JENN
Training and Consultancy
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Province of the
EASTERN CAPE
EDUCATION

SUBJECT: PHYSICAL SCIENCES

GRADE 12

AUTUMN CLASSSES

TEACHER AND LEARNER CONTENT MANUAL

Topics

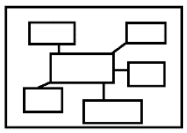
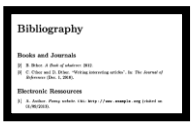
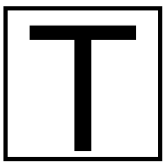
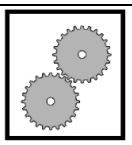
Organic Chemistry (Nomenclature, Physical Properties and Reactions)

PHYSICAL SCIENCES PROGRAMME FOR 2024 AUTUMN CLASSES

PAPER	TOPICS	TOTAL MARKS	WEIGHTING
5 DAYS			
PAPER 2: CHEMISTRY	**Organic Chemistry**		
	1. Nomenclature	± 22	± 15 %
	2. Physical Properties	± 15	± 10%
	3. Reactions	±18	±13
TOTAL		**± 55**	**± 38%**
Pre-test and Post-test to be administered since it's a revision of Term 1 & 2.			

CONTENTS **PAGE**

ICON DESCRIPTION

 MIND MAP	 EXAMINATION GUIDELINE	 CONTENTS	 ACTIVITIES
 BIBLIOGRAPHY	 TERMINOLOGY	 WORKED EXAMPLES	 STEPS

DATA FOR PHYSICAL SCIENCES GRADE 12
PAPER 1 (PHYSICS)

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

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

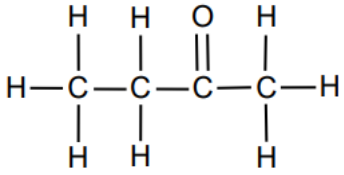
ORGANIC CHEMISTRY: EXAMINATION GUIDELINES

- 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, molecular formulae, and IUPAC names (up to 8 carbon atoms) for:
  1. Alkanes (no ring structures)
  2. Alkenes (no ring structures)
  3. Alkynes
  4. Halo-alkanes (primary, secondary and tertiary halo alkanes; no ring structures)
  5. Alcohols (primary, secondary and tertiary alcohols)
  6. Carboxylic acids
  7. Esters
  8. Aldehydes
  9. Ketones

- Know the following definitions/terms:
  1. **Molecular formula:** A chemical formula that indicates the element and numbers of each of the atoms in a molecule. Example: C_4H_8O
  2. **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:

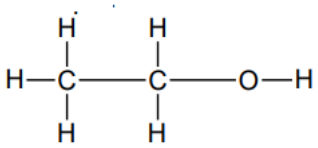
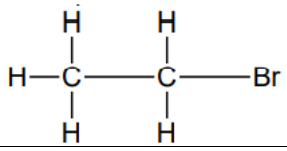


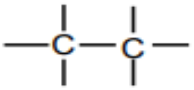
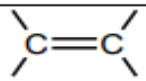
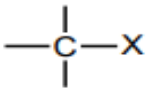
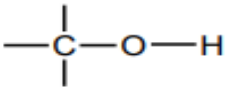
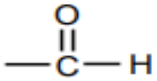
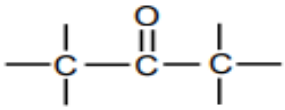
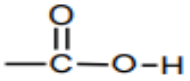
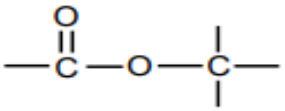
  3. **Condensed structural formula:** This notation shows the way in which atoms are bonded together in the molecule but DOES NOT SHOW ALL bond lines. Example:

$CH_3CH_2COCH_3$ OR $CH_3CH_2\overset{\overset{O}{\|}}{C}CH_3$

  4. **Hydrocarbon:** Organic compounds that consist of hydrogen and carbon only.
  5. **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.
  6. **Saturated compounds**: Compounds in which there are no multiple bonds between C atoms in their hydrocarbon chains
  7. **Unsaturated compounds**: Compounds with one or more multiple bonds between C atoms in their hydrocarbon chains

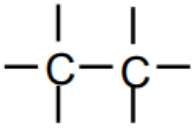
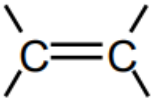
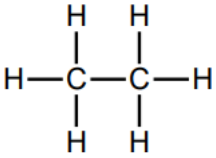
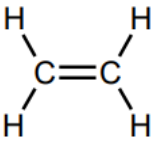
IMPORTANT TERMS AND DEFINITIONS

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

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 C atom in an alkane
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		-

NOMENCLATURE AND STRUCTURE

ORGANIC MOLECULES

	Saturated Hydrocarbons	Unsaturated Hydrocarbons	Unsaturated Hydrocarbons
Homologous Series	Alkanes	Alkenes	Alkynes
General Formula	C_nH2_{n+2}	C_nH_{2n}	C_nH_{2n-2}
Functional Group	Only C-H and **C-C single bonds** Alkanes have no multiple	**Carbon-carbon double bond**	**Carbon-carbon triple bond**
Structural Formula of the functional group			
Example of **Structural Formula of a Compound.**			
Example of the **Condescended Structural Formula of a Compound.**	CH_3CH_3	CH_2CH_2	CHCH
Example of the **Molecular Formula of a Compound.**	C_2H_6	C_2H_4	C_2H_2
Example of the **IUPAC Name of a Compound.**	Ethane	Ethene	Ethyne

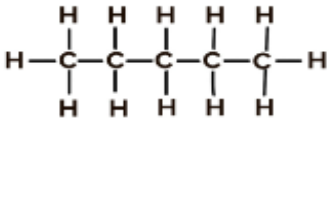
STRUCTURAL ISOMERS

Same molecular formula, different structural formulae.

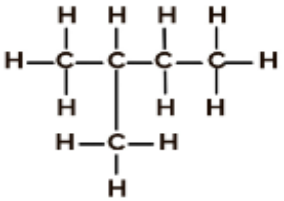
CHAIN ISOMERS

Same molecular formula, different chains

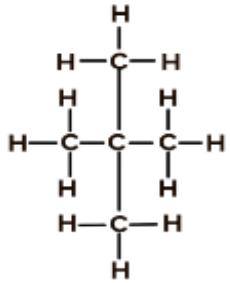
C_5H_{12}



Pentane



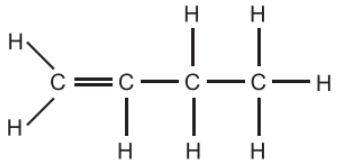
2-Methylbutane



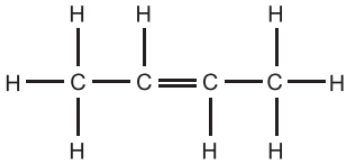
2,2 dimethylpropane

POSITIONAL ISOMERS

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



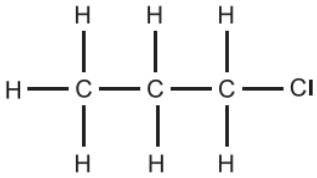
but-1-ene

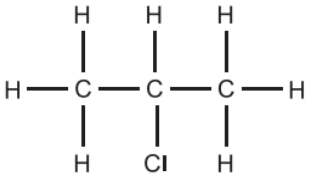


but-2-ene

C_4H_8

C_3H_7Cl

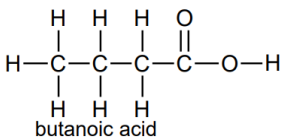




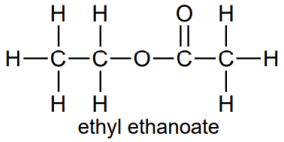
FUNCTIONAL ISOMERS

Same molecular formula, different functional groups.

$C_4H_8O_2$



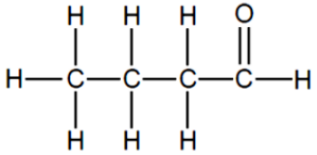
butanoic acid



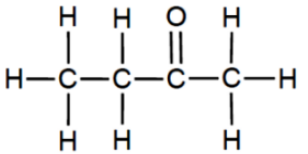
ethyl ethanoate

Butanal

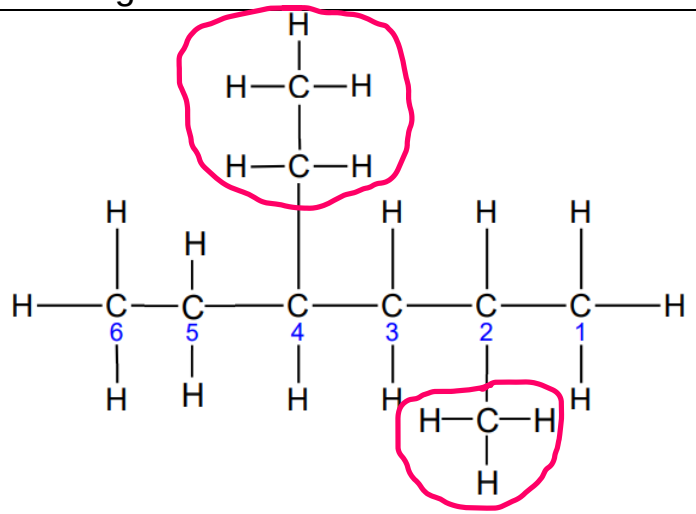
C_4H_8O



Butan-2-one

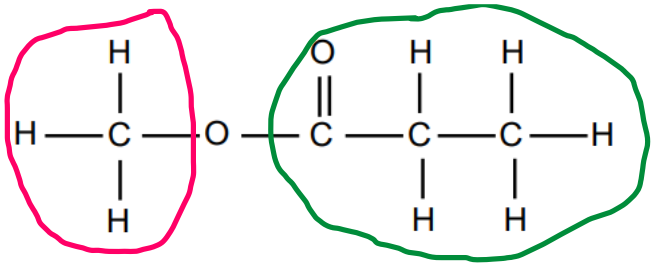


WRITING IUPAC NAMES OF ORGANIC COMPOUNDS

Alkanes and haloalkanes: Number from the side that will give the substituents the smallest numbers.	
Organic Compound	**Left**  **Right**
Suffix What is the functional group/homologous series?	The compound is a saturated hydrocarbon with only C-C single bonds. Homologous series is an **alkane**. The name ends on – **ane.**
Parent name How many C atoms are in the longest continues carbon chain in the molecule?	The longest chain contains 6 C atoms - the parent name is **hex**-.
Prefix What, where and how many are the substituents attached to the longest carbon chain?	One substituent has 1 C atom - methyl group. Another substituent contains 2 C atoms - an ethyl group. Numbering should be such that **the substituents have the lowest numbers**. For example, numbering from right 2+4 =6 and from left 3+5=8. Therefore, we number from right with lowest possible numbers for the substituents (2+4 =6). Commas separate numbers, while hyphens separate numbers and prefixes.

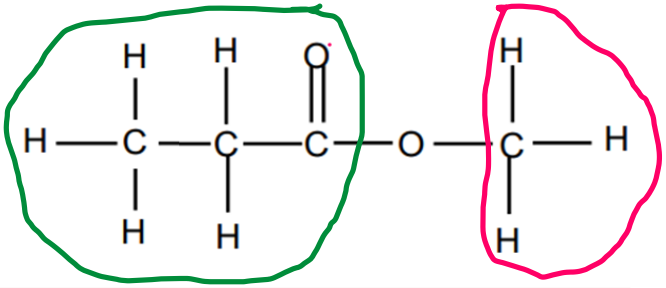
IUPAC Name	When writing IUPAC names, substituents should be placed in alphabetical order. **4-ethyl-2-methylhexane**

Methyl **Propanoate**



IUPAC Name: Methyl propanoate.

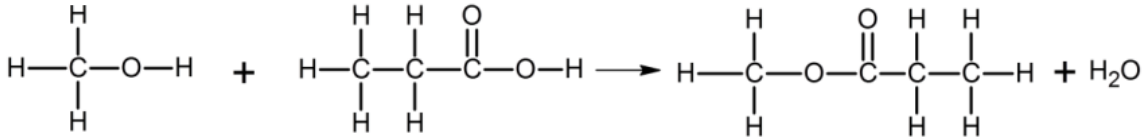
Propanoate **Methyl**



IUPAC Name: Methyl propanoate.

- The compound contains a formyl (–COO-) group. The Homologous series is **Ester.**
- Divide ester between two O atoms:
  1. **Alkyl group bonded to the single bonded O atom:** To determine the first part of the name, count the C atoms attached to the single bonded O atom of the functional group. Add –yl to this part e.g., Alkyl group has One C atom: **Methyl**
  2. **Group containing the carbonyl group:** To determine the last part of the name, number from the C atom bonded to the O atom with a double bond. Add the -anoate to this part e.g. group containing carbonyl has 2 C atoms: **propanoate**
- The name of alkyl group written first in name of ester:
- IUPAC Name: **Methyl propanoate.**

Methanol **Propanoic acid** **Methyl propanoate.**



Conditions: concentrated sulphuric acid as catalyst + heat **Type:** esterification

Reactants: alcohol + carboxylic acid **Products:** ester + water

WRITING STRUCTURAL FORMULAE FROM IUPAC NAMES

1.Identify the parent name in the IUPAC name. Draw a carbon skeleton with the number of C atoms indicated by the parent name.

2. Identify the functional group (suffix) or homologous series to which this compound belongs.

Use the number in front of the functional group (suffix) to place the functional on the correct C atom.

3. Identify the substituents (prefix). Use the number in front of each substituent to place the substituents on the correct C atoms.

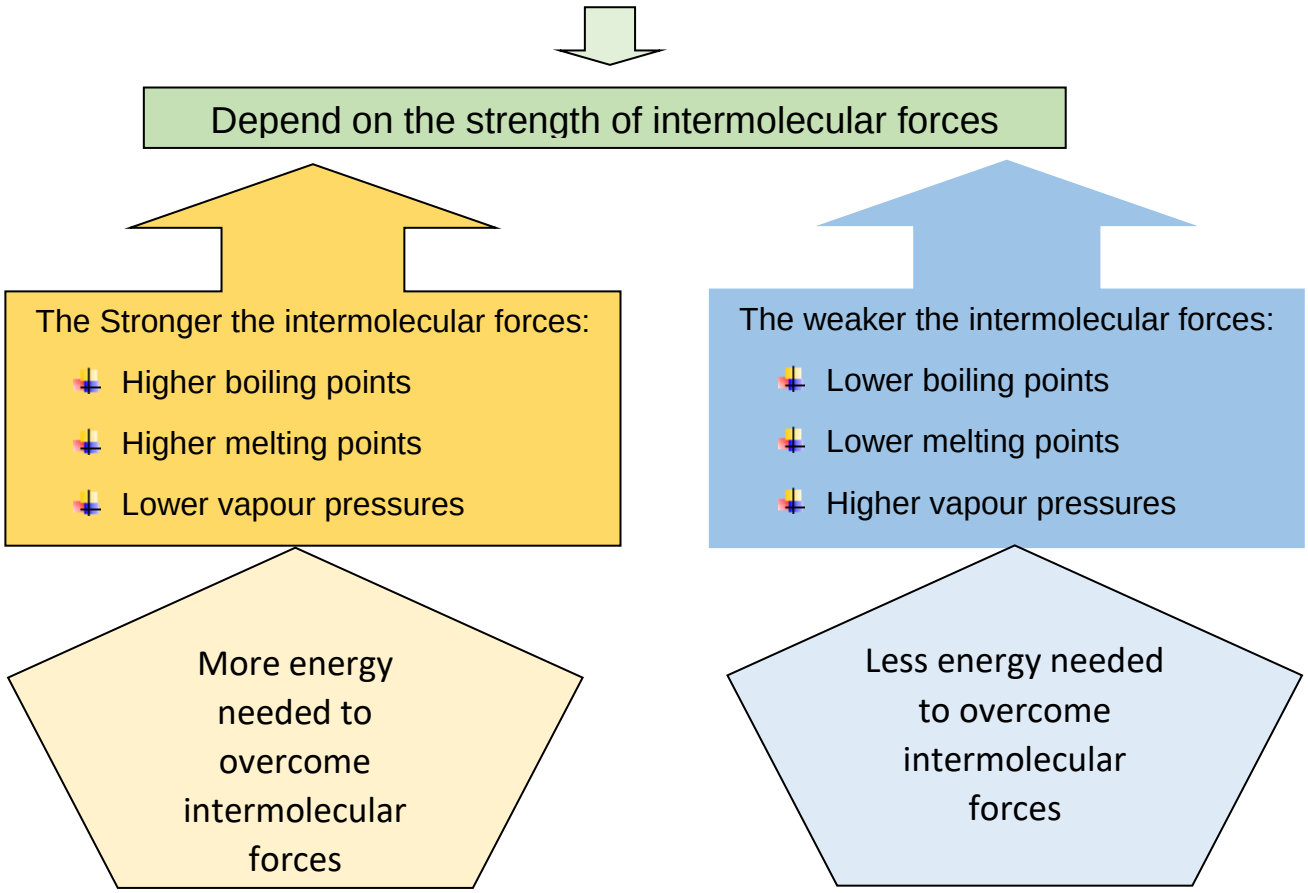
4. Ensure that each C atom is surrounded by 4 bonds (lines indicating bonds).

5. Include H atoms at all open bonds after ensuring that each C atom is surrounded by 4 bonds.

6. All bonds should be shown. Do not draw any part of the molecule condensed e.g. –CH3.

7. As a final check ensure all C atoms form 4 bonds, all O atoms form 2 bonds and Hydrogen atoms form 1 bond.

PHYSICAL PROPERTIES



Steps to write explanations related to physical properties of compound:

- **Comparing two compounds from different homologous series:**

  Step 1: State the type of intermolecular force in each compound.

  Step 2: Compare the strength of these intermolecular forces.

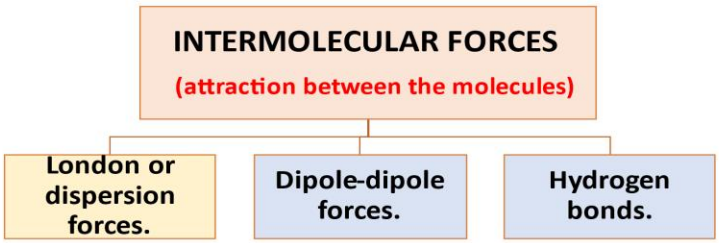
  Step 3: Compare the energy needed to overcome intermolecular forces.

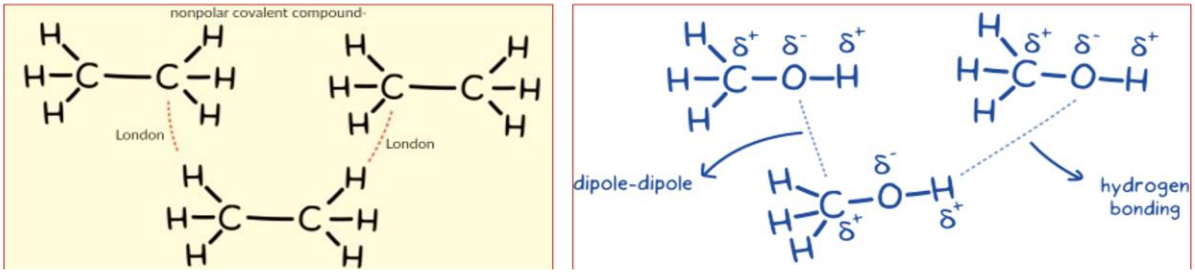
- **Comparing two compounds from the same homologous series:**

  Step 1: Compare the surface areas of the molecules.

  Step 2: Compare the strength of intermolecular forces.

  Step 3: Compare the energy needed to overcome intermolecular forces.





INTERMOLECULAR FORCES

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

London or dispersion forces

Weakest intermolecular forces – These forces are present between all molecules

Dipole–dipole forces

Stronger than London forces – between polar molecules **(Aldehydes, Ketones, Esters, Haloalkanes, Alcohols and Carboxylic acids)**

Hydrogen bonds (special type of intermolecular force)

Strongest intermolecular forces - between molecules in which H is bonded to O.

Alcohol & Carboxylic acid

INTERMOLECULAR FORCES

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

London or dispersion forces

Weakest intermolecular forces – These forces are present between all molecules

Dipole–dipole forces

Stronger than London forces – between polar molecules **(Aldehydes, Ketones, Esters, Haloalkanes, Alcohols and Carboxylic acids)**

Hydrogen bonds **(special type of intermolecular force)**

Strongest intermolecular forces - between molecules in which H is bonded to O.

Alcohol & Carboxylic acid

Comparing two compounds from different homologous series:

Refer to the TYPE and the STRENGTH of intermolecular forces to explain the difference in boiling points between organic compounds:

	TYPE OF INTERMOLECULAR FORCES	STRENGTH OF INTERMOLECULAR FORCES	ENERGY
But-2-ene -6,3 °C	Between molecules of **but-2-ene** are London forces	Intermolecular forces in **but-2-ene** are weak.	Less energy is needed to overcome the intermolecular forces in **but-2-ene.**
Butanal 74,8 °C	Between molecules of **butanal** are dipole -dipole forces in addition to London forces.	Intermolecular forces in **butanal** are stronger than in **but-2-ene.**	More energy is needed to overcome the intermolecular forces in **butanal** than in **but-2-ene.**
Butan-2-ol 117,7 °C	Between molecules of **butan-2-ol** are hydrogen bonds in addition to dipole - dipole and London forces.	Intermolecular forces in **butan-2-ol** are stronger than in **butanal** and **but-2-ene.**	More energy is needed to overcome the intermolecular forces in **butan-2-ol** than in **butanal** than in **but-2-ene.**

Example 1

Refer to the TYPE and the STRENGTH of intermolecular forces to explain the difference i points between:

1 Compounds A and B

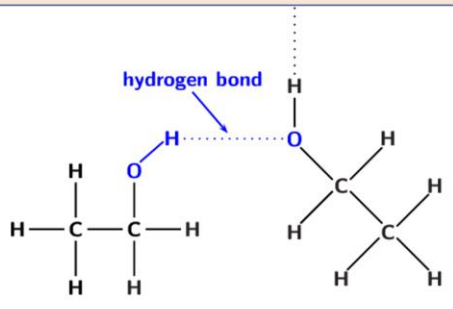
The boiling point of propan-2-one is higher than that of propane

COMPOUND]		BOILING POINT (°C)
A	Propane	-42
B	Propan-2-one	56
C	Propan-1-ol	97
D	Propanoic acid	141

TYPE OF INTERMOLECULAR FORCES	• Between molecules of propane (A) are London forces • Between molecules of propan-2-one (B) are dipole-dipole forces in addition to London forces
STRENGTH OF INTERMOLECULAR FORCES	• Intermolecular forces in propan-2-one are stronger than those in propane
ENERGY	• More energy is needed to break/ overcome the intermolecular forces in propan-2-one than in propane.

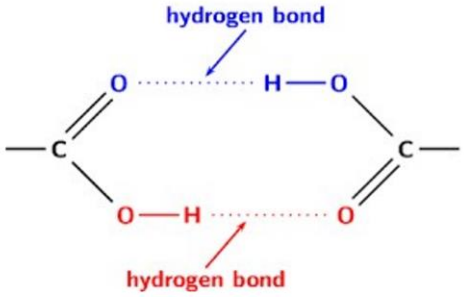
Why do carboxylic acids have stronger intermolecular forces than alcohols?

ALCOHOL



Between **alcohol** molecules there is one/less sites for hydrogen bonding.

CARBOXYLIC ACIDS



Between **carboxylic acid** molecules there are two/more sites for hydrogen bonding.

Example 2

Refer to the TYPE and the STRENGTH of intermolecular forces to explain the difference in boiling points between:

1 Compounds C and D

The boiling point of propanoic acid is higher than that of propan-1-ol

COMPOUND]		BOILING POINT (°C)
A	Propane	-42
B	Propan-2-one	56
C	Propan-1-ol	97
D	Propanoic acid	141

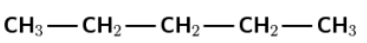
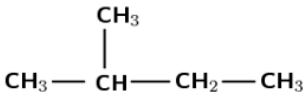
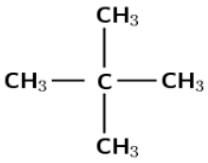
TYPE OF INTERMOLECULAR FORCES	• Both propan-1-ol (C) and propanoic acid (D) have hydrogen bonds. • Propan-1-ol (C) has one/less sites for hydrogen bonding • Propanoic acid(D) has two/more sites for hydrogen bonding
STRENGTH OF INTERMOLECULAR FORCES	• Intermolecular forces in propanoic acid are stronger than those in propan-1-ol
ENERGY	• More energy is needed to overcome the intermolecular forces in propanoic acid than in propan-1-one.

Surface area – chain length

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

- For compounds with the **same functional group**
- The **longer the carbon chain**, the **larger the surface area** and the **higher the boiling point/melting point and the lower the vapour pressure**. .
- **Carbon chain length increases** 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 needed to overcome them (London/ dispersion/ induced dipole force).**

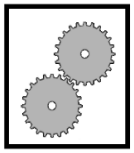
Comparing two compounds from the same homologous series:

	COMPOUND
A	**Pentane** 
B	**2-methylbutane** 
C	**2,2-dimethylpropane.** 

Link the shape/structure of the molecule to the strength of the intermolecular forces, and then the energy needed to overcome the intermolecular forces.

Compound with Longer chain length Larger surface area → Have strong intermolecular forces. → More energy is needed to overcome intermolecular forces → Higher Boiling point Higher Melting point. Low Vapour Pressure.

Compound More branched Smaller surface area → Have weak intermolecular forces. → Less energy is needed to overcome intermolecular forces → Lower Boiling point Lower Melting point High Vapour Pressure



Example 1

Learners investigate factors that influence the boiling points. In their investigations they determine the boiling points of the first three alkanes.

1. Fully explain why the boiling point increases from methane to propane.

STRUCTURE	• The chain length / surface area increases.
STRENGTH OF INTERMOLECULAR FORCES	• Strength of intermolecular forces/ London forces increases
ENERGY	• More energy is needed to overcome the intermolecular forces

Example 2

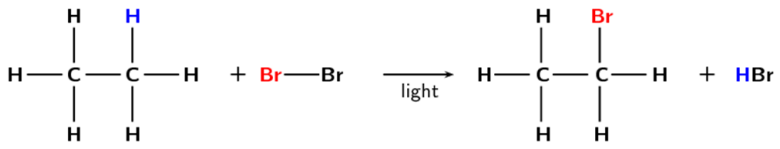
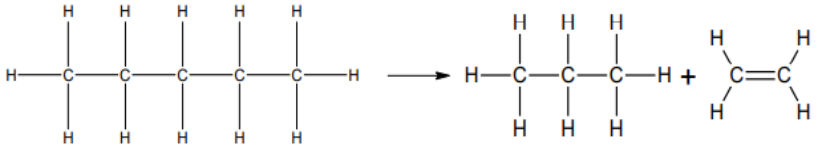
Explain the trend in the boiling points from compound A to compound C.

The boiling point increases from compound A to compound C

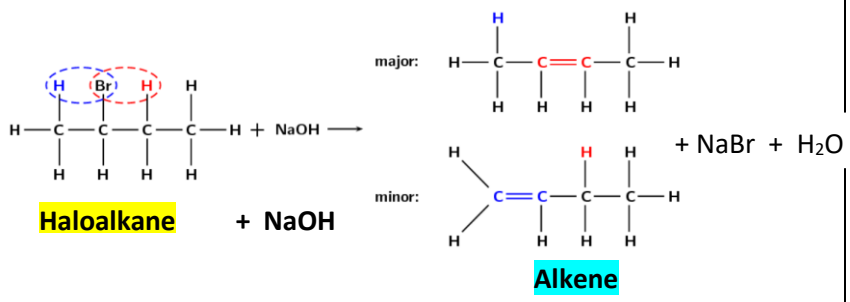
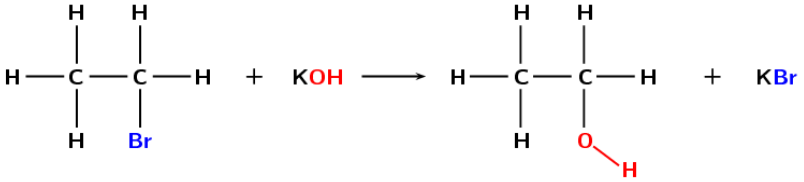
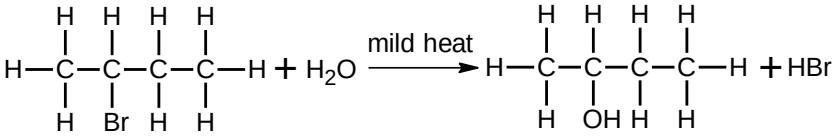
	ISOMERS	BOILING POINT (°C)
A	2,2-dimethylpropane	9
B	2-methylbutane	28
C	pentane	36

STRUCTURE	• From A to C • Less branched / larger surface area over which intermolecular forces act
STRENGTH OF INTERMOLECULAR FORCES	• Strength of intermolecular forces/ London forces increases from A to C
ENERGY	• More energy is needed to overcome the intermolecular forces from A to C

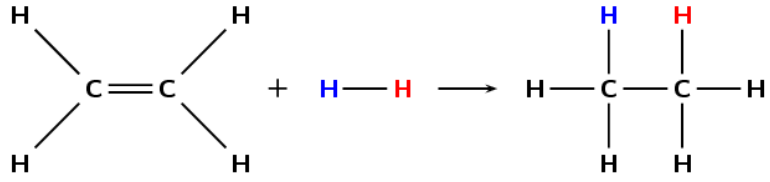
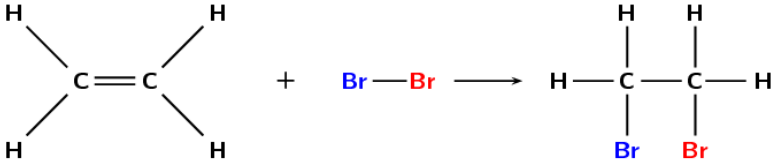
ORGANIC REACTIONS

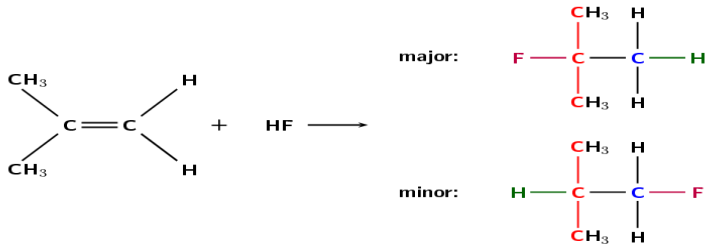
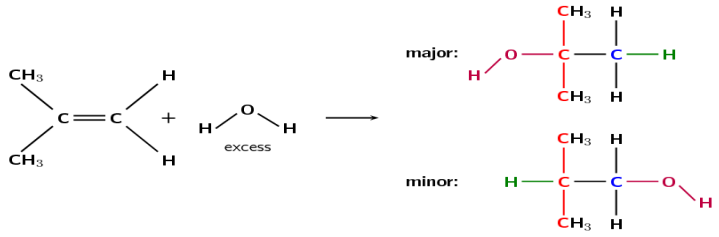
REACTIONS OF ALKANES		
Type of reaction	**Example**	**Reaction conditions**
Oxidation (Combustion)	$2C_6H_{14} + 19O_2 \rightarrow 12CO_2 + 14H_2O$ Alkane + oxygen → carbon dioxide + water + **energy**	Burns in EXCESS oxygen
Substitution: Halogenation	 **Alkane** + Br_2 → **Haloalkane** + HBr	Heat OR sunlight
Elimination: (thermal) cracking	 **Alkane** → **Alkane** + **Alkene**	heat + high pressure OR catalyst

REACTIONS OF HALOALKANES

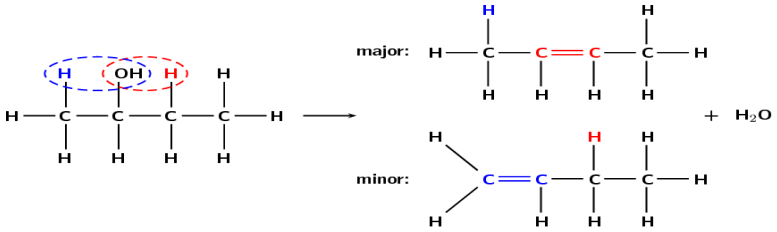
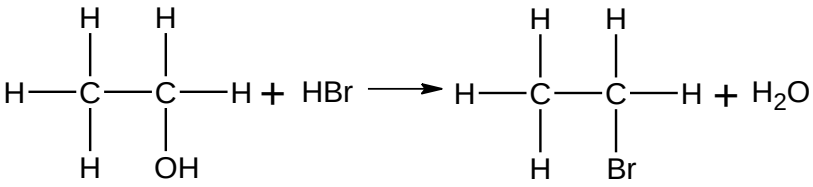
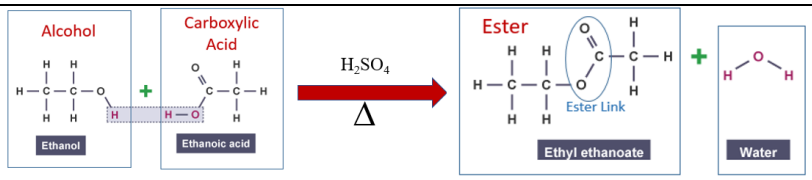
Type of reaction	Example	Reaction conditions
Elimination: dehydrohalogenation	 Haloalkane + NaOH → Alkene	Concentrated strong base **(NaOH/KOH /LiOH)** (in ethanol) + heat
Substitution: Hydrolysis	 Haloalkane + KOH → Alcohol + KBr	Dilute strong base **(NaOH/KOH/LiOH)** + mild heat
Substitution: Hydrolysis	 Haloalkane + H_2O → Alcohol + HBr	Excess H_2O + mild heat

REACTIONS OF ALKENES

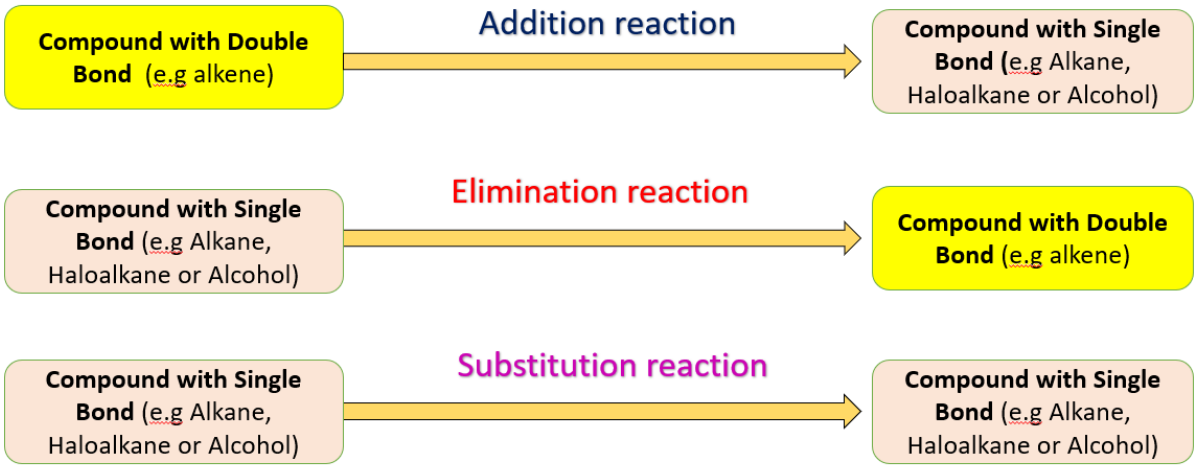
Type of reaction	Example	Reaction conditions
Addition reaction: Hydrogenation	 Alkene + **H_2** → Alkane	Pt, Pd or Ni as catalyst
Addition: Halogenation	 Alkene + **Br_2** → Haloalkane	Unreactive Solvent

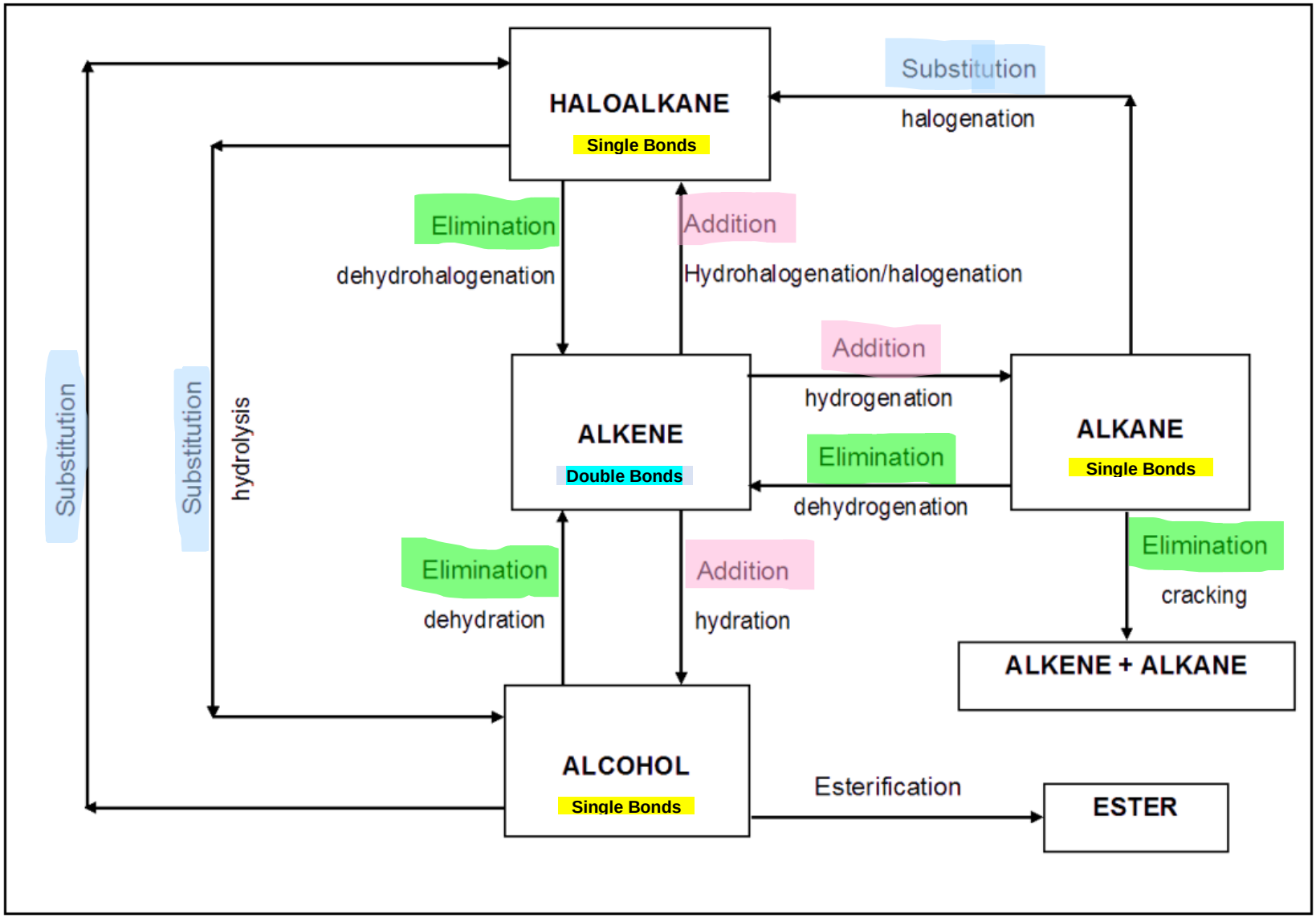
Addition: Hydrohalogenation	 Alkene + → Haloalkane	No water present; Unreactive solvent.
Addition: **Hydration**	 Alkene + H_2O → Alcohol	Excess H_2O. Small amount of acid (H_2SO_4/ H_3PO_4) as catalyst

REACTIONS OF ALCOHOLS

Type of reaction	Example	Reaction conditions
Elimination: Dehydration	 Alcohol → Alkene	Dehydrating agent (H_2SO_4/H_3PO_4) + heat
Substitution:	 Alcohol → Haloalkane + H_2O	Heat
Esterification	 Alcohol + Carboxylic acid → Ester + H_2O	Concentrated H_2SO_4 as catalyst + heat

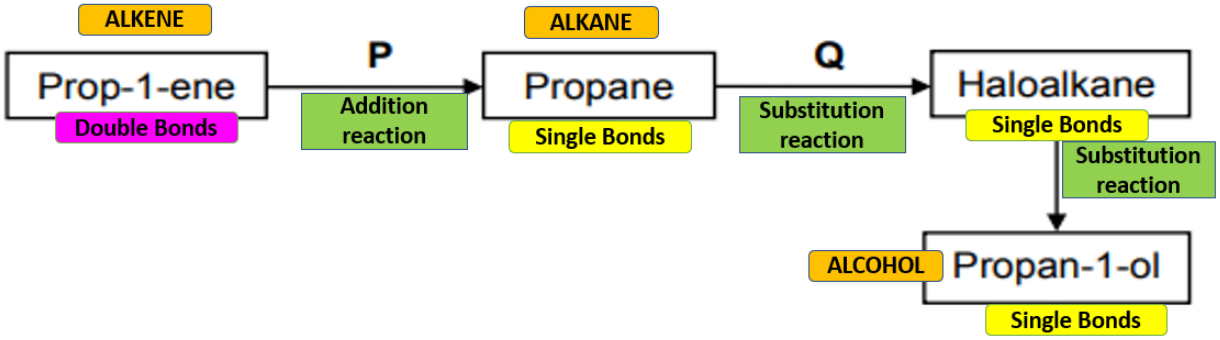
A flow diagram should be used in class to show the difference between elimination, substitution and addition reactions.




HALOALKANE
Single Bonds
Substitution
halogenation
Elimination
dehydrohalogenation
Addition
Hydrohalogenation/halogenation
Substitution
Substitution
hydrolysis
Addition
hydrogenation
ALKENE
Double Bonds
Elimination
dehydrogenation
ALKANE
Single Bonds
Elimination
cracking
Elimination
dehydration
Addition
hydration
ALKENE + ALKANE
ALCOHOL
Single Bonds
Esterification
ESTER

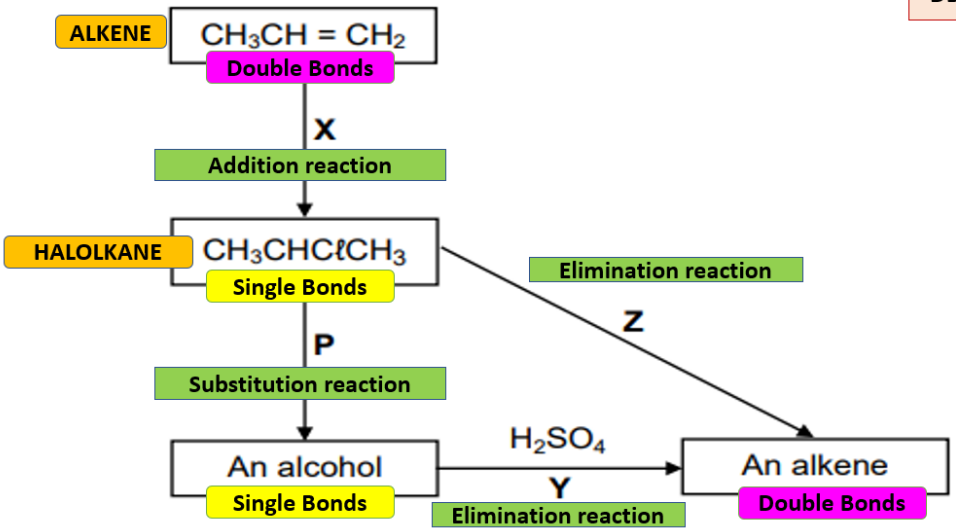
The flow diagram below shows the preparation of an ester using prop-1-ene as a starting reagent. P, Q, and R represent different organic reactions.

DBE/November 2014



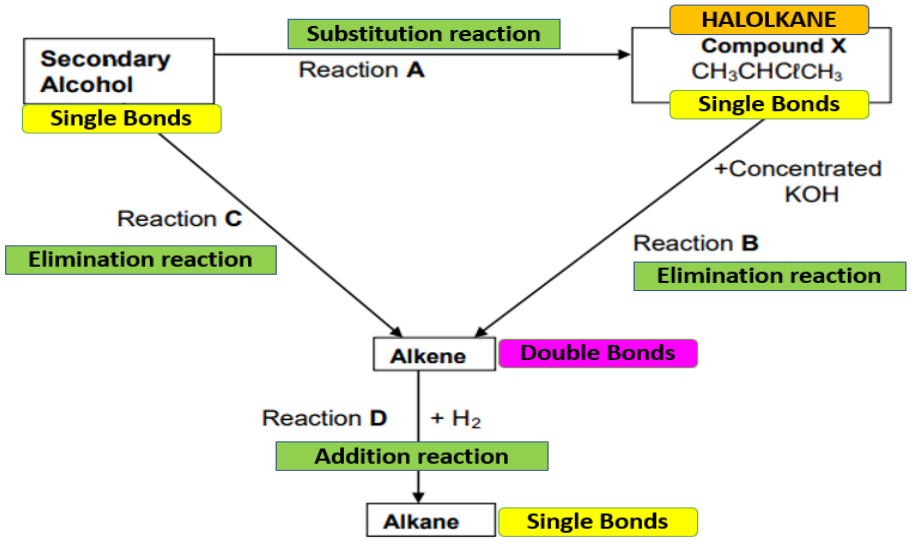
The flow diagram below shows the preparation of different organic compounds using $CH_3CH = CH_2$ as starting material. **X**, **Y**, **Z** and **P** represent different organic reactions.

DBE/EXAMPLER 2014



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

FS/September 20



ACTIVITY 1 **(30 Marks; 30 Minutes)**

1.1 Define the term:

1.1.1 Organic molecule (2)

1.1.2 Homologous series.

1.1.3 Functional group (2)

1.1.4 Positional isomer (2)

1.1.5 Primary alcohol (2)

1.1.6 Tertiary haloalkane (2)

(12)

1.2 Various options are provided as possible answers to the following questions. Choose the answer and write only the letter (A–D) next to the question numbers (1.1 to 1.5) in the ANSWER BOOK, e.g. 1.6 E.

1.2.1 Which one of the following compounds belongs to the same homologous series as C_3H_8?

A C_2H_2

B C_2H_4

C C_3H_6

D C_3H_8 (2)

1.2.2 The EMPIRICAL FORMULA of hexanoic acid is …

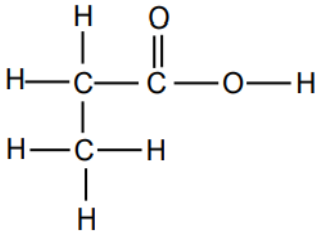
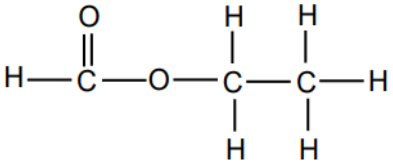
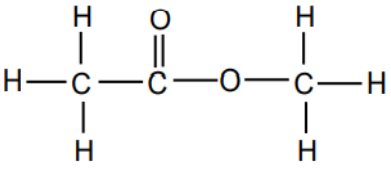
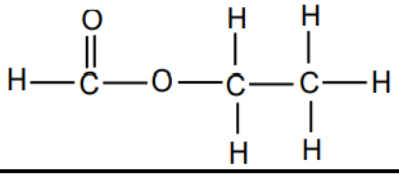
A $C_3H_6O_2$

B $C_6H_6O_2$

C $C_6H_{12}O_2$

D C_3H_6O (2)

1.2.3 Which ONE of the following is the CORRECT structural formula for METHYL ETHANOATE?

A		**B**	
C		**D**	

(2)

1.2.3 The name of the functional group of propanal is ...

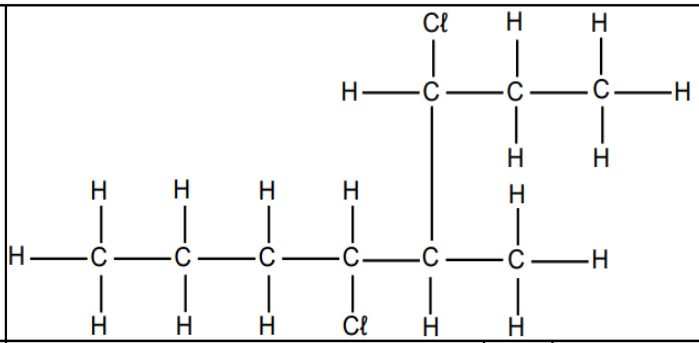
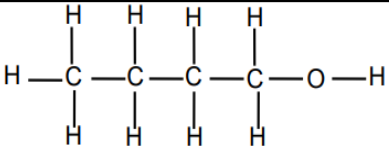
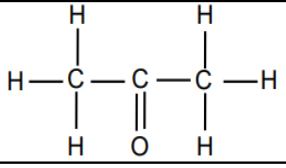
A Carboxyl

B Carbonyl

C Hydroxyl

D Formyl (2)

[18]

A			
B		**C**	

Write down the:

1.1 1.1.1 Name of the homologous series to which compound C belongs (1)

1.1.2 IUPAC name of compound A (3)

1.1.3 Structural formula of a tertiary alcohol that is a structural isomer of compound B (2)

1.2 An alcohol and methanoic acid are heated in the presence of concentrated sulphuric acid to form an ester.

1.2.1 What is the role of the concentrated sulphuric acid in this reaction? (1)

1.2.2 Write down the NAME or FORMULA of the inorganic product formed. (1)

The ester contains 6,67% hydrogen (H), 40% carbon (C) and 53,33% oxygen (O). The molar mass of the ester is 60 g·mol-1. Use a calculation to determine its:

1.2.3 Empirical formula (5)

1.2.4 Molecular Formula (2)

Write down the:

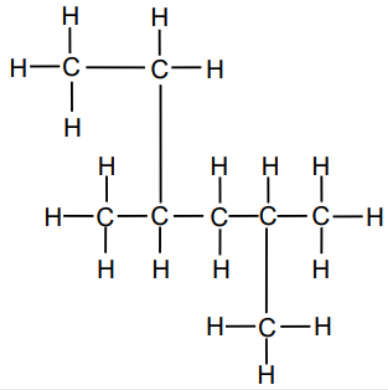
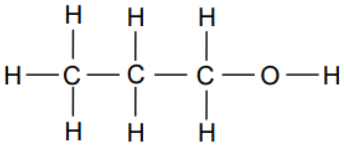
1.2.5 Structural formula of methanoic acid (1)

1.2.6 IUPAC name of the ester (2)

[18]

ACTIVITY 1 B **(25 Marks; 20 Minutes)**

Study the table below and answer the questions that follow.

A		**B**	
C	C_4H_8O	**D**	$CH_3(CH_2)_4CHCH_2$
E	$C_XH_YO_Z$		

1.1 1.1.1 Define the following terms:

(a) Organic molecules (2)

(b) Hydrocarbon (2)

1.2 Write down the:

1.2.1 Letter that represents an UNSATURATED hydrocarbon. (1)

1.2.2 IUPAC name of compound A (2)

1.2.3 IUPAC name of the POSITIONAL isomer of compound B (2)

1.2.4 IUPAC name of compound D (2)

1.2.5 Balanced equation, using MOLECULAR FORMULAE for the complete combustion of compound A (2)

1.3. The formula C_4H_8O represents two compounds that are functional isomers of each other.

1.3.1 Define the term functional isomer (2)

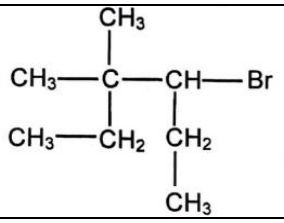
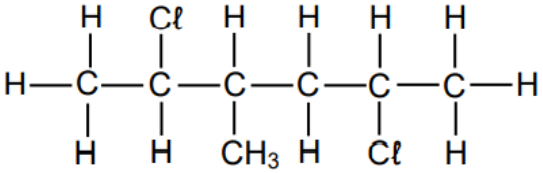
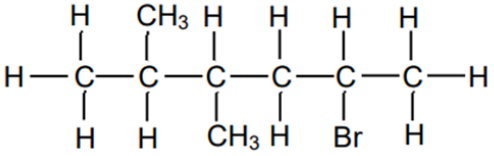
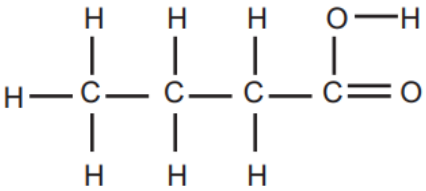
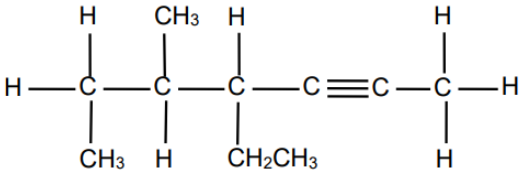
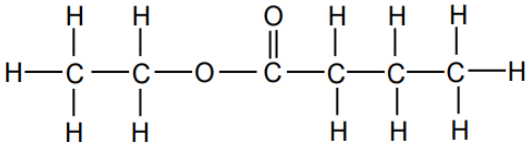
1.3.2 Write down the STRUCTURAL FORMULAE of each of these two FUNCTIONAL isomers. (4)

1.3.3 A 2 g sample of compound E contains 1,09 g carbon and 0,18 g hydrogen. The molecular mass of compound E is 88 $g \cdot mol^{-1}$. (6)

[25]

ACTIVITY 2.1 -2.2 **(18 Marks; 18 Minutes)**

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

A		**B**	
C	$CH_3CH(CH_3)CHO$	**D**	
E		**F**	
G	4-ethyl-3,3-difluorohexane	**H**	

2.1 Write down the IUPAC name of:

2.1.1 Compound **A** (2)

2.1.2 Compound **B** (2)

2.1.3 Compound **C** (2)

2.1.4 Compound **D** (2)

2.1.5 Draw the :STRUCTURAL formula of compound **G** (2)

(10)

ACTIVITY 2.2

2.2 Write down the:

2.2.1 HOMOLOGOUS SERIES to which compound **B** belongs. (1)

2.2.2 GENERAL FORMULA to which compound **F** belongs. (1)

2.2.3 NAME of the functional group of compound **C**. (1)

2.2.4 STRUCTURAL FORMULA of the functional group of compound **D** (1)

STRUCTURAL FORMULA of the functional isomer of compound **H.** (2)

2.2.5 Is compound **D,** a PRIMARY, SECONDARY or TERTIARY haloalkane? Give a reason for the answer. (2)

(8)

ACTIVITY 2.3 **(4 Marks; 3 Minutes)**

2.3 Next to each letter, A to F, in the table below is the molecular formula of an organic compound.

A	C_2H_5Br	**B**	C_2H_4
C	C_4H_{10}	**D**	C_2H_6O
E	C_3H_6O	**F**	$C_3H_6O_2$

Choose a molecular formula above that represents an organic compound below. Write down only the letter (A to F) next to the question numbers.

2.3.1 A haloalkane (1)

2.3.2 An alcohol (1)

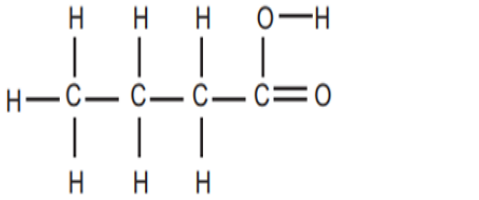
2.3.3 An unsaturated hydrocarbon (1)

2.3.4 An aldehyde (1)

(4)

ACTIVITY 2.4 **(10 Marks; 10 Minutes)**

2.4 Compound **E** reacts with another organic compound **X** to form Compound **H**.

E	

2.4.1 What type of reaction takes place here? (1)

2.4.2 State the TWO reaction conditions for this reaction. (2)

2.4.3 Write down the balanced equation using STRUCTURAL FORMULA for the reaction that takes place. (5)

2.4.4 Write down the IUPAC name of compound **X**. (1)

2.4.5 FORMULA of an inorganic product formed for this reaction. (1)

(10)

ACTIVITY 2.5 **(7 Marks; 7 Minutes)**

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

B	CxHy

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

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

2.5.2 State one reaction condition for this reaction. (1)

2.5.3 Determine the MOLECULAR FORMULA of compound **B** (1)

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

2.5.3 Calculate the TOTAL VOLUME of gas formed the container when 50cm3of CxHy reacts completely with oxygen. (4)

(7)

ACTIVITY 2.6 **(5 Marks; 5 Minutes)**

A laboratory assistant uses bromine water to distinguish between Compound **A**(alkane**)** and **B**(alkene). She adds bromine water to a sample of each in two different test tubes. She observes that one compound decolourises the bromine water immediately, whilst the other one only reacts after placing in direct sunlight.

2.6 Write down the:

2.6.1 Letter (**A** or **B**) of the compound that will immediately decolourise the bromine water (1)

2.6.2 Type of reaction that takes place in the test tube containing compound **A** (1)

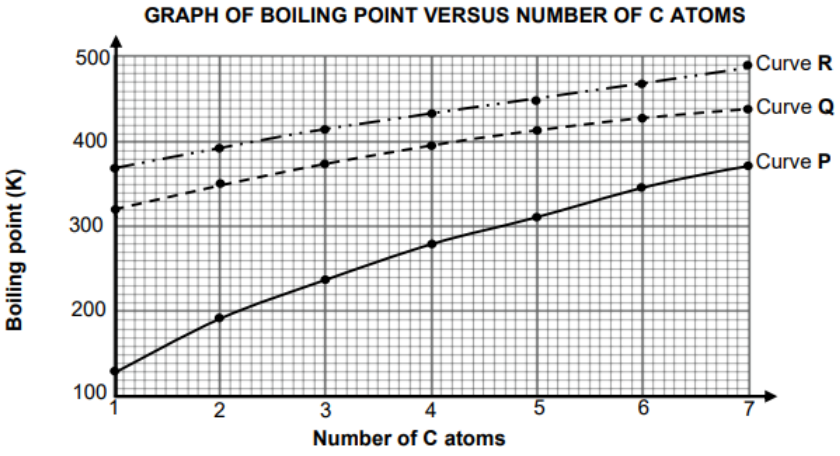
2.6.3 Type of reaction that takes place in the test tube containing compound **B** (1)

2.6.4 Structural formula of the organic product formed in the test tube containing compound **B** (2)

(5)

ACTIVITY 3 **(10 Marks; 10 Minutes)**

The relationship between boiling point and the number of carbon atoms in straight chain molecules of alkanes, carboxylic acids and alcohols is investigated. Curves **P, Q** and **R** are obtained.



3.1 Define the term boiling point. (2)

3.2 For curve **P**, write down a conclusion that can be drawn from the above results (2)

3.3 Identify the curve (**P, Q or R**) that represents each of the following:

3.3.1 Alkanes (1)

3.3.2 Carboxylic acids (1)

3.4 Explain the answer to QUESTION 3.3.2 by referring to the:

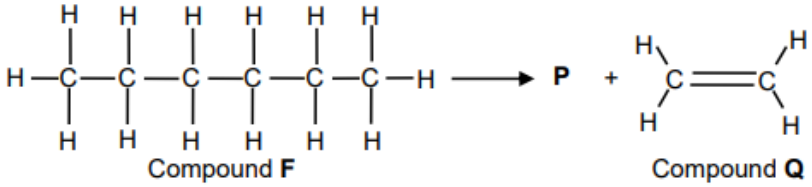
- Types of intermolecular forces present in alkanes, carboxylic acids and alcohols
- Relative strengths of these intermolecular forces
- Energy needed

(4)

[10]

ACTIVITY 4.1 **(5 Marks; 5 Minutes)**

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



Write down the:

4.1.1 Type of reaction that takes place . (1)

4.1.2 Homologous series to which compound **P** belongs. (1)

4.1.3 IUPAC name of compound **Q.** (2)

4.1.4 Molecular formula of compound **P.** (1)

[5]

ACTIVITY 4.2 **(5 Marks; 5 Minutes)**

4.2 Compound C ($C_{10}H_{22}$) reacts at high temperatures and pressures to form a three-carbon alkene **Y** and an alkane **Z**, as shown below.

$$C_{10}H_{22} \rightarrow \mathbf{Y} + \mathbf{Z}$$

Write down the:

4.2.1 Type of reaction that takes place. (1)

4.2.2 Two reaction conditions for this reaction. (2)

4.2.3 Which one of the two compounds is saturated? (1)

4.2.4 IUPAC name of compound **Z.** (2)

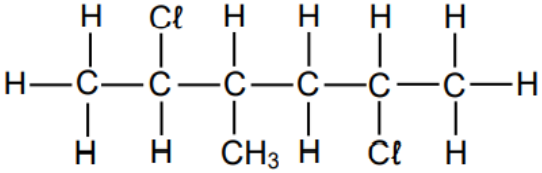
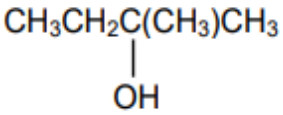
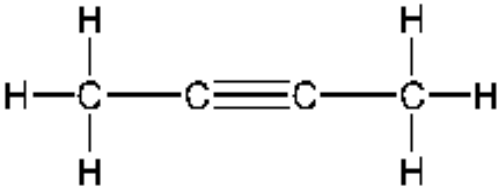
4.2.5 Molecular formula of compound **X.** (1)

[7]

ADDITIONAL ACTIVITIES

ACTIVITY 1 **(37 Marks; 40 Minutes)**

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

A		**B**	3-methylbutanal
C	3-methylbutan-2-one	**D**	C_2H_4
E		**F**	$CH_3CH_2CH_2COCH_3$
G		**H**	3-methylpentane

1.1 Write down the IUPAC name of:

1.1.1 Compound **A** (3)

1.1.3 Compound **E** (2)

1.2 Write down the STRUCTURAL FORMULA of:

1.2.1 Compound **B** (3)

1.2.2 Compound **C** (2)

1.3 For compound **H**, Write down the:

1.3.1 Is this a SATURATED or UNSATURATED hydrocarbon? Give a reason for your answer. (2)

1.3.2 IUPAC name of its POSITIONAL isomer. (2)

1.3.3 Structural formula of its CHAIN isomer. (2)

1.4 Write down the:

1.4.1 HOMOLOGOUS SERIES to which compound **B** belongs. (1)

1.4.2 STRUCTURAL FORMULA of the functional group of compound **F.** (1)

1.4.3 Letter of a compound which belongs to the same homologous series as compound **F.** (1)

1.4.4 Letters that represent TWO organic compounds that are functional isomers of each other. (1)

1.5 For compound **E**, Write down the:

1.5.1 GENERAL FORMULA of the Homologous series to which it belongs. (1)

1.5.2 NAME of the functional group of this compound. (1)

1.5.3 Is compound A, a PRIMARY, SECONDARY or TERTIARY alcohol? Give a reason for the answer. (2)

[37]

ACTIVITY 2 **(37 Marks; 40 Minutes)**

Three compounds are used to investigate one of the factors that influences boiling

points. The results obtained are shown in the table below.

	COMPOUND	MOLECULAR MASS ($g \cdot mol^{-1}$)	BOILING POINT (°C)
X	Ethyl ethanoate	88	77
Y	Pentan-1-ol	88	137
Z	Butanoic acid	88	165

2.1 For this investigation, write down the following:

2.1.1 Independent variable. (1)

2.1.2 Dependent variable. (1)

2.1.3 Controlled variable. (1)

2.1.4 Investigative question. (2)

2.1.5 Conclusion that can be drawn from the above results. (2)

2.2 Is this a fair investigation? State only YES or NO. (2)
Refer to the data in the table and give a reason for the answer.

2.3 Name the type of Van der Waals forces between molecules of ethyl ethanoate. (1)

2.4 The boiling point of pentan-1-ol is higher than that of ethyl ethanoate. (4)

Explain this observation by referring to the TYPE of INTERMOLECULAR
FORCES present in each of these compounds.

2.5 Refer to the intermolecular forces present in compounds Y and Z, and FULLY explain the difference in boiling points, as shown in the table. (4)

2.6 Which ONE of the compounds (X, Y or Z) has the highest vapour pressure? Give a reason for the answer. (2)

2.7 Will the boiling points of the chain isomer of compound Y be HIGHER THAN, LOWER THAN or EQUAL TO that of compound Y? Fully explain the answer (4)

[23]

ACTIVITY 3 **(37 Marks; 40 Minutes)**

During a practical investigation the boiling points of the first six straight-chain

ALKANES were determined and the results were recorded in the table below.

ALKANE	MOLECULAR FORMULA	BOILING POINT (°C)
Methane	CH_4	−164
Ethane	C_2H_6	−89
Propane	C_3H_8	−42
Butane	C_4H_{10}	−0,5
Pentane	C_5H_{12}	36
Hexane	C_6H_{14}	69

For this investigation, write down the following:

3.1.1 Dependent variable. (1)

3.1.2 Independent variable. (1)

3.1.3 Controlled variable. (1)

3.1.4 Investigative question. (2)

3.1.5 Suitable hypothesis. (2)

3.1.6 Conclusion that can be drawn from the above results. (2)

3.2 Write down the NAME of an alkane that is a liquid at 25 °C.

3.3 Fully explain why the boiling point increases from methane to hexane. (3)

3.4 Is this a fair investigation? Choose YES or NO. (2)
Give a reason for the answer.

3.5 Write down the type of Van der Waals force that occurs between these organic compounds. (1)

3.6 Which compound has the higher vapour pressure? Give the reason for the answer. (2)

3.7 Does the vapour pressure of the alkanes INCREASE or DECREASE with an increase in the number of carbon atoms? (1)

3.8 Will the boiling points of the structural isomers of hexane be HIGHER THAN, (4)
LOWER THAN or EQUAL TO that of hexane? Fully explain the answer

Hexane is now compared to 2,2-dimethylbutane.

3.8.1 Is the molecular mass of hexane GREATER THAN, LESS THAN or EQUAL to that of 2,2-dimethylbutane? (2)
Give a reason for the answer.

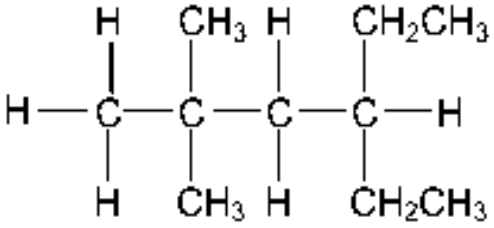
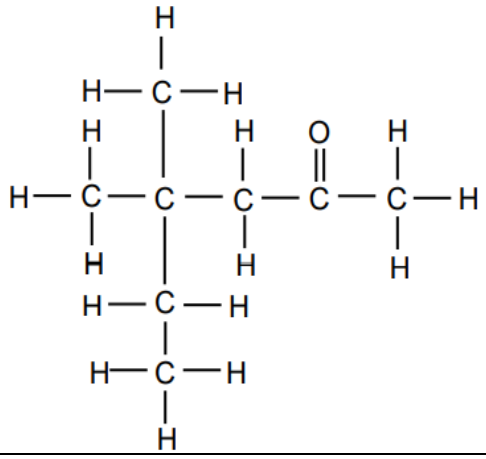
3.8.2 Is the boiling point of 2,2-dimethylbutane HIGHER THAN, (4)

LOWER THAN or EQUAL TO that of hexane? Fully explain the answer

[20]

ACTIVITY 4 **(33 Marks; 35 Minutes)**

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

A	C_3H_8O	**B**	
C		**D**	Propyl methanoate

4.1 Write down the IUPAC name of:

4.1.1 Compound **A** (2)

4.1.2 Compound **B** (3)

4.1.3 Compound **C** (2)

4.2 Write down the STRUCTURAL FORMULA of:

4.2.1 Compound **A** (2)

4.2.2 Compound **D** (2)

4.3 Compound **A** reacts with another organic compound **Z** to form compound **D**. Write down the:

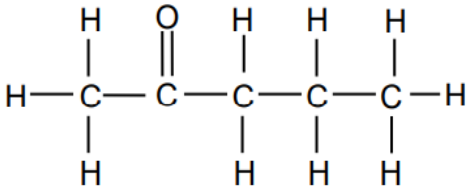
4.3.1 Type of reaction that takes place. (1)

4.3.2 Homologous series to which compound **Z** belongs. (1)

4.3.3 STRUCTURAL FORMULA of compound **Z**. (2)

4.4 Write down the name of the functional group of compound **C**. (1)

4.5 The organic compound below has one positional isomer and one functional isomer.



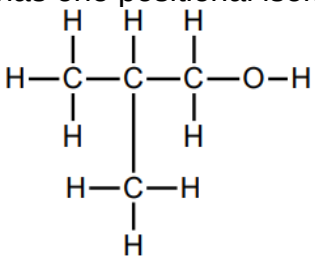
For this compound, write down the:

4.5.1 IUPAC name of its POSITIONAL isomer (1)

4.5.2 The homologous series to which the FUNCTIONAL isomer belongs. (1)

4.5.3 Structural formula of its FUNCTIONAL isomer (2)

4.6 The organic compound below has one positional isomer and one chain isomer.



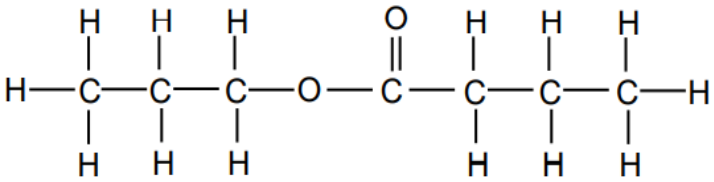
For this compound, write down the:

4.6.1 IUPAC name (2)

4.6.2 IUPAC name of its POSITIONAL isomer (2)

4.6.3 Structural formula of its CHAIN isomer (2)

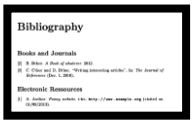
4.7 Study the structural formula below



For this compound, write down the:

4.7.1	Homologous series to which it belongs	(1)
4.7.2	IUPAC name	(2)
4.7.3	IUPAC name of the organic acid used in its preparation	(2)
4.7.4	STRUCTURAL FORMULA of its straight chain (unbranched) functional isomer	(2)

[33]



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