINGLE BONDS (alcohols, alkanes or haloalkanes) form compounds with SINGLE BONDS from a different homologous series (alcohols or haloalkanes).		
Type of substitution	**Example**	**Reaction conditions**
1.1 Halogenation Alkane to Haloalkane		Heat/ sunlight/ UV light
1.2 Hydrolysis Haloalkane to alcohol		Excess H_2O + mild heat
1.3 Hydrolysis Haloalkane to alcohol		Dilute strong base (NaOH / KOH / LiOH) + mild heat
1.4 Alcohol to Haloalkane		Heat

2. Addition reactions: Compounds with DOUBLE BONDS (alkenes) form compounds with SINGLE BONDS (alcohols, alkanes or haloalkanes)

Type of substitution	Example	Reaction conditions
2.1 Hydration		excess H_2O; small amount of acid (H_2SO_4/H_3PO_4) as catalyst
2.2 Halogenation		Unreactive solvent
2.3 Hydrohalogenation		No water; unreactive solvent
2.4 Hydrogenation		Pt, Pd or Ni as catalyst

3. Elimination reactions: compounds with SINGLE BONDS (alcohols, alkanes or haloalkanes) form compounds with DOUBLE BONDS (alkenes)		
Type of substitution	**Example**	**Reaction conditions**
3.1Dehydrohalogenation		concentrated strong base (NaOH / KOH / LiOH) in ethanol + heat
3.2 Thermal cracking		heat + high pressure
3.3 Catalytic cracking	$CH_3CH_2CH_2CH_3 \xrightarrow[\text{Catalyst}]{\text{heat}}$ $CH_3CH_3 + CH_2 = CH_2$ ethane ethene	Catalyst (alumina, silica), heat
3.4 Dehydration		Dehydrating agent ($H\ _2SO_4/H_3PO_4$) + heat
3.5 Dehydrogenation	$CH_3CH_2CH_3$ $CH_2{=}CH_2\ + H_2$	Catalyst (Pt)

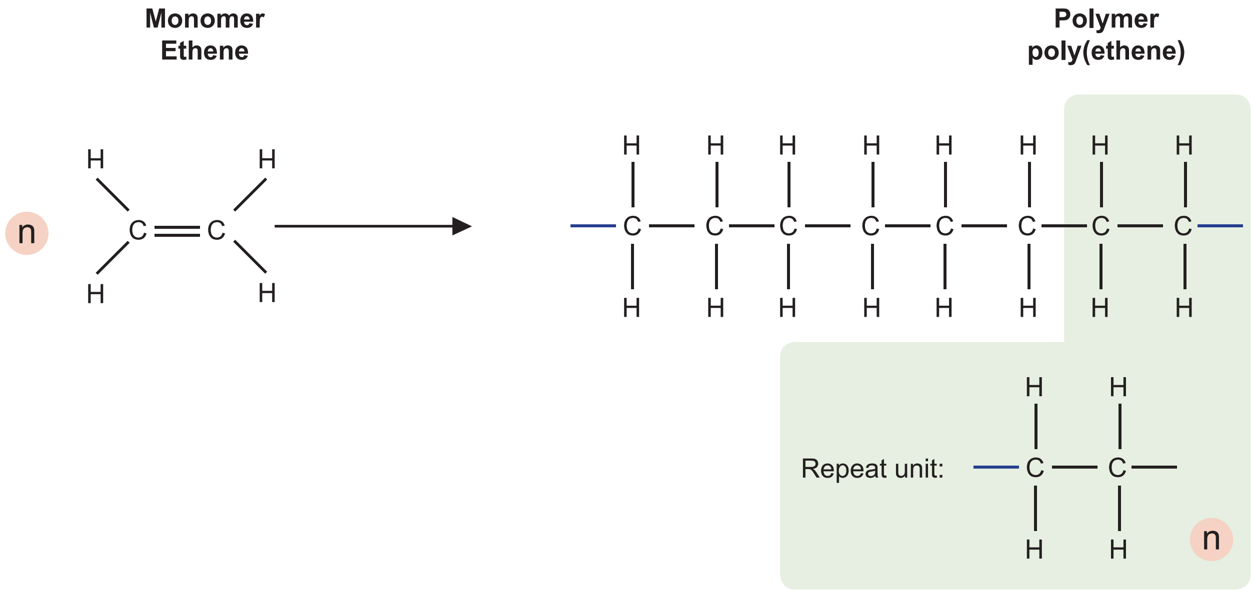
4. Reactions of alcohols and carboxylic acids (Esterification)		
Type of substitution	**Example**	**Reaction conditions**
Esterification		concentrated sulphuric acid as catalyst + heat

4.7 Macromolecules and Polymers

A macromolecule is a molecule that consists of a large number of atoms.

- A **macromolecule** is a very large molecule, such as protein, which is commonly created by the polymerization of smaller sub-units (monomers). The most common macromolecules in biochemistry are: biopolymers (nucleic acids, proteins, carbohydrates and lipids); large non-polymeric molecules (such as lipids and macrocycles), and carbohydrates (polymers of simple sugars.

A polymer is a large molecule composed of smaller monomer units that are covalently bonded to each other in a repeating pattern

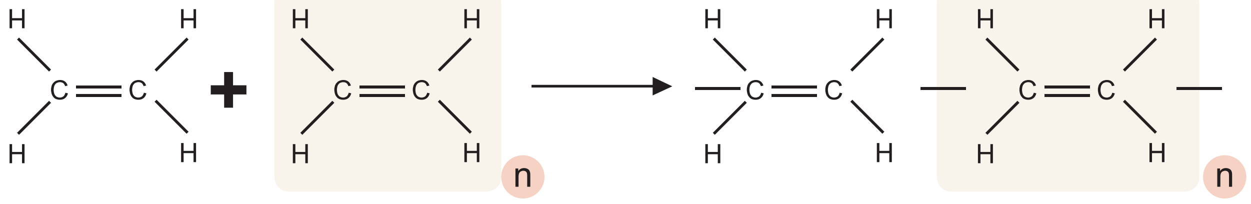


See how the bonds breaks during polymerisation. POLYETHENE on the right does not have double bonds. It takes its name from the molecule ethene, the molecules from which it started (NOT POLYETHANE).

A monomer is a small organic molecule that can be covalently bonded to each other in a repeating pattern. In the example above, ethane is the monomer.

Polymerisation is 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 double bonds.



Condensation polymerisation is when molecules of two monomers with different functional groups undergo condensation reactions with the loss of small molecules, usually water.
A **carboxylic acid monomer** and an alcohol monomer can join in an **ester linkage**. They are all joined by ester linkages, the **polymer chain** is a **polyester.**

ACTIVITY A

Question 1

Next to each letter in the table below (A – F) is the molecular formula of an organic compound.

A	C_2H_5Br	**B**	C_2H_4
C	C_4H_{10}	**D**	C2H_6O
E	C_2H_6O	**F**	$C_2H_6O_2$

1.1 Choose a molecular formula from the list above that represents the organic compound indicated below.

Write down only the letter (**A** to **F**) next to the question number (2.1.1 to 2.1.5), e.g. 2.1.6 G.

1.1.1 haloalkane (1)
1.1.2 alcohol (1)
1.1.3 unsaturated hydrocarbon (1)
1.1.4 aldehyde (1)
1.1.5 A product of thermal cracking of compound **C.** (1)

1.2 If compound **F** is a carboxylic acid, write down the following:
1.2.1 The structural formula of the FUNCTIONAL isomer of F. (2)
1.2.2 The IUPAC name of the FUNCTIONAL isomer of F. (2)

1.3 Compound **B** is a monomer used to make a polymer.
Write down the following:

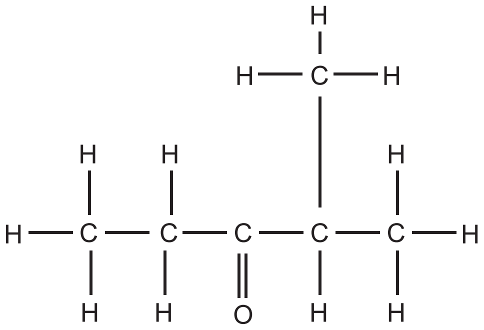
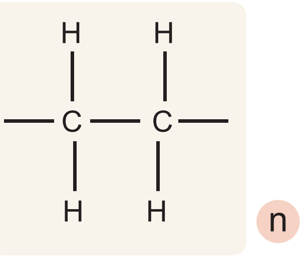
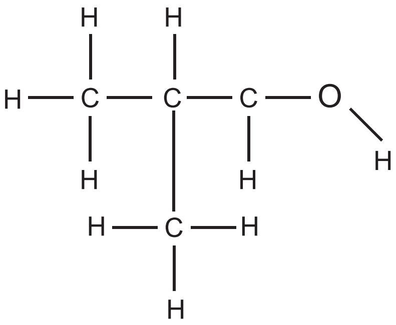
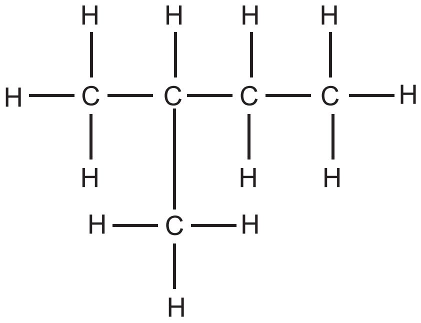
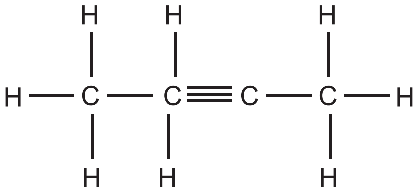
1.3.1 The definition of a polymer. (2)
1.3.2 The IUPAC name of the polymer. (1)
1.3.3 The balanced equation for the polymerisation reaction. (3)

1.4 Compound A is used as a reactant in the production of compound D. Name the type of reaction that takes place. (1)

1.5 Compound A is used as a reactant in the production of compound D. Name the type of reaction that takes place. (2)

Question 2

The letters **A** to **G** in the table below represent seven organic compounds.

A		**B**	
C		**D**	
E	butane	**F**	
G	ethyl propanoate		

2.1. Write down the following:

2.1.1. The name of the homologous series to which compound F belongs. (1)

2.1.2. The name of the functional group of compound D. (1)

2.1.3. The letter that represents a primary alcohol. (1)

2.1.4. The IUPAC name of compound A. (2)

2.1.5. The structural formula of the monomer of compound B. (2)

2.1.6. The balanced equation, using molecular formulae, for the combustion of compound E in excess oxygen. (3)

2.2. Briefly explain why compounds C and D are classified as POSITIONAL ISOMERS. (2)

2.3. Compound G is prepared using an alcohol as one of the reactants.
Write down the balanced equation for the reaction using structural formulae for all the organic reagents. (7)

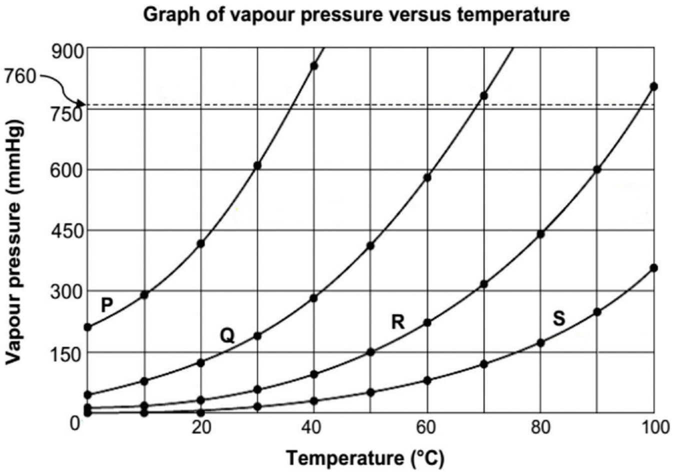
ACTIVITY B

Question 1

1. Please study the vapour pressure versus temperature graph below. It was obtained for four straight chain (unbranched) alkanes (**P**, **Q**, **R** and **S**).

   ROM P TO S, EACH COMPOUND DIFFERS FROM THE PREVIOUS COMPOUND BY A – CH2 GROUP.

   The vapour pressures are measured in mmHg. Atmospheric pressure is 76mmHg.



1.1 Give a reason why alkanes are said to be SATURATED. (1)

1.2 Define vapour pressure. (2)

1.3 Use the information in the graph above to answer the following questions.
   1.3.1 What is the effect of an increase in temperature on vapour pressure? Choose from INCREASES, DECREASES or NO EFFECT. (1)
   1.3.2 Which compound has a boiling point of approximately 68 °C? Give a reason for your answer. (2)
   1.3.3 Which compound has the longest chain length? Explain your answer in full. (4)

1.4 Compound A is used as a reactant in the production of compound D. Name the type of reaction that takes place.
   1.4.1 Draw the structural formula of the chain isomer of P. Write down the IUPAC name of this isomer. (3)
   1.4.2 How will the vapour pressure of this isomer compare with that of compound P? Choose from: HIGHER THAN, LOWER THAN or EQUAL TO. (1)

Question 2

The table below shows the results obtained from experiments to determine the boiling point of some alkanes and alcohols of comparable molecular mass.

Compound	Relative molecular mass	Boiling point (ºC)
CH_3CH_3	30	-89
CH_3OH	32	65
$CH_3CH_2CH_3$	44	-42
CH_3CH2OH	46	78
$CH_3CH_2CH_2CH_3$	58	0
$CH_3CH_2CH_2OH$	60	97
$CH_3CH_2CH_2CH_2CH_3$	72	36
$CH_3CH_2CH_2CH_2OH$	74	117

2. Define the term boiling point. (2)

2.1 Consider the boiling point of each of the four alkanes in the table above.
2.2 Describe the trend in the boiling points. (1)

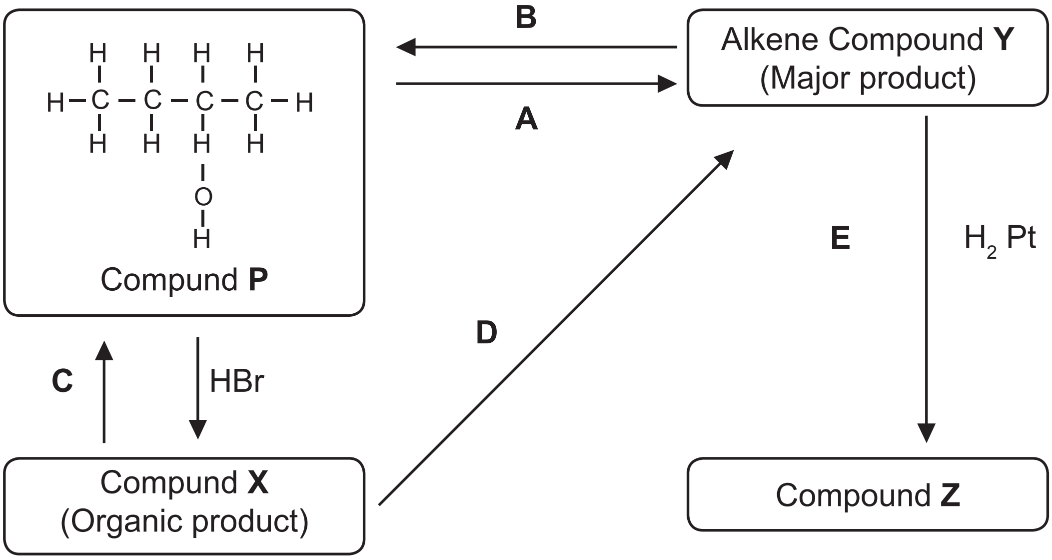
Explain the trend identified in QUESTION 2 in full. (3)

2.3 The boiling point of each alcohol is much higher than that of the alkane of comparable relative molecular mass. Explain this observation by referring to the type and strength of the intermolecular forces in alkanes and alcohol. (2)

Question 3

The flow diagram below shows how an alcohol (compound P) can be used to prepare other organic compounds.

The letters A to E represent different organic reactions. X, Y and Z are organic compounds.



3.1 Is compound P a PRIMARY, SECONDARY or TERTIARY alcohol? Give a reason for your answer. (2)

3.2 Write down the following:
- 3.2.1 The full elimination reaction represented by A. (1)
- 3.2.2 The addition reaction represented by B. (1)
- 3.2.3 The elimination reaction represented by D. (1)

3.3 Sodium hydroxide is used as one of the reactants in reaction C.
- 3.3.1 What type of reaction takes place here? (1)
- 3.3.2 What is the IUPAC name of a FUNCTIONAL isomer of F? (2)
- 3.3.3 What is the IUPAC name of a FUNCTIONAL isomer of F? (2)

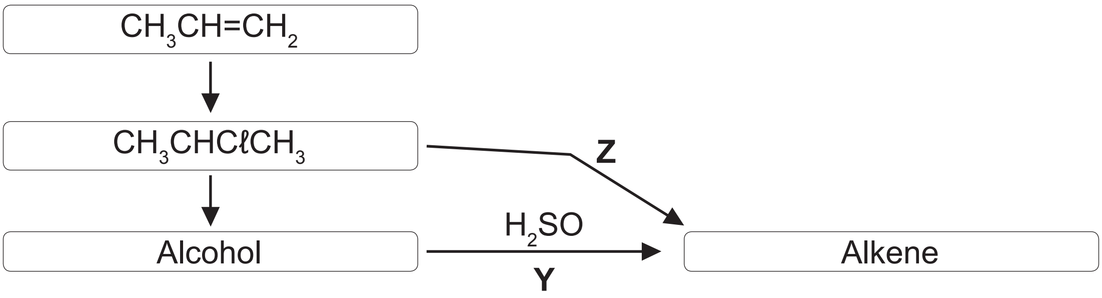
3.4 Write down the FORMULA of the inorganic reactant needed for reaction D. (1)

3.5 Using STRUCTURAL FORMULAE, write down the balanced equation for reaction E. (3)

3.6 Write down the IUPAC name of compound Z. (1)

Question 4

The flow diagram below shows the preparation of the organic compounds when using CH3CH=CH2 as the starting material. X, Y, Z and P represent different organic reactions.



4.1 To which homologous series does CH3CH=CH2 belong? (1)

4.2 Write down the following:

- The type of reaction of which **X** is an example. (1)
- The structural formula and IUPAC name of the alcohol produced during reaction **P.** (3)
- The type of reaction of which **Y** is an example. (1)
- The function of the acid in reaction **Y.** (1)

4.3 For reaction **Z,** write down the following:

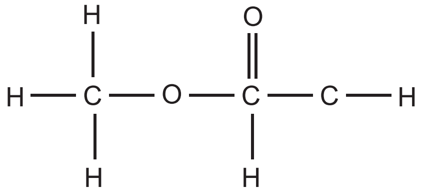
- The NAME of the inorganic reagent needed. (1)
- TWO reaction conditions needed. (2)
- A balanced equation for the production of the alkene, using structural formulae. (5)

CHECK YOUR ANSWERS

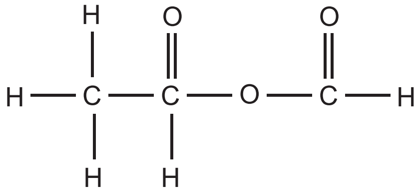
Activity A

1.1.1 A ✔ (1)
1.1.2 D ✔ (1)
1.1.3 B ✔ (1)
1.1.4 E ✔ (1)
1.1.5 B ✔ (1)

1.2.1



OR



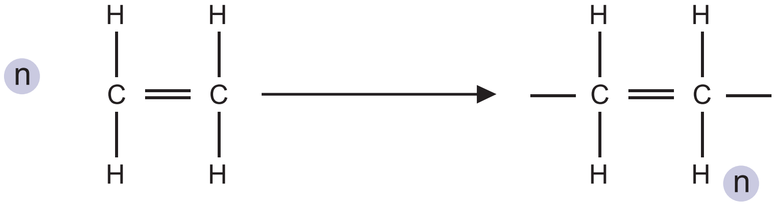
(2)

1.2.2 Methyl ✔ ethanoate ✔ OR
Ethyl ✔ methanoate ✔ (2)

1.3.1 A large molecule composed of smaller monomer units covalently bonded to each other in a repeating pattern. ✔✔ (2)

1.3.2 Polyethene ✔ (1)

1.3.3 (3)



1.4 Substitution/ hydrolysis (1)

1.5 • A concentrated strong base like NaOH/KOH/LiOH.
• Heat strongly. (2)

[18]

Question 2A

2.1.

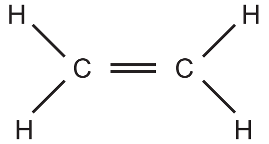
2.1.1. Alkynes ✔ (1)

2.1.2. Hydroxyl group ✔ (1)

2.1.3. C ✔ (1)

2.1.4. 2-methylpentan-3-one ✔✔ (2)

2.1.5.



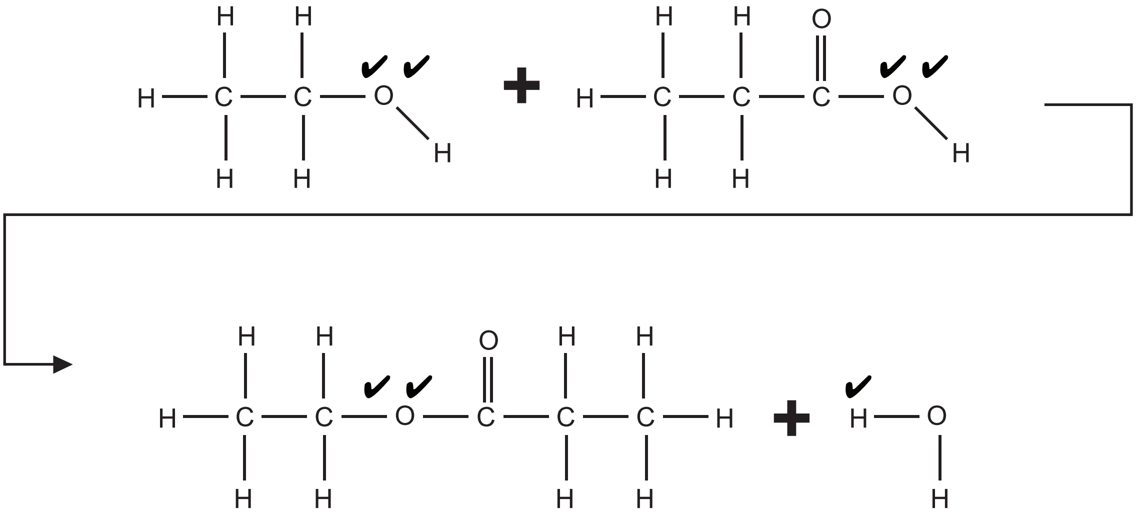
(2)

✔

2.1.6. $2C_4 H_{10} + 13O_2$ ✔ → $8CO_2 + 10H_2$ ✔ Bal. ✔ (3)

2.2. Same molecular formula, ✔ but different positions of the functional group. ✔ (2)

2.3.



[19]

2.1 They have ONLY single bonds between C atoms.

OR

They have NO MULTIPLE bonds between C atoms.

OR

They contain the maximum number of H atoms bonded to C atoms. (1)

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

✔ ✔ mm (2)

2.3.1 INCREASES ✔ ✔ (1)

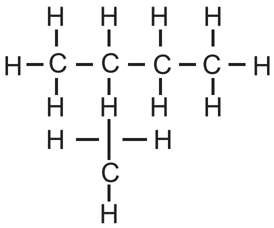
2.3.2 **Q** ✔ It is the temperature where the graph intercepts the dotted line. ✔

OR It is the temperature where the vapour pressure of compound **Q** equals atmospheric pressure/ is equal to 760 mmHg. (2)

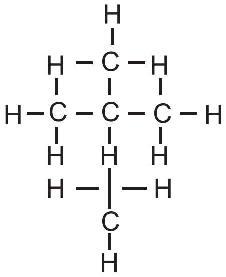
2.3.3 S ✔ ✔

- At a given temperature, **S** has the lowest vapour pressure/ highest boiling point. ✔
- Strongest intermolecular forces/ London forces/ dispersion forces/ induced dipole forces. ✔
- Highest energy needed to overcome/ break the intermolecular forces. ✔ (4)

2.4.1



2-Methylbutane



2,2-dimethylpropane

2.4.2 HIGHER THAN ✔ (1)

Question 2

2.1 Temperature ✔ at which the vapor pressure of the substance equals atmospheric pressure. (2)

2.2 Boiling point increases as the chain length / molecular mass increases.

OR/ OF

Boiling point increases from methane to butane. (1)

Chain length increases from methane to butane.✔

- Strength of London forces/ induced dipole forces increases from methane to butane. ✔
- More energy is needed in butane than in methane to overcome the intermolecular forces. ✔ (3)

2.3 There are weak London forces or induced dipole forces between the molecules of the alkanes.✔

In addition to weak London Forces or induced dipole forces, there are also strong hydrogen bonds between the alcohol molecules. ✔ (2)

Question 3

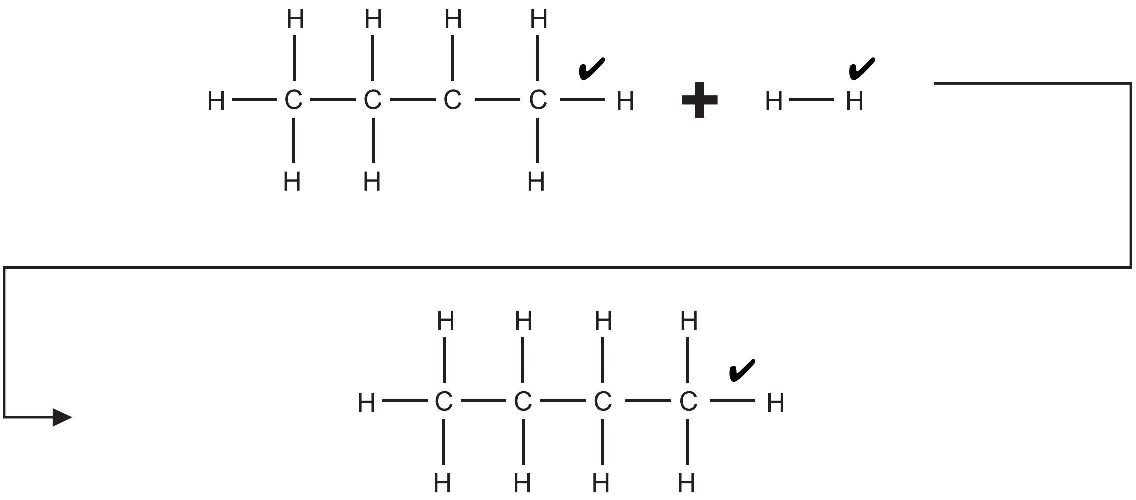
3.1 Secondary. ✔ The C atom bonded to the –OH group is bonded to TWO other C atoms. ✔ (2)

3.2.1 Dehydration ✔
3.2.2 Hydration ✔
3.2.3 Dehydrohalogenation/ dehydrobromination ✔

3.3.1 Dilute base/ sodium hydroxide/ NaOH ✔
3.3.2 Moderate temperature/ (mild) heat ✔
3.3.3. 2-bromobutane ✔

3.4 NaOH/KOH ✔

3.5



(3)

3.6 Butane ✔

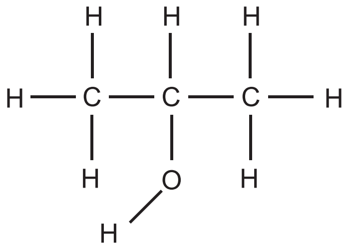
Question 4

4.1 Alkenes ✔ (1)

4.2

4.2.1 Addition/ hydrohalogenation/ hydrochlorination✔ (1)

4.2.2



Propan-2-ol✔ (3)

4.2.3 Elimination/ dehydration ✔ (1)

4.2.4 Catalyst ✔ (1)

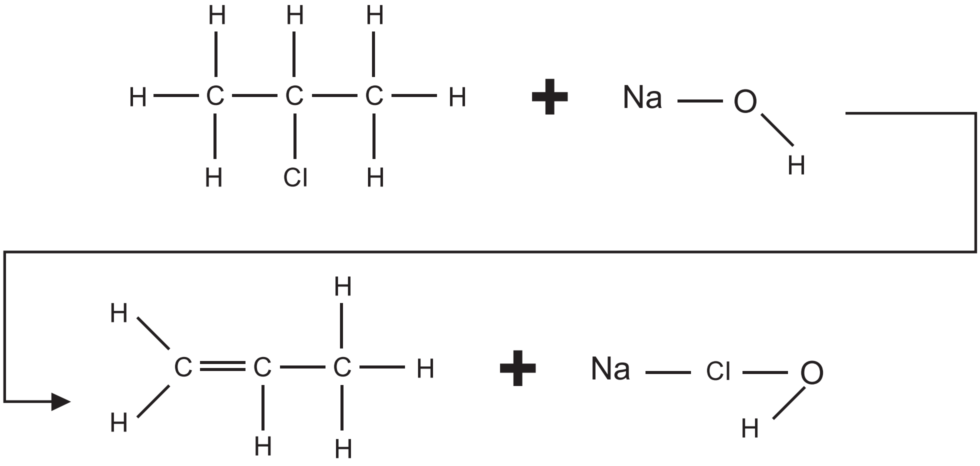
4.3

4.3.1 Sodium hydroxide/ potassium hydroxide ✔ (1)

4.3.2 Dissolve base in ethanol/ concentrated (strong) base ✔

Heat strongly ✔ (2)

4.3.3 (5)



[15]

Message to Grade 12 learners from the writers

Good luck to all learners writing their matric examinations this year. This booklet is an addition to your class notes, textbook a well as all other relevant materials. Start early in the year to prepare for your matric examination and not on the eve of the examination.

Thank you and Acknowledgements

Thank you to all who contributed to this booklet.

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PHYSICAL SCIENCE PAPER 2

ORGANIC MOLECULE CHEMISTRY

GRADE 12

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