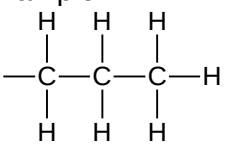
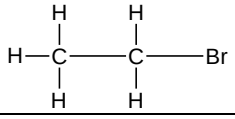
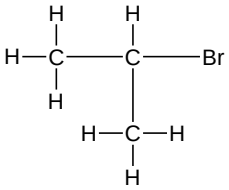
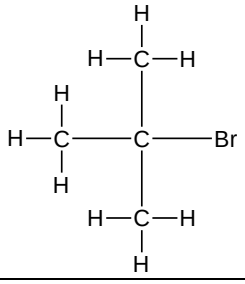
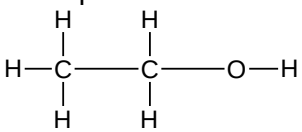
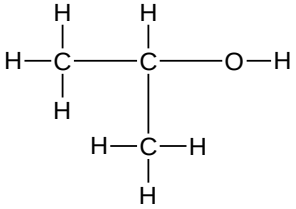
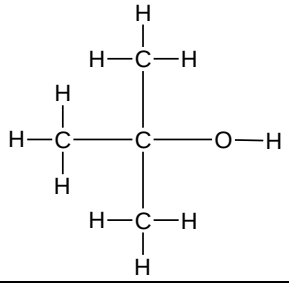
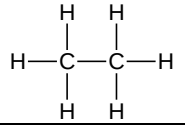
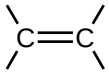
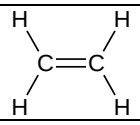
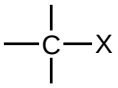
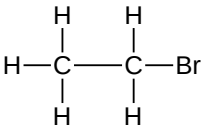
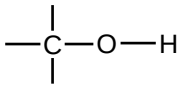
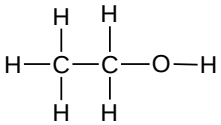
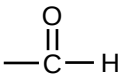
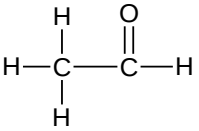
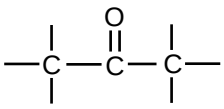
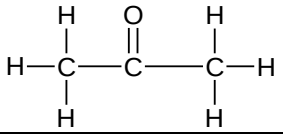
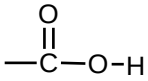
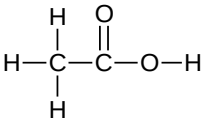
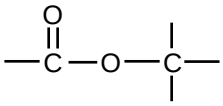
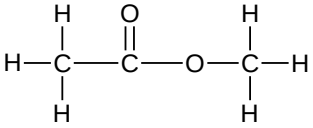
GRADE 12 REVISION 2013
MATTER AND MATERIALS: ORGANIC MOLECULES

TERMS AND DEFINITIONS	
Organic Chemistry	Chemistry of carbon compounds
Homologous series	A group of organic compounds that can be described by the same general formula and have the same functional group. OR A group of organic compounds in which one member differs from the next/previous member in the group by a CH_2 group.
General formula	A formula that can be used to determine the molecular formula of any member in a homologous series. Alkanes, for example, can be described by the general formula C_nH_{2n+2}. The alkane with 100 carbon atoms therefore has the molecular formula $C_{100}H_{202}$.
Functional group	A bond, an atom or a group of atoms that determine(s) the physical and chemical properties of a group of organic compounds.
Molecular formula	A chemical formula that indicates the type of atoms and the correct number of each in a molecule. Example: C_3H_8
Condensed structural formula	Shows the way in which atoms are bonded together in a molecule, but DOES NOT SHOW ALL bond lines. Example: $CH_3CH_2CH_3$
Structural formula	Shows which atoms are attached to which within the molecule. Atoms are represented by chemical symbols, lines are used to represent ALL the bonds that hold atoms together. Structural formulae usually do NOT depict the actual geometry/shape of molecules. Example: 
Isomerism	The property of an organic molecule to have a molecular formula that corresponds with that of another molecule.
Structural isomers	Compounds with the same molecular formula, but different structural formulae.
Hydrocarbons	Compounds consisting of carbon and hydrogen atoms only.
Substituent	A group or branch attached to the longest continuous chain of C atoms in an organic compound.
Alkanes	Alkanes are organic compounds containing only C-H and C-C single bonds. General formula: C_nH_{2n+2}
Saturated hydrocarbons	Hydrocarbons with only C-H and C-C single bonds (and thus contain the maximum number of hydrogen atoms per carbon). OR Hydrocarbons with no multiple (double or triple) bonds.
Unsaturated hydrocarbons	Hydrocarbons which have carbon-carbon double bonds and thus do not contain the maximum number of hydrogen atoms per carbon.
Alkyl group	A group formed by removing one H atom from an alkane.
Cycloalkanes	Organic compounds of carbon and hydrogen in which carbon atoms are bonded in rings with single bonds only. General formula: C_nH_{2n}
Alkene	A compound of carbon and hydrogen that contains a carbon-carbon double bond. General formula: C_nH_{2n}
Cycloalkene	A compound of carbon and hydrogen in which carbon atoms are bonded in a ring containing one double bond. General formula: C_nH_{2n-2}

TERMS AND DEFINITIONS	
Diene	A compound of carbon and hydrogen that contains two carbon-carbon double bonds. General formula: C_nH_{2n-2}
Alkyne	A compound of carbon and hydrogen that contains a carbon-carbon triple bond. General formula: C_nH_{2n-2}
Haloalkane (or an alkyl halide)	An organic compound in which one or more H atoms in an alkane have been replaced with halogen atoms. General formula: $C_nH_{2n+1}X$ (X = F, Cℓ, Br or I)
Primary haloalkane	One C atom is bonded to the carbon bonded to the halogen. Example: 
Secondary haloalkane	Two C atoms bonded to the carbon bonded to the halogen. Example: 
Tertiary haloalkane	Three C atoms bonded to the carbon bonded to the halogen. Example: 
Alcohol	An organic compound in which H atoms in an alkane have been substituted with hydroxyl groups (-OH groups). General formula: $C_nH_{2n+1}OH$
Primary alcohol	One C atom is bonded to the carbon bonded to hydroxyl group. Example: 
Secondary alcohol	Two C atoms bonded to the carbon that is bonded to hydroxyl group. Example: 

TERMS AND DEFINITIONS	
Tertiary alcohol	Three C atoms bonded to carbon that is bonded to hydroxyl group. Example: 
Aldehydes	Organic compounds having the general structure RCHO where R = H or alkyl. General formula: RCHO (R = alkyl group)
Carboxyl group	Functional group of carboxylic acids (-COOH)
Carbonyl group	Functional group of ketones (>C=O)
Boiling point	The temperature at which the vapour pressure of a liquid equals atmospheric pressure (external pressure).
Melting point	The temperature at which a solid changes to the liquid phase.
Viscosity	The resistance of a fluid (liquid or gas) to flow. (The greater a fluid's viscosity, the more slowly it flows.)
Vapour pressure	The pressure at which the vapour of a substance is in dynamic equilibrium with its liquid or solid form. (Substances with high vapour pressure are **volatile**, and such substances have high **volatility.)**
Substitution reaction	A reaction in which an atom or a group of atoms in a molecule is replaced by another atom or group of atoms.
Elimination reaction	A reaction in which elements of the starting material are "lost" and a double bond is formed.
Addition reaction	A reaction in which a double bond in the starting material is broken and elements are added to it.
Halogenation	The reaction of a compound with a halogen (Br_2, $C\ell_2$, I_2, F_2).
Cracking	The break-up of molecules with a large molecular mass into molecules with smaller molecular masses.
Hydrogenation	The addition of hydrogen to a molecule.
Hydrohalogenation	The addition of a hydrogen halide (HX) to a molecule.
Hydration	The addition of water to a molecule.
Dehydrohalogenation	The elimination reaction in which hydrogen and a halogen are lost from a molecule.
Dehydration	The removal water of from a molecule.
Esterification	The preparation of an ester from the reaction of a carboxylic acid with an alcohol.

FUNCTIONAL GROUPS OF ORGANIC COMPOUNDS

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

NAMING OF ORGANIC COMPOUNDS

The name of every organic molecule has three parts:

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

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

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

PHYSICAL PROPERTIES OF ORGANIC COMPOUNDS

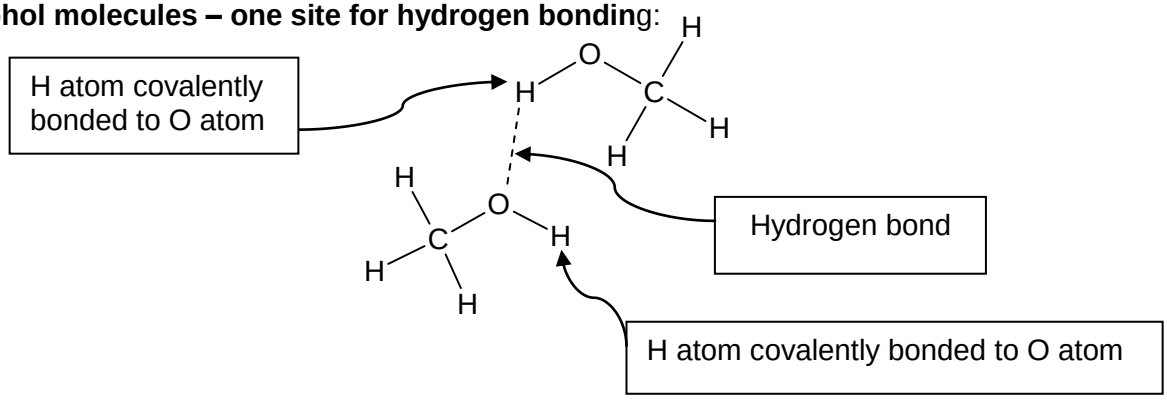
Relationship between vapour pressure and boiling point

- Compounds with **HIGH BOILING POINTS** have **LOW VAPOUR PRESSURES**.

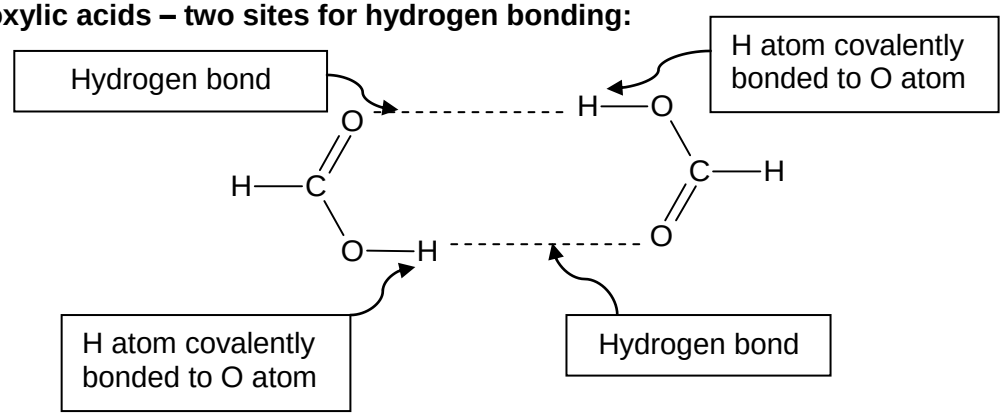
Physical properties and intermolecular forces

- Physical properties of compounds depend on the STRENGTH OF INTERMOLECULAR FORCES (forces between molecules).
- **STRONGER INTERMOLECULAR FORCES** results in **HIGHER** BOILING POINTS, **HIGHER** MELTING POINTS, **HIGHER** VISCOSITIES and **LOWER** VAPOUR PRESSURES.
- **TYPES OF INTERMOLECULAR FORCES**
  - ✓**Strong hydrogen bonds** – only between molecules in which an H atom is covalently bonded to a N, O or F atom.
    For our purposes: Only between molecules of alcohols and molecules of carboxylic acids.

    Examples:
    Alcohol molecules – one site for hydrogen bonding:



    Carboxylic acids – two sites for hydrogen bonding:



  - ✓**Weak Van der Waals forces** – between ALL molecules. Between polar molecules (aldehydes, ketones, esters and haloalkanes) the Van der Waals forces are stronger than between non-polar molecules (alkanes, alkenes, alkynes).

Relationship between boiling point / melting point / viscosity / vapour pressure and CHAIN LENGTH

$CH_3CH_2CH_3$
propane
$M_r = 44$
bp = -42 °C
Van der Waals forces
(only London)

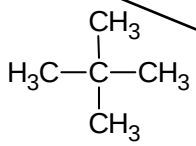
$CH_3CH_2CH_2CH_3$
butane
$M_r = 58$
bp = -0,5 °C
Van der Waals forces
(only London)

$CH_3CH_2CH_2CH_2CH_3$
pentane
$M_r = 72$
bp = 36 °C
Van der Waals forces
(only London)

INCREASING CHAIN LENGTH, increasing surface area, increasing strength of intermolecular forces, **INCREASING BOILING POINT / MELTING POINT / VISCOSITY,** but **DECREASING VAPOUR PRESSURE**

Relationship between boiling point /vapour pressure and BRANCHING

INCREASING BRANCHING, decreasing surface area, decreasing strength of intermolecular forces, **DECREASING BOILING POINT,** but **INCREASING VAPOUR PRESSURE**



2,2-dimethylpropane
$M_r = 72$
bp = 10 °C
Van der Waals forces
(only London)

2-methylbutane
$M_r = 72$
bp = 30 °C
Van der Waals forces
(only London)

$CH_3CH_2CH_2CH_2CH_3$
pentane
$M_r = 72$
bp = 36 °C
Van der Waals forces
(only London)

DECREASING BRANCHING, increasing surface area, increasing strength of intermolecular forces, **INCREASING BOILING POINT, BUT DECREASING VAPOUR PRESSURE**

Relationship between boiling point / melting point / viscosity and TYPE OF FUNCTIONAL GROUP

$CH_3CH_2CH_2CH_2CH_3$
pent**ane**
$M_r = 72$
bp = 36 °C
Van der Waals forces
(only London forces)

$CH_3CH_2CH_2$**CHO**
butan**al**
$M_r = 72$
bp = 76 °C
Van der Waals forces
(London + dipole-dipole)

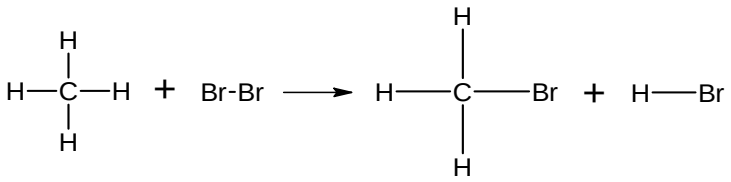
$CH_3CH_2CH_2CH_2$**OH**
butan-1-**ol**
$M_r = 74$
bp = 118 °C
Van der Waals forces
(London + dipole-dipole) +
hydrogen bonds

INCREASING POLARITY OF FUNCTIONAL GROUP, increasing strength of intermolecular forces, **INCREASING BOILING POINT / MELTING POINT / VISCOSITY, but DECREASING VAPOUR PRESSURE**

SUMMARY OF ORGANIC REACTIONS GRADE 12

REACTIONS OF ALKANES

SUBSTITUTION
Alkane → haloalkane

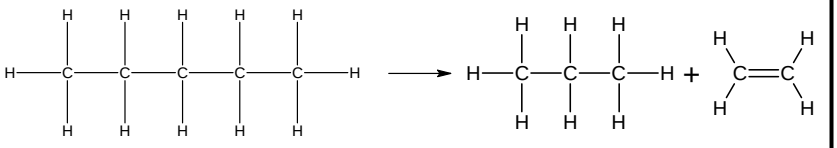


Conditions: heat OR sunlight **Reactants:** alkane + X_2 (F, Cl, Br, I)
Type of substitution: halogenation **Products**: haloalkane + HX

OXIDATION (COMBUSTION)

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

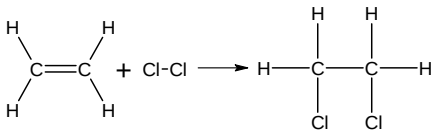
ELIMINATION
Alkane → alkene(s) + alkane with shorter chain



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

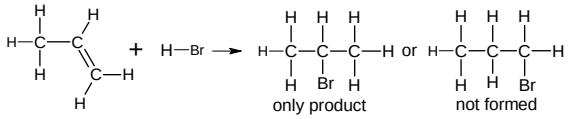
REACTIONS OF ALKENES

ADDITION



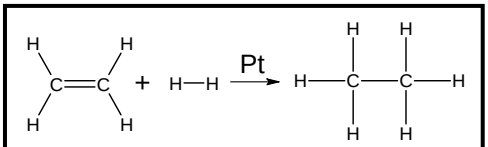
Conditions: unreactive solvent
Type of addition: halogenation
Reactants: alkene + X_2 (X = Cl, Br)
Product: haloalkane

ADDITION



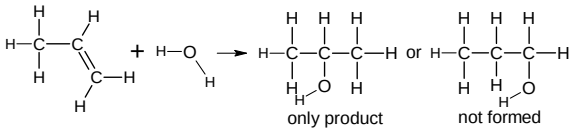
Conditions: no water; unreactive solvent
Type of addition: hydrohalogenation
Reactants: alkene + HX (X = I, Br, Cl)
Product(s): haloalkane(s)
Only product: H atom bonds to the C atom already having the greater number of H atoms.

ADDITION

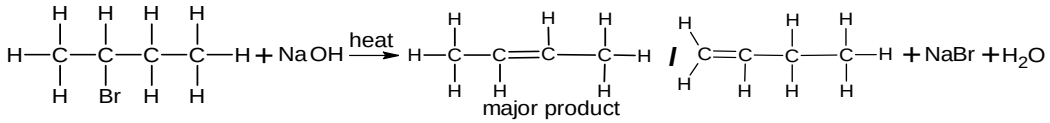


Conditions: Pt, Pd or Ni as catalyst
Type of addition: hydrogenation
Reactants: alkene + H_2
Product: alkane

ADDITION



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

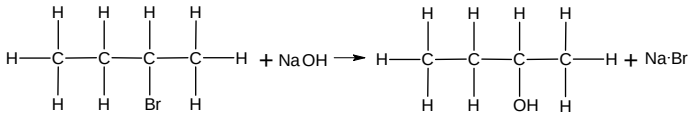


Conditions: concentrated strong base (NaOH, KOH, LiOH) in ethanol + heat
Type of elimination: dehydrohalogenation
Reactants: haloalkane + concentrated strong base **Products:** alkene + NaBr + H_2O
Major product: The one where the H atom is removed from the C atom with the least number of H atoms (most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

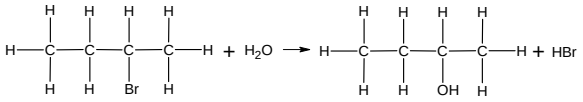
ELIMINATION
Haloalkane → alkene

REACTIONS OF HALOALKANES

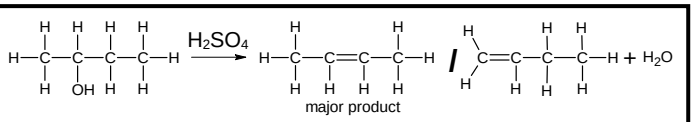
SUBSTITUTION
Haloalkane → alcohol



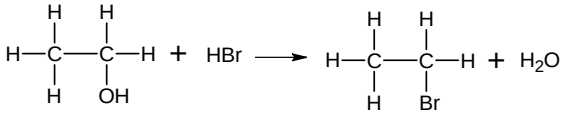
Conditions: dilute strong base (NaOH/KOH/LiOH) + mild heat
Type of substitution: hydrolysis
Reactants: haloalkane + dilute strong base
Products: alcohol + NaBr/KBr/LiBr



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



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



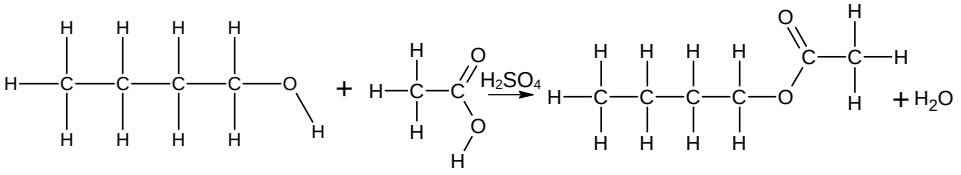
Conditions: heat
Reactants needed: alcohol + HX
Primary & secondary alcohols:
NaBr + H_2SO_4 used to make HBr in reaction flask
Tertiary alcohols: water free HBr (or HCl)
Products: haloalkane + H_2O

ELIMINATION
Alcohol → alkene

SUBSTITUTION
Alcohol → haloalkane

REACTIONS OF ALCOHOLS

ESTERIFICATION
Acid catalysed condensation



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

TYPICAL QUESTIONS

ONE-WORD ANSWERS: NOMENCLATURE

1. Organic compounds with the functional group ─OH
2. The homologous series to which propan-2-one belongs
3. The IUPAC name of the alkene with two carbon atoms
4. The homologous series to which the compound $CH_3C\ell$ belongs
5. The general term that describes compounds that consist of hydrogen and carbon atoms only
6. The homologous series to which H – C Ξ C – H belongs
7. The IUPAC name of the first aldehyde in the homologous series
8. Atoms, groups of atoms or bonds that give a homologous series its characteristic properties
9. The IUPAC name of the first alkyne in the homologous series
10. The IUPAC name of the first ketone in the homologous series
11. A group of organic compounds with the carbonyl group as functional group
12. The homologous series to which compounds with the functional group –OH belong
13. An atom or a group of atoms that gives an organic compound its chemical properties
14. Hydrocarbons containing triple bonds
15. Alkanes in which a hydrogen atom has been substituted by a halogen atom
16. Compounds with the same molecular formula but different structural formulae

ONE-WORD ANSWERS: PHYSICAL PROPERTIES

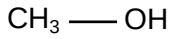
17. The resistance that a fluid offers to flow
18. The temperature at which the vapour pressure of a liquid equals atmospheric pressure
19. The pressure at which the vapour of a substance is in dynamic equilibrium with its liquid or solid form
20. The forces between molecules
21. The type of intermolecular force formed between molecules of alkanes

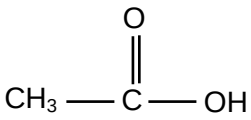
ONE-WORD ANSWERS: ORGANIC REACTIONS

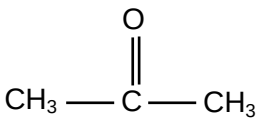
22. The type of addition reaction in which a hydrogen halide reacts with an alkene
23. The type of chemical reaction that takes place when an alcohol reacts with a carboxylic acid
24. The reaction type that can be used to convert hydrocarbons with high molecular masses to hydrocarbons with low molecular masses
25. The process in which large alkane molecules are broken up into smaller alkanes and alkenes
26. The type of addition reaction in which a hydrogen halide is added to an alkene
27. The type of elimination reaction during which a hydrogen halide is removed from a haloalkane
28. The type of addition reaction in which water reacts with an alkene
29. Elimination of H_2O from an alcohol
30. The reaction of alkanes and alkenes with halogens

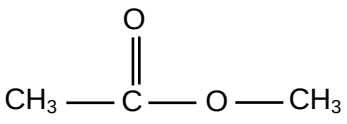
MULTIPLE CHOICE QUESTIONS: NOMENCLATURE

1. Which formula shown below represents a molecule of an ester?

A 

B 

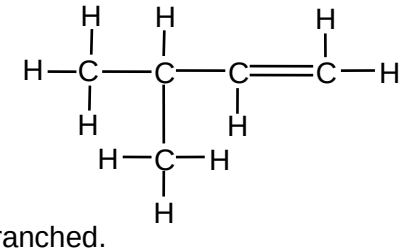
C 

D 

2. Which ONE of the following CANNOT be an ester or a carboxylic acid?

A C_3H_6O B $C_3H_4O_2$ C CH_2O_2 D $C_2H_4O_2$

3. Consider the organic compound represented below.



The compound is ...

A saturated and branched.
B unsaturated and branched.
C saturated and straight-chained.
D unsaturated and straight-chained.

4. A structural isomer of butane is ...

A propane.
B 2-methylbutane.
C 2-methylpropane.
D 2,2-dimethylpropane.

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

A similar chemical properties.
B similar physical properties.
C the same molecular formula.
D the same structural formula.

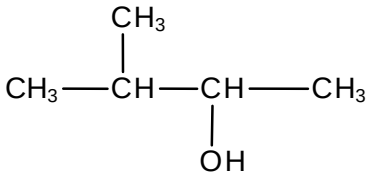
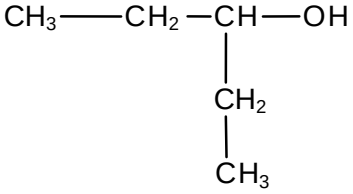
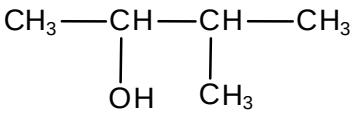
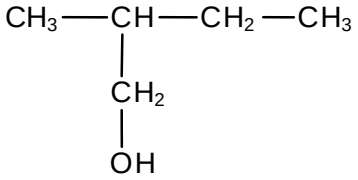
6. Which ONE of the following general formulae represents alkynes?

A C_nH_{2n+2} B C_nH_{2n-2} C C_nH_{2n} D C_nH_{2n-1}

7. Which ONE of the following homologous series does NOT contain a CARBONYL group ($\backslash C{=}O /$)?

A Aldehydes
B Alcohols
C Carboxylic acids
D Esters

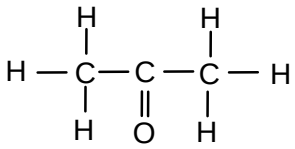
8. The structures of four organic compounds are shown below.

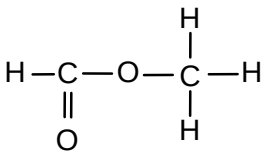
I		**II**	
III		**IV**	

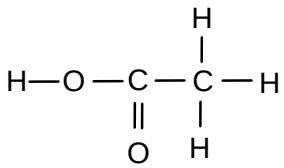
Which of the above compounds have the same IUPAC name?

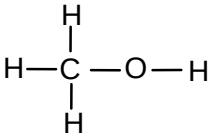
A I and II only
B III and IV only
C I and III only
D II and IV only

9. Which ONE of the following compounds represents a ketone?

A 

B 

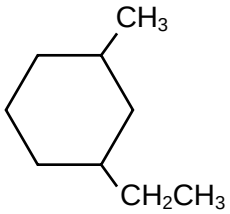
C 

D 

10. Consider the compound with molecular formula C_4H_{10}. How many structural isomers does this compound have?

A 1 B 2 C 3 D 4

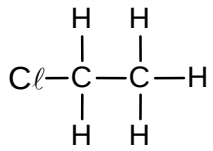
11. A cyclic hydrocarbon is represented below.

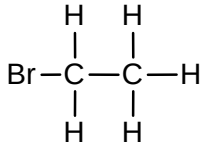


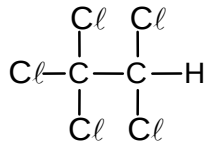
The IUPAC name of the above compound is:

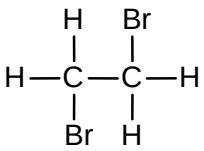
A 3-methyl-1-ethylcyclohexane
B 1-ethyl-5-methylcyclohexane
C 1-methyl-5-ethylcyclohexane
D 1-ethyl-3-methylcyclohexane

12. Which ONE of the following compounds has structural isomers?

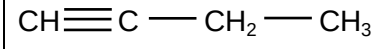
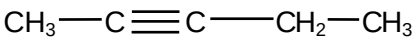
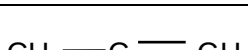
A 

B 

C 

D 

13. Consider the organic compounds (**I** to **IV**) shown below.

I		**II**	
III		**IV**	

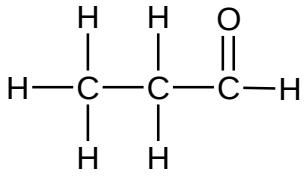
Which of the compounds above are structural isomers?

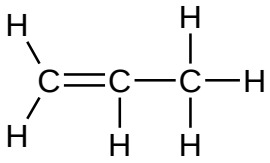
A I and II B I and III C I and IV D II and III

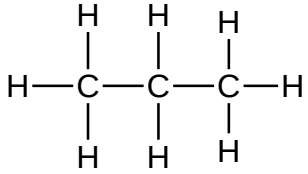
14. Which ONE of the following compounds CANNOT be an alkene?

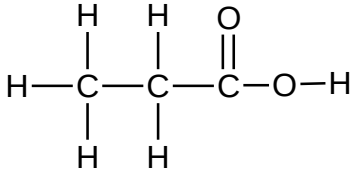
A C_2H_4 B C_3H_6 C C_3H_8 D C_4H_8

15. Which ONE of the compounds represented below is an UNSATURATED hydrocarbon?

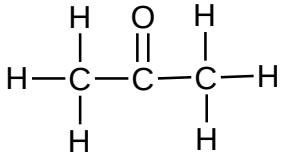
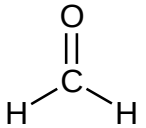
A 

B 

C 

D 

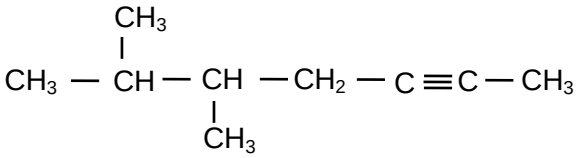
16. Consider the two organic compounds represented by **I** and **II**, as shown below.

I	**II**
	

Which ONE of the following correctly represents the homologous series to which each belongs?

	I	**II**
A	aldehyde	alcohol
B	ketone	alcohol
C	ketone	aldehyde
D	aldehyde	ketone

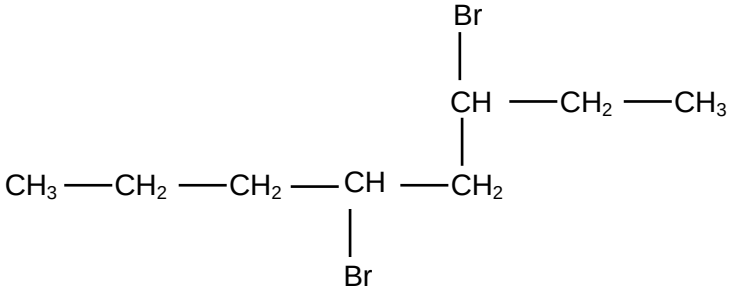
17. The structural formula of an organic compound is given below.



The IUPAC name of this compound is ...

A 2,3-dimethylhept-5-yne.
B 5,6-dimethylhept-2-yne.
C 2,3-methylhept-2-yne.
D 5,6-dimethylhept-3-yne.

18. The condensed structural formula of an organic compound is shown below:



Which ONE of the following is the correct IUPAC name of this compound?

A 4,6-dibromooctane
B 4-bromo-5-bromo-5-propylpentane
C 3,5-dibromooctane
D 2-bromo-1-bromo-1-propylpentane

19. Which ONE of the following organic compounds is represented by the molecular formula $C_5H_{10}O_2$?

A Ethyl ethanoate
B Butyl ethanoate
C Ethyl propanoate
D Propyl butanoate

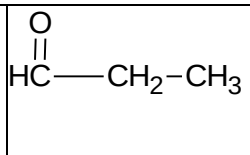
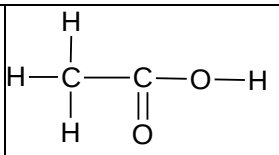
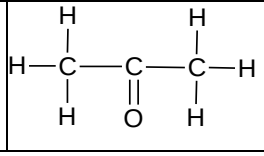
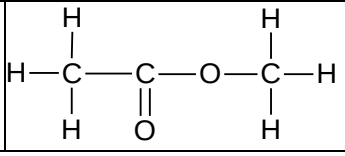
20. Which ONE of the following CANNOT be an ester or a carboxylic acid?

A $C_2H_4O_2$ B $C_3H_4O_2$ C CH_2O_2 D C_3H_6O

21. Which ONE of the following is an alkane?

A C_8H_{16} B C_6H_{14} C C_7H_{10} D C_7H_{12}

22. Which ONE of the following compounds is an isomer of CH_3CH_2COOH?

A		B	
C		D	

23. Which ONE of the following compounds is saturated?

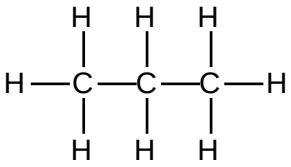
A C_4H_{10} B C_5H_{10} C C_5H_9OH D C_6H_{10}

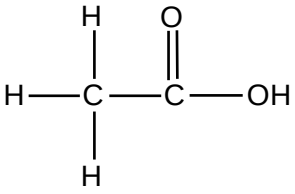
24. When the group $-\overset{\overset{O}{\|}}{C}-O-$ is present in a compound, the compound may be …

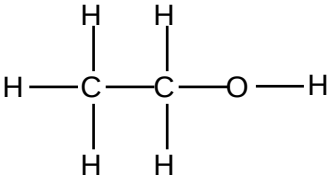
A propanal.
B 1-propanol.
C propan-2-one.
D methyl ethanoate.

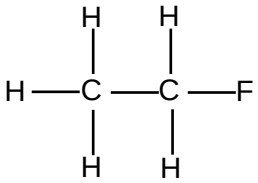
MULTIPLE CHOICE QUESTIONS: PHYSICAL PROPERTIES

25. Which ONE of the compounds shown below has the highest vapour pressure at room temperature?

A 
propane

B 
Ethanoic acid

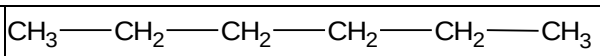
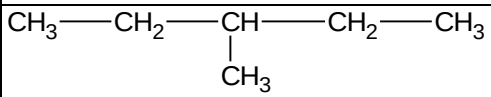
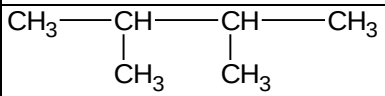
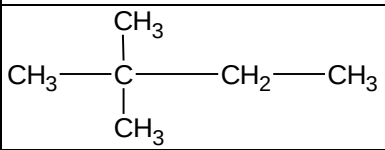
C 
ethanol

D 
fluoroethane

26. Which ONE of the following compounds has the highest melting point?

A CH_3CH_3
B $CH_3CH_2CH_3$
C $CH_3CH_2CH_2CH_3$
D $CH_3CH_2CH_2CH_2CH_3$

27. Which ONE of the following compounds has the highest boiling point?

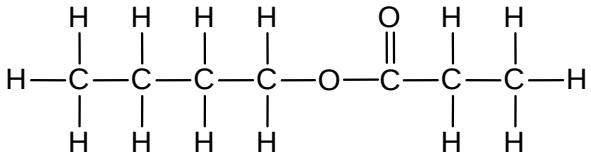
A	
B	
C	
D	

MULTIPLE CHOICE QUESTIONS: ORGANIC REACTIONS

28. Which ONE of the following pairs of reactants can be used to prepare the ester ethyl butanoate in the laboratory?

    A Ethanal and butan-1-ol
    B Ethanoic acid and butan-1-ol
    C Ethanol and butanoic acid
    D Ethanal and butanoic acid

29. The structural formula of an ester is shown below.



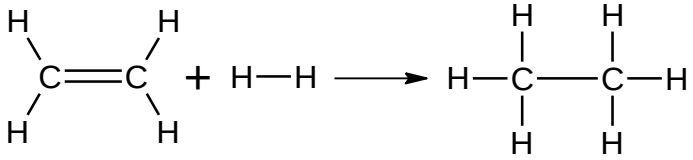
    Which ONE of the following pairs of compounds can be used to prepare the above ester?

    A Propanoic acid and butan-1-ol
    B Propanoic acid and butan-2-ol
    C Butanoic acid and propan-1-ol
    D Butanoic acid and propan-2-ol

30. Which ONE of the following reaction types can be used to prepare ethene from octane?

    A Addition
    B Hydrogenation
    C Cracking
    D Substitution

31. Consider the reaction represented below.



    The reaction is an example of …

    A addition.
    B oxidation.
    C elimination.
    D substitution.

32. Which ONE of the following pairs of compounds correctly represents the products formed during the COMPLETE combustion of octane?

    A CO and H_2O
    B CO and H_2
    C CO_2 and H_2
    D CO_2 and H_2O

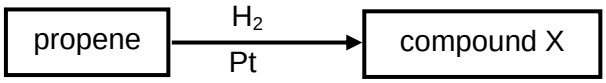
33. Which ONE of the following pairs of reactants can be used to prepare the ester ethyl methanoate in the laboratory?

    A Ethane and methanoic aid
    B Methanol and ethanoic acid
    C Ethanol and methanoic acid
    D Ethene and methanol

34. The type of compound formed when but-1-ene reacts with water in the presence of a suitable catalyst is a/an ...

A alcohol.
B alkane.
C haloalkane.
D ester.

35. Consider the flow diagram below:



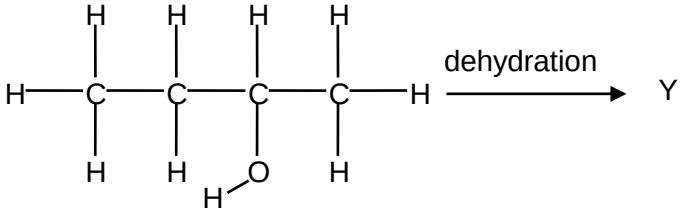
The IUPAC name for compound **X** is:

A propyne
B propan-1-ol
C propane
D propan-2-ol

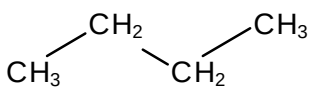
36. Cracking is an example of a/an … reaction.

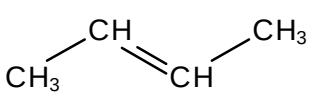
A addition
B elimination
C substitution
D dehydration

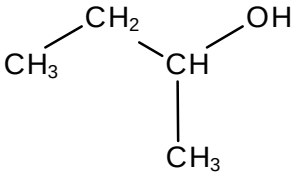
37. During the dehydration of butan-2-ol, represented below, compound Y forms as one of the products.

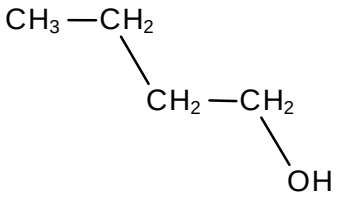


Which ONE of the following is the correct condensed structural formula for compound Y?

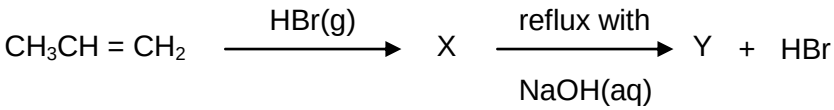
A 

B 

C 

D 

38. A simple reaction scheme is shown below.



The formula for Y is …

A CH_3CH_2COOH
B $CH_3CHOHCH_3$
C $CH_3CHBrCH_2OH$
D $CH_3CHOHCH_2Br$

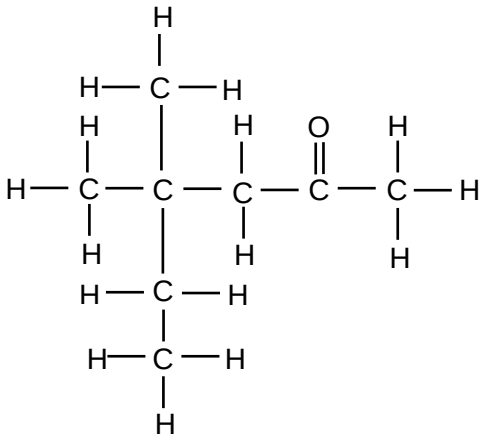
STRUCTURED QUESTIONS: NOMENCLATURE

QUESTION 1

Consider the organic compounds labelled **A – C**.

A $CH_3CH_2CH_2CH_2CH_2CH_3$

B

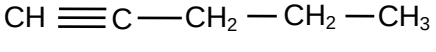
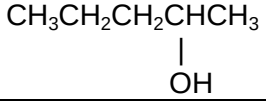
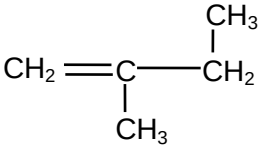
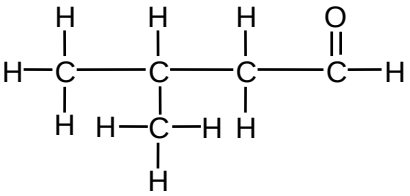
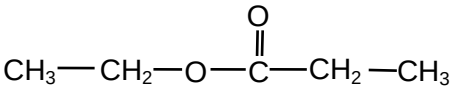


C CH_2CH_2

1.1 To which homologous series does compound **C** belong?
1.2 Compound **C** reacts with chlorine gas in an inert solvent. Using structural formulae, write a balanced equation for the reaction that takes place.
1.3 Write down the IUPAC name for compound **B**.
1.4 Write down the structural formula of an isomer of compound **A** that has only FOUR carbon atoms in the longest chain.

QUESTION 2

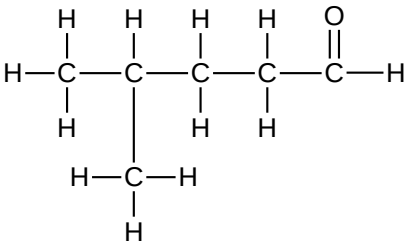
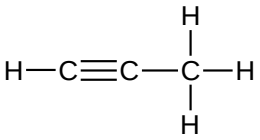
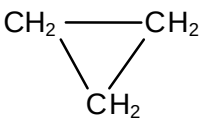
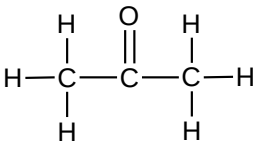
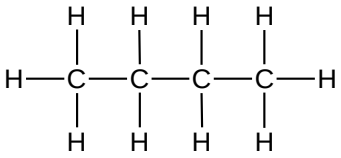
The letters **A** to **F** in the table below represent six organic compounds.

A		**B**	
C		**D**	Pentanoic acid
E		**F**	

2.1 Write down the letter(s) that represent(s) each of the following:
2.1.1 An alkyne
2.1.2 Two compounds that are structural isomers
2.1.3 A compound containing a carboxyl group
2.1.4 An aldehyde
2.1.5 An alcohol
2.2 Write down the:
2.2.1 IUPAC name of compound **C**
2.2.2 Structural formula of compound **D**
2.3 Compound **F** is prepared in the laboratory.
2.3.1 How can one quickly establish whether compound **F** is indeed being formed?
2.3.2 Write down the IUPAC name of the alcohol needed to prepare compound **F**.
2.3.3 Write down the IUPAC name of compound **F**.

QUESTION 3

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

A 	**B** 
C 	**D** 
E 	**F** ethyl butanoate

3.1 Write down the letter that represents the following:

3.1.1 A ketone

3.1.2 A compound which is an isomer of prop-1-ene

3.2 Write down the IUPAC name of the following:

3.2.1 Compound **A**

3.2.2 Compound **B**

3.3 Write down the NAME or FORMULA of EACH of the TWO products formed during the complete combustion of compound **E**.

3.4 Compound **F** is the organic product of the reaction between a carboxylic acid and ethanol. Write down the following:

3.4.1 The name of the homologous series to which compound **F** belongs

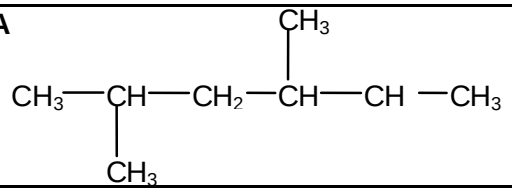
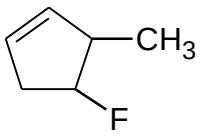
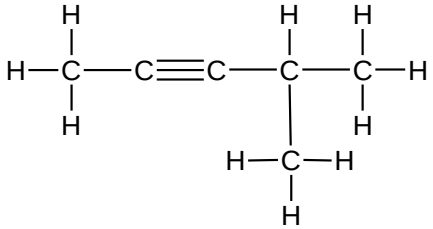
3.4.2 The structural formula of the FUNCTIONAL GROUP of carboxylic acids

3.4.3 The IUPAC name of the carboxylic acid from which compound **F** is prepared

3.4.4 The structural formula of compound **F**

QUESTION 4

Four compounds, labelled **A**, **B**, **C** and **D**, are shown below.

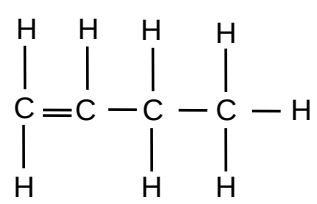
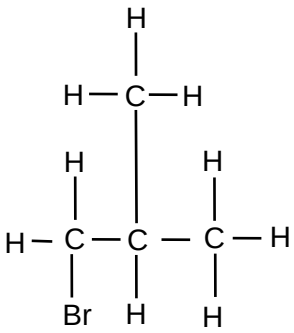
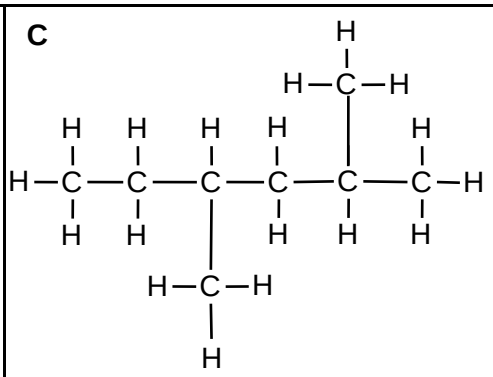
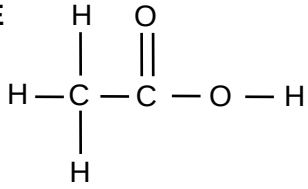
A 	**B** 
C 	**D** hexanoic acid

Write down the:

4.1 Homologous series to which compound **A** belongs

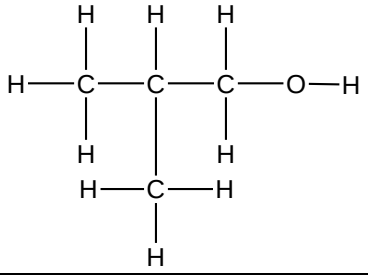
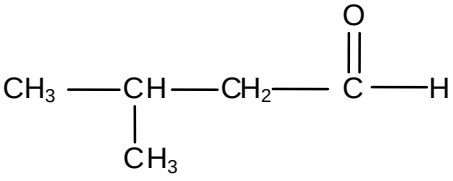
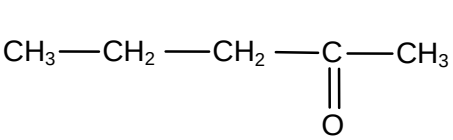
4.2 IUPAC name of compound **A**
4.3 IUPAC name of compound **B**
4.4 IUPAC name of compound **C**
4.5 Structural formula of compound **D**

QUESTION 5
The chemical properties of organic compounds are determined by their functional groups. The letters **A** to **F** in the table below represent six organic compounds.

A 	**B** 	**C** 
D Methanal	**E** 	**F** Methyl methanoate

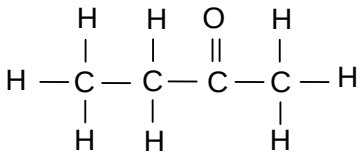
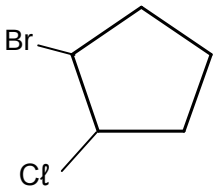
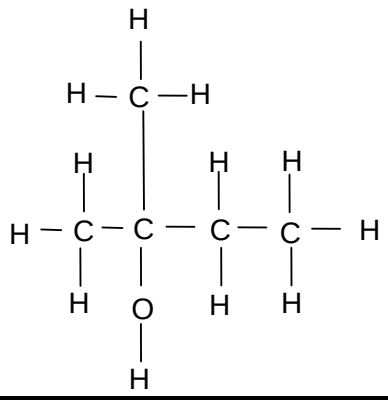
5.1 Write down the LETTER that represents the following:
5.1.1 An alkene
5.1.2 An aldehyde
5.2 Write down the IUPAC name of the following:
5.2.1 Compound **B**
5.2.2 Compound **C**
5.3 Write down the structural formula of compound **D**.
5.4 Write down the IUPAC name of the carboxylic acid shown in the table.
5.5 Write down the structural formula of compound **F**.

QUESTION 6
The letters **A** to **F** in the table below represent six organic compounds.

A	Pent-2-ene	**B**	
C	Propyl methanoate	**D**	2,5-dimethylheptane
E		**F**	

6.1 Write down the letter representing the compound which:
6.1.1 Is an aldehyde
6.1.2 Has the general formula C_nH_{2n}
6.1.3 Is unsaturated
6.1.4 Is a ketone
6.1.5 Is a hydrocarbon
6.1.6 Can be prepared by the reaction of an alcohol with a carboxylic acid
6.2 Write down the structural formula of:
6.2.1 Compound **A**
6.2.2 Compound **D**
6.3 Write down the:
6.3.1 NAME of the functional group of compound **F**
6.3.2 IUPAC name of compound **B**

QUESTION 7
Millions of organic compounds are known to date. Four of these compounds, represented by the letters **P, Q, R and S**, are shown in the table below.

P	methanal	**Q**	
R		**S**	

7.1 Write down the following:
7.1.1 Structural formula of the functional group of **P**
7.1.2 Homologous series to which **Q** belongs
7.1.3 Structural formula of an isomer of **Q**
7.1.4 IUPAC name of **R**
7.2 **S** represents an alcohol. Classify this alcohol as primary, secondary or tertiary.

QUESTION 8
Consider the following terms/compounds in organic chemistry.

aldehydes	ketones	oxidation	haloalkane	hydrolysis	ethyne	hydrohalogenation
hydration	but-1-ene	water	chlorine	butane	potassium hydroxide	alkynes

Choose from the above terms/compounds: (Write down the question number only and next to each the correct term/compound.)
8.1 The homologous series that has a carbonyl group as functional group
8.2 A saturated hydrocarbon
8.3 The product formed when an alkane reacts with a halogen

8.4 The homologous series to which propanal belongs
8.5 The homologous series to which 2-bromobutane belongs
8.6 The reaction of 2-bromobutane with water
8.7 An unsaturated compound that has isomers
8.8 A compound which belongs to the homologous series with the general formula C_nH_{2n-2}
8.9 The type of organic reaction during which hydrogen chloride reacts with ethene

QUESTION 9
Rubber is a naturally occurring compound. The diene, 2-methyl-1,3-butadiene, is one of the repeating units found in rubber.

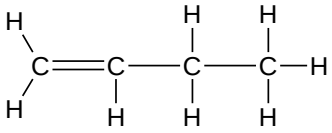
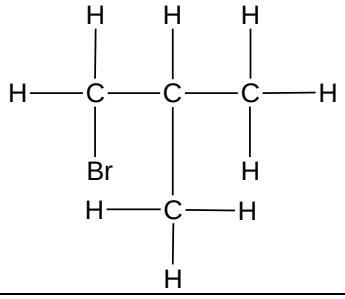
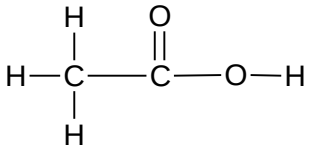
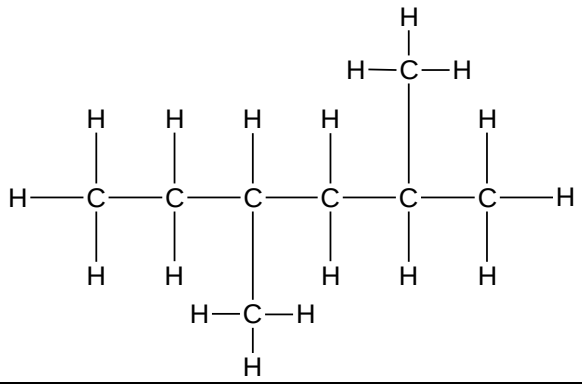
Over 20 million families depend on rubber cultivation for their livelihood. Tens of thousands of hectares of tropical forests have been cleared to make way for rubber plantations.

Chemists have been able to combine other dienes to obtain synthetic rubbers. Some rubber products include latex products such as hand gloves, raincoats and other products used in the battle against HIV/Aids.

The world's largest use of rubber is in tyres, and most tyres contain both natural rubber, which withstands heat better, and one or more kinds of synthetic rubber.

9.1 Is 2-methyl-1,3-butadiene an example of a saturated or an unsaturated hydrocarbon? Give a reason for your answer.
9.2 Write down the structural formula of 2-methyl-1,3-butadiene.
9.3 With regard to the environment, name TWO disadvantages of rubber and the production of rubber.
9.4 With regard to human life, name TWO benefits of rubber and the production of rubber.

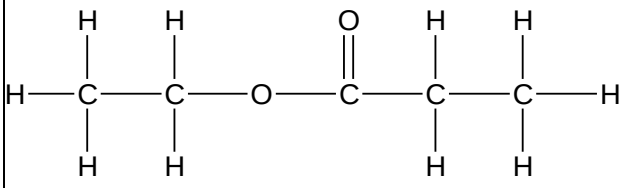
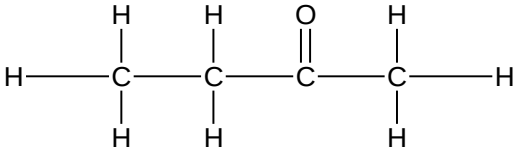
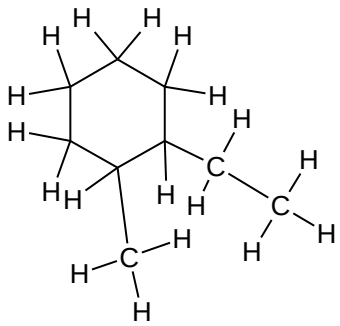
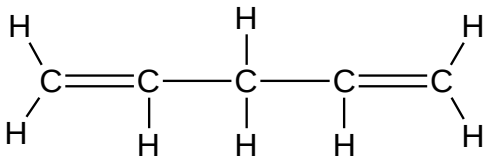
QUESTION 10
The letters **A** to **F** in the table below represent six organic compounds.

A 	**B** 	**C** Butanal
D 	**E** 	**F** Ethyl methanoate

10.1 Write down the LETTER(S) that represent(s):
10.1.1 Two hydrocarbons
10.1.2 A carboxylic acid

10.2 Write down the IUPAC name of:
10.2.1 Compound **B** 10.2.2 Compound **E**
10.3 The IUPAC name of compound **F** is given in the above table.
Write down the:
10.3.1 Structural formula of compound **F**
10.3.2 Homologous series to which compound **F** belongs
10.3.3 IUPAC name of an alcohol that can be used to prepare compound **F**
10.4 Write down the:
10.4.1 Homologous series to which compound **C** belongs
10.4.2 Structural formula of a ketone that is a structural isomer of compound **C**

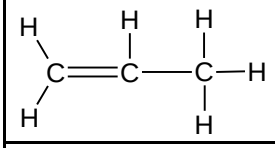
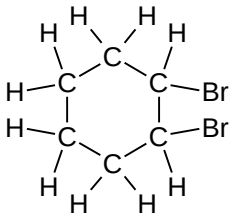
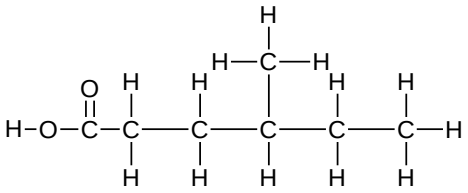
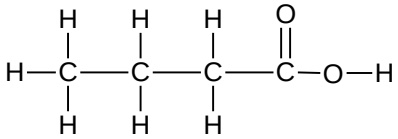
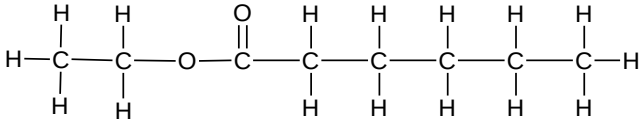
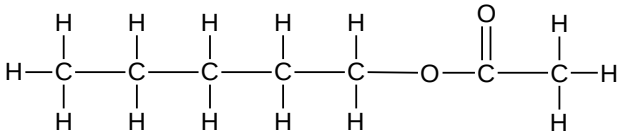
QUESTION 11
Consider the organic compounds represented by the letters **A** to **F** in the table below.

	**B** 
C propanoic acid	**D** 3,4-dimethylpentan-2-ol
E 	**F** 

11.1 Write down the IUPAC name of:
11.1.1 Compound **A** 11.1.2 Compound **E** 11.1.3 Compound **F**
11.2 Write down the structural formula of:
11.2.1 Compound **C** 11.2.2 Compound **D**
11.3 Write down the name of the homologous series to which each of the following belongs:
11.3.1 Compound **B** 11.3.2 Compound **A**
11.4 Write down the name of the functional group of compound **B.**
11.5 Write down the letters **(A** to **F)** that represent TWO compounds in the above table that are hydrocarbons. Give a reason for the answer.
11.6 Write down the letter **(A** to **F)** that represents an UNSATURATED compound in the above table. Give a reason for the answer.
11.7 Write down the general formula of the homologous series to which compound **C** belongs.

QUESTION 12

The letters **A** to **J** in the table below represent different organic compounds.

A 	**B** propan-2-ol
C but-2-yne	**D** propanal
E 	**F** 
G 	**H** 
I 2,4-dimethylpentan-3-one	**J** 

12.1 Write down the homologous series to which each of the following belong:

12.1.1 Compound A

12.1.2 Compound **F**

12.2 Which TWO compounds in the above table are HYDROCARBONS? Only write down the letters (**A** to **J**) representing these two compounds. Give a reason for the answer.

12.3 Which TWO compounds in the above table are UNSATURATED? Only write down the letter (**A** to **J**) representing these two compounds. Give a reason for the answer.

12.4 Write down the IUPAC name of:

12.4.1 Compound **E**

12.4.2 Compound **G**

12.4.3 Compound **H**

12.5 Write down the structural formula of:

12.5.1 The functional group of compound **B**

12.5.2 Compound **C**

12.5.3 Compound **D**

12.5.4 Compound **I**

12.6 Which TWO compounds in the above table are STRUCTURAL ISOMERS? Only write down the letter (**A** to **J**) representing these two compounds. Give a reason for the answer.

12.7 Write down the general formula of the homologous series to which compound C belongs.

STRUCTURED QUESTIONS: PHYSICAL PROPERTIES

QUESTION 13

In the petroleum industry smaller, more useful hydrocarbons are obtained from larger ones by a process called cracking.

13.1.1 Define the term hydrocarbon.

The compound $C_{10}H_{22}$ is cracked to obtain alkane X and another hydrocarbon. The cracking reaction is represented by the following incomplete equation:

$$C_{10}H_{22} \rightarrow C_5H_{10} + X$$

13.1.2 Write down the molecular formula of compound X.

The cracking process requires very high temperatures. Therefore engineers use a catalyst in the reaction.

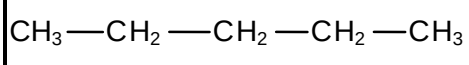
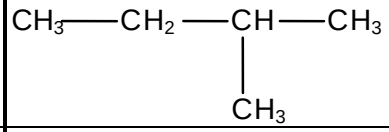
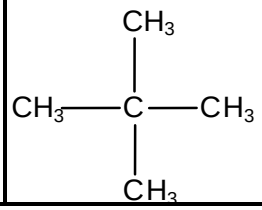
13.1.3 Give TWO reasons why they use a catalyst.

2-methylbut-1-ene (C_5H_{10}) is one of the compounds formed in this reaction.

13.1.4 Write down the structural formula of 2-methylbut-1-ene.

13.1.5 Name the type of reaction that occurs when 2-methylbut-1-ene reacts with hydrogen.

13.2 Consider the structural isomers represented by A, B and C shown below.

	COMPOUND	BOILING POINT (°C)
A		36
B		28
C		9

13.2.1 Give a reason why the above compounds are considered to be structural isomers.

13.2.2 Describe the trend in the boiling points from A to C, as shown in the table. Explain this trend by referring to molecular structure, intermolecular forces and energy involved.

13.2.3 Give a reason why branched hydrocarbons are preferred to straight chain hydrocarbons as fuel.

QUESTION 14

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

14.1 Write down the:

14.1.1 Most important use of the alkanes in the above table

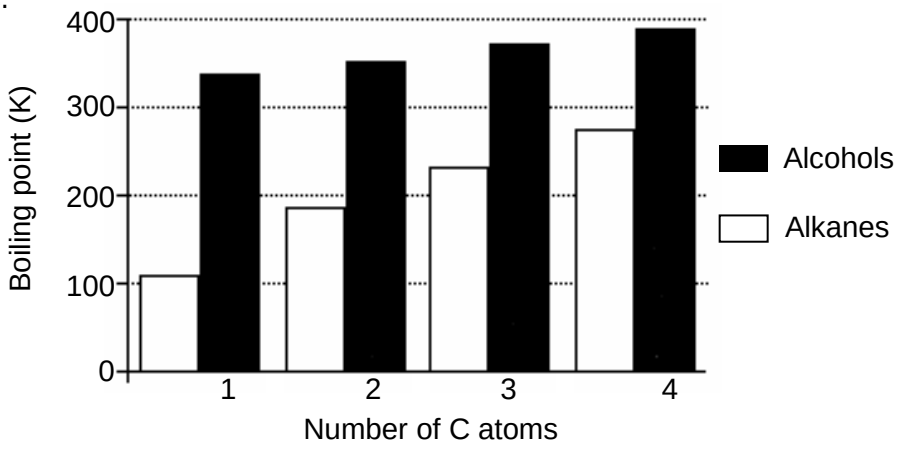
14.1.2 General formula of the alkanes

Refer to the table to answer the following questions.

14.2 For this investigation, write down the following:
14.2.1 Dependent variable
14.2.2 Independent variable
14.2.3 Conclusion that can be drawn from the above results
14.3 Write down the NAME of an alkane that is a liquid at 25 °C.
14.4 Alkanes burn readily in oxygen. Write down a balanced equation, using molecular formulae, for the combustion of propane in excess oxygen.
14.5 Will the boiling points of the structural isomers of hexane be HIGHER THAN, LOWER THAN or EQUAL TO that of hexane? Refer to MOLECULAR STRUCTURE, INTERMOLECULAR FORCES and ENERGY NEEDED to explain the answer.

QUESTION 15

The double column graph below represents the results obtained during an investigation to compare the boiling points of the first four straight chain alkanes and the boiling points of the first four primary alcohols.



15.1 In what phase do the above four alkanes occur at room temperature? Motivate your answer with information from the graph.
15.2 What is the relationship, between boiling point and molecular size, as illustrated in the graph? Explain this relationship by referring to intermolecular forces.
15.3 How do the boiling points of the first four alcohols compare with the boiling points of the corresponding alkanes? Explain your answer by referring to intermolecular forces.
15.4 The alkane consisting of four carbon atoms occurs as two structural isomers.
15.4.1 Define the term structural isomer.
15.4.2 Write down the structural formula for the branched isomer of this alkane.

QUESTION 16

Three hydrocarbons (**A**, **B** and **C**) with molecular formula C_5H_{12} are used to investigate the effect of BRANCHING on the BOILING POINTS of hydrocarbons. The results obtained are shown in the table below.

HYDROCARBON	BOILING POINT (°C)
A	36
B	28
C	10

16.1 Write down the term used to describe compounds with the same molecular formula, but with different structural formulae.
16.2 Write down for this investigation the following:
16.2.1 Dependent variable
16.2.2 Independent variable
16.2.3 Controlled variable
16.3 Are these hydrocarbons saturated or unsaturated? Explain the answer.

16.4 One of the hydrocarbons (**A**, **B** or **C**) has a straight chain with no branches. Write down the following:
16.4.1 The letter (**A**, **B** or **C**) that represents this hydrocarbon
16.4.2 Its IUPAC name
16.5 Consider hydrocarbon **C** and its boiling point.
16.5.1 Write down the structural formula of hydrocarbon **C**.
16.5.2 Explain why hydrocarbon **C** has the lowest boiling point. In your explanation, refer to its structure, intermolecular forces and the energy involved.
16.6 Which ONE of hydrocarbons (**A**, **B** or **C**) has the highest vapour pressure? Refer to the data in the table to give a reason for the answer.

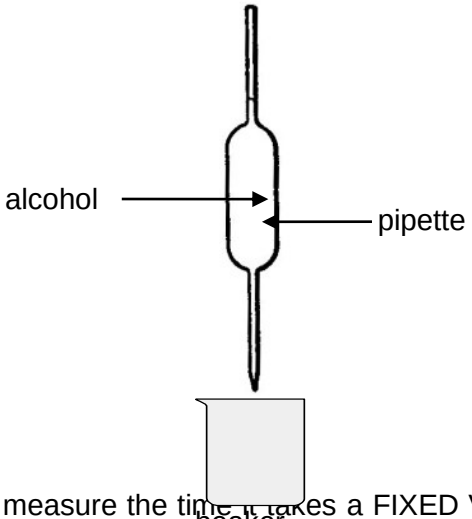
QUESTION 17
Five alcohols represented by the letters **A** – **E** are listed in the table below.

A	Methanol	**B**	Ethanol
C	Propan-1-ol	**D**	Butan-2-ol
E	2-methylpropan-2-ol		

17.1 Which ONE of the above alcohols is a SECONDARY alcohol? Write down only the LETTER that represents the alcohol.
17.2 The letter E represents 2-methylpropan-2-ol. For this alcohol, write down the following:
17.2.1 Its structural formula
17.2.2 The LETTER in the table that represents one of its structural isomers

17.3 Viscosity is a measure of a fluid's resistance to flow. Learners conduct an investigation to compare the viscosities of the first three alcohols (**A** – **C**) in the table above. They use the apparatus shown below.


stopwatch



The learners use the stopwatch to measure the time it takes a FIXED VOLUME of each of the alcohols to flow from the pipette. They record this flow time, which is an indication of the viscosity of each alcohol, as given in the table below.

	Alcohol	Flow time (s)
A	Methanol	4,0
B	Ethanol	7,9
C	Propan-1-ol	14,3

17.3.1 Formulate an investigative question for this investigation.
17.3.2 Which ONE of the alcohols (**A**, **B**, or **C**) has the highest viscosity? Use the data in the table to give a reason for the answer.
17.3.3 Refer to the intermolecular forces of the three alcohols (**A**, **B** and **C**) to explain the trend in viscosities as shown in the table.
17.3.4 Lubricants reduce friction. Which one of alcohols, **A**, **B** or **C**, will be the best lubricant?
17.4 Which ONE of 2-methylpropan-2-ol and butan-2-ol has the higher viscosity?
17.5 Refer to intermolecular forces to explain the answer to QUESTION 17.4.

QUESTION 18

The table below shows data collected for four organic compounds, represented by the letters **A** – **D**, during a practical investigation.

	Organic compound	Relative molecular mass	Boiling point (°C)
A	$CH_3CH_2CH_3$	44	- 42
B	CH_3CHO	44	21
C	CH_3CH_2OH	46	78

18.1 Is compound **A** a saturated or an unsaturated hydrocarbon? Give a reason for your answer.
18.2 To which homologous series does compound **B** belong?
18.3 Write down the IUPAC name for each of the following compounds:
18.3.1 **B**
18.3.2 **C**
18.4 Which variable was controlled during this investigation?
18.5 Name the following in this investigation:
18.5.1 The dependent variable
18.5.2 The independent variable
18.6 Refer to intermolecular forces to explain the difference in boiling points between compounds **A** and **C**.
18.7 Which ONE of compound **B** or **C** will have the highest vapour pressure at a specific temperature? Give a reason for your answer.

QUESTION 19

The table below shows the boiling points of four organic compounds, represented by the letters **A** to **D**, of comparable molecular mass.

Compound		Molecular mass	Boiling point (^oC)
A	Butane	58	0
B	Propanal	58	49
C	Propan-1-ol	60	97
D	Ethanoic acid	60	118

19.1 Compound **A** is used as a fuel in gas burners.
19.1.1 Is compound **A** in the GAS, LIQUID or SOLID phase at 25 °C? (1)
19.1.2 How will the boiling point of an ISOMER of compound **A** compare to that of compound A? Write down HIGHER THAN, LOWER THAN or EQUAL TO. Refer to MOLECULAR STRUCTURE, INTERMOLECULAR FORCES and the ENERGY needed to explain the answer.
19.1.3 Using molecular formulae, write down the balanced equation for the combustion of compound **A** in excess oxygen.
19.1.4 Compound A has a lower boiling point than compound **B**. Give reasons for this difference in boiling points by referring to the following:
- Structural differences between the two compounds
- Polarity

19.2 Consider the boiling points of compounds **C** and **D**.
19.2.1 Give a reason for this difference in boiling points by referring to the intermolecular forces present in EACH of these compounds.
19.2.2 Which ONE of compound **C** or **D** has a higher vapour pressure? Refer to their boiling points to give a reason for the answer.

QUESTION 20

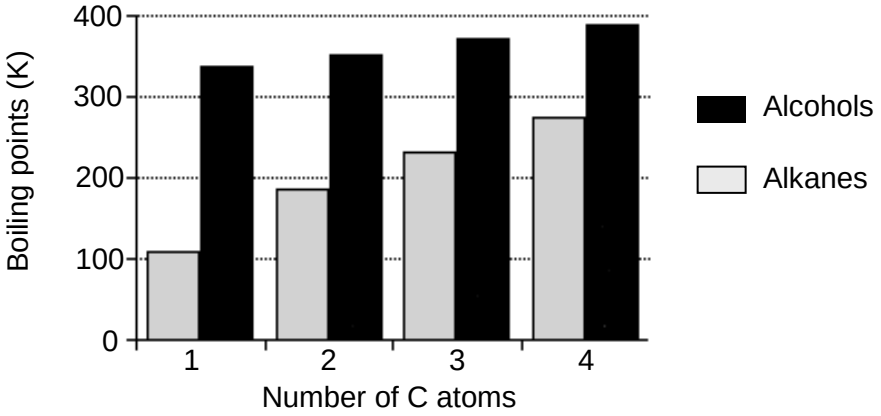
Knowledge of boiling points can be used to identify chemical compounds. The boiling points of four organic compounds, represented by the letters **A**, **B**, **C** and **D**, are given in the table below.

	COMPOUND	BOILING POINT (°C)
A	Propane	-42
B	Pentane	36
C	2-methylbutane	27,8
D	Pentan-1-ol	137

20.1 Define the term boiling point.
20.2 Which ONE of A or B has the higher vapour pressure?
20.3 An unknown STRAIGHT CHAIN ALKANE has a boiling point of -0,5 °C. Use the information in the table to identify this alkane and write down its IUPAC name.
20.4 **B** and **C** are structural isomers.
20.4.1 Define the term structural isomer.
20.4.2 Explain why **B** has a higher boiling point than **C**. Refer to structure, intermolecular forces and energy in your explanation.
20.5 Explain the difference in the boiling points of **B** and **D**. Refer to intermolecular forces and energy in your explanation.

QUESTION 21

The double column graph below shows the boiling points of the first four alkanes and the boiling points of the first four primary alcohols.



21.1 How do the boiling points of the four alcohols compare to that of the corresponding alkanes? Only write down HIGHER THAN, LOWER THAN or EQUAL TO.
21.2 Fully explain the answer to QUESTION 20.1. In your explanation refer to the type of intermolecular forces that are present in alkanes and alcohols, as well as the energy involved.
21.3 Write down the IUPAC name of the alcohol represented in the above graph, with the lowest boiling point.
21.4 Fully explain why the alcohol mentioned in QUESTION 20.3 has the lowest boiling point. In your explanation refer to molecular structure, intermolecular forces and energy involved.
21.5 Write down the IUPAC name of the alcohol, represented in the above graph, with the lowest vapour pressure.

QUESTION 22
A learner uses four alcohols (**A, B, C** and **D)** to investigate the EFFECT OF CHAIN LENGTH on BOILING POINT. The results obtained are shown in the table below.

Alcohol	Condensed structural formula	Boiling point (ºC)
A	$CH_3CH_2CH_2CH_2CH_2OH$	138
B	$CH_3CH_2CH_2OH$	96
C	CH_3CH_2OH	77
D	CH_3OH	64

22.1 Write down the name of the functional group of the alcohols.
22.2 For this investigation, write down the:
22.2.1 Dependent variable
22.2.2 Independent variable
22.3 Write down a conclusion that the learner can draw from the above results.
22.4 The boiling point of butan-1-ol is not shown in the above table. Write down an estimated value for the boiling point of butan-1-ol.
22.5 Write down the letter (**A, B, C** or **D**) representing the alcohol with the highest:
22.5.1 Vapour pressure at a given temperature
22.5.2 Viscosity at a given temperature
22.6 Which one of butane or butan-1-ol has the higher boiling point?
Explain your answer by referring to molecular structure, intermolecular forces and the energy involved.
22.7 Write down the IUPAC name of alcohol **C**.

QUESTION 23
Jana wants to investigate how molecular mass influences the boiling points of the first eight straight chain alcohols.

23.1 Which property of the alcohols could make this investigation dangerous?
23.2 Structural isomers can influence the outcome of this investigation. Alcohols with more than two carbon atoms have more than one structural isomer.
23.2.1 Write down the structural formulae and IUPAC names of the structural isomers of the alcohol containing three carbon atoms.
23.2.2 Jana uses heptan-1-ol as one of the compounds in the investigation. Which ONE of the isomers named in QUESTION 23.2.1 must she use for this to be a fair test?
23.2.3 Explain the need for this choice in QUESTION 23.2.2.
23.3 Design an investigation that Jana can conduct. Use the following headings in your design:
23.3.1 Hypothesis
23.3.2 Precautions
23.3.3 Apparatus
23.3.4 Method

QUESTION 24
The first six members of the alkanes occur as gases and liquids at normal temperatures. Alkanes are currently our most important fuels, but the use of alcohols as renewable energy source is becoming more and more important. Alcohols are liquids that might be a solution to the energy crisis.

24.1 Which chemical property of alkanes and alcohols make them suitable to be used as fuels?

24.2 The table shows the boiling points of the first six alkanes and the first six alcohols.

Alkane	Boiling point (°C)	Alcohol	Boiling point (°C)
methane	- 164	methanol	65
ethane	- 89	ethanol	79
propane	- 42	1-propanol	97
butane	- 0,5	1-butanol	117
pentane	36	1-pentanol	138
hexane	69	1-hexanol	156

Draw a graph of boiling points versus number of carbon atoms for the first six ALCOHOLS. Choose 50 °C and 1 carbon atom as origin and use an appropriate scale. Plot the points and draw the best curve through the points.

24.3 What trend in boiling point can be observed from the graph?

24.4 Provide a reason for the trend mentioned in QUESTION 24.3 by referring to the type of intermolecular forces.

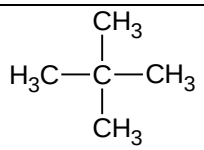
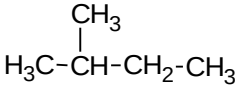
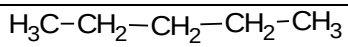
24.5 Explain, referring to the type of intermolecular forces, why the boiling points of alcohols are higher than the boiling points of alkanes.

24.6 People are always cautioned to keep liquids such as petrol (a mixture of alkanes) out of reach of children. Use the boiling points of alkanes and justify this precaution.

24.7 Briefly explain why ethanol is a renewable energy source, while the alkanes are non-renewable.

QUESTION 25

A learner uses three organic compounds, **A**, **B** and **C**, to investigate the EFFECT OF BRANCHING OF CARBON CHAINS ON BOILING POINT. The results obtained are shown in the table below.

Compound		Relative molecular mass	Boiling point (°C)
A		72	10
B		72	30
C		72	36

25.1 Write down the NAME of the homologous series to which compounds **A**, **B** and **C** belong.

25.2 Write down the IUPAC name of:

25.2.1 Compound **A**

25.2.2 Compound **C**

25.3 Formulate an investigative question for this investigation.

25.4 For this investigation, write down the:

25.4.1 Independent variable

25.4.2 Dependent variable

25.5 Apart from experimental conditions for determining boiling points, write down ONE variable that is controlled during this investigation.

25.6 Give a reason why the variable mentioned in QUESTION 25.5 must be controlled.

25.7 Write down a conclusion that the learner can draw from the results as shown in the table

25.8 Explain the trend in boiling points as shown in the table. Refer to molecular shape, intermolecular forces and the energy involved in the explanation.

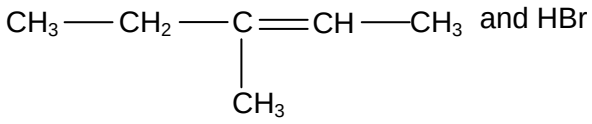
25.9 Which ONE of the compounds (**A**, **B** or **C**) has the highest vapour pressure at a given temperature?

STRUCTURED QUESTIONS: ORGANIC REACTIONS

QUESTION 26

26.1 Write down the structural formulae and IUPAC names for the product(s) formed when the following compounds react with each other:

26.1.1 cyclohexene and HCℓ

26.1.2  and HBr

26.2 The following equations represent chemical reactions:

Reaction 1: $A + HBr \rightarrow CH_3\text{-}CH_2\text{-}CH_2Br + H_2O$

Reaction 2: $CH_3\text{-}CH_2\text{-}CH_2Br \xrightarrow{NaOH}$ **A** + NaBr

26.2.1 Name the type of reaction in reaction **2**.

26.2.2 Write down the structural formula for the organic compound A.

26.3 Cracking is a process that is generally used in the oil industry.

26.3.1 What is meant by cracking?

26.3.2 Why is cracking used in the fuel industry?

26.3.3 Give a reason for the difference in the melting and boiling points of the following two compounds, produced from a specific cracking process:

COMPOUND	MELTING POINT (˚C)	BOILING POINT (˚C)
Butane	-138	-1
Heptane	-91	89

26.3.4 In which phase (gas, liquid or solid) is each of the following when used as a fuel:

(a) Butane

(b) Heptane

QUESTION 27

Alcohols are used in a variety of chemical reactions and as preservatives in certain medicines. All alcohols are toxic. Although **ethanol** is the least toxic of all alcohols, it is still a poisonous substance. It is rapidly absorbed into the blood. High blood alcohol levels can cause brain poisoning. The body can reduce high blood alcohol levels by oxidising the alcohol. Contrary to what people believe, alcohol is a depressant and not a stimulant.

The following table indicates the effects of various blood alcohol levels:

The effects of blood alcohol levels	
% per volume	**Effect**
0,005 – 0,15	Loss of coordination
0,15 – 0,20	Severe intoxication
0,20 – 0,40	Loss of consciousness
0,50	Death

The liver enzyme, ADH, catalyses the oxidation of ethanol to ethanol and then to non-toxic ethanoic acid. The liver is able to remove only 28 grams of pure alcohol per hour.

27.1 Write down the NAMES of the homologous series to which the compounds ethanal and ethanoic acid respectively belong.

27.2 Write down the structural formula of ethanal.

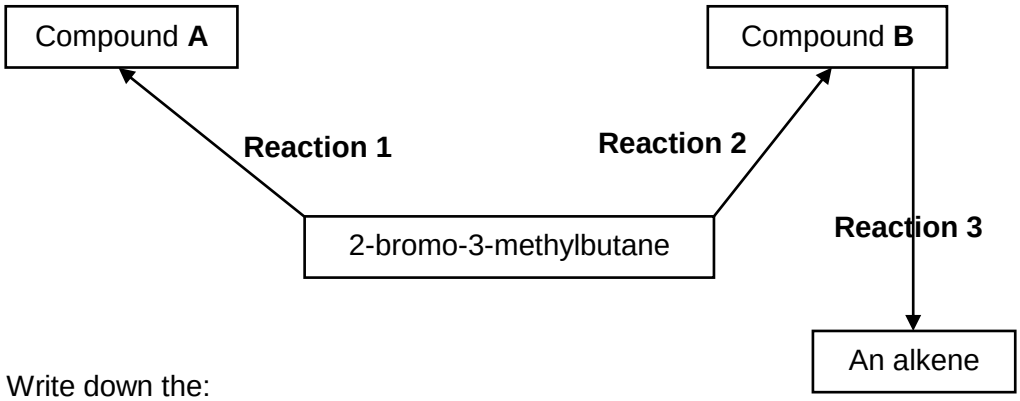
27.3 Alcohols are prepared by the hydration of alkenes. Use structural formulae to write down the equation which represents the formation of ethanol.

27.4 The warning on the labels of certain medicines reads as follows:
The effect of this medicine is aggravated by the simultaneous intake of alcohol.

Use the information in the passage above to justify this warning.

QUESTION 28

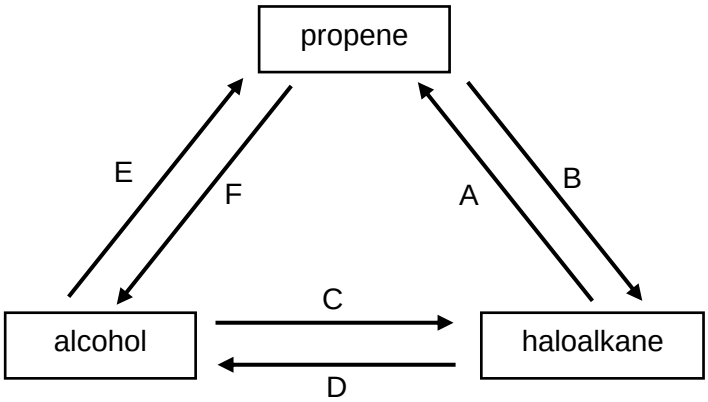
The flow diagram below shows how three organic compounds can be prepared from 2-bromo-3-methylbutane.



28.1 Write down the:
28.1.1 Homologous series to which 2-bromo-3-methylbutane belongs
28.1.2 Structural formula of 2-bromo-3-methylbutane
28.2 Reaction 2 takes place in the presence of a dilute sodium hydroxide solution.
Write down the:
28.2.1 Name of the type of reaction which takes place
28.2.2 Structural formula of compound **B**
28.3 Reaction 1 takes place in the presence of concentrated sodium hydroxide.
Write down:
28.3.1 Another reaction condition needed for this reaction
28.3.2 The name of the type of reaction which takes place
28.3.3 The structural formula of compound A, the major product formed
28.4 Reaction 3 takes place when compound B is heated in the presence of concentrated sulphuric acid. Write down the IUPAC name of the major product formed.

QUESTION 29

The flow diagram below shows the interconversion between alcohols, alkenes and haloalkanes. The letters **A** - **F** represent addition or substitution or elimination reactions.



29.1 What type of reaction is represented by **F**? Choose from ADDITION or SUBSTITUTION or ELIMINATION.
29.2 Use structural formulae and write a balanced equation for reaction **F** to show the formation of the major product.
29.3 Reaction **E** is sometimes referred to as a dehydration. Write down the FORMULA of the substance eliminated during dehydration.
29.4 Letter **C** represents the reaction of the alcohol with NaBr(aq) in the presence of sulphuric acid as catalyst.
29.4.1 Write down the structural formulae for the organic product of this reaction.

29.4.2 What type of reaction is represented by **C**? Choose from ADDITION or SUBSTITUTION or ELIMINATION.
29.5 The haloalkane can be converted to the alcohol via reaction **D**, or to propene via reaction **A**.
29.5.1 What type of reaction is represented by **A**? Choose from ADDITION or SUBSTITUTION or ELIMINATION.
29.5.2 What type of reaction is represented by **D**? Choose from ADDITION or SUBSTITUTION or ELIMINATION.
29.5.3 Under what conditions will reaction **A** take place?

QUESTION 30
Prop-1-ene is a flammable alkene.

30.1.1 Why is prop-1-ene considered to be a dangerous compound?)

Through addition reactions, prop-1-ene can be converted to other compounds, such as alkanes and alcohols.

30.2 Which part of the structure of an alkene allows it to undergo addition reactions?
30.3 In one type of addition reaction, prop-1-ene can be converted to an alcohol.
30.3.1 Use structural formulae to write a balanced equation for the formation of the alcohol during this addition reaction.
30.3.2 Name the type of addition reaction that takes place.
30.3.3 Write down the name or formula of the catalyst used in this reaction.
30.4 Use molecular formulae to write down a balanced chemical equation for the complete combustion of propane.

Prop-1-ene can be produced from an alcohol by an elimination reaction.
30.5 Use structural formulae to write a balanced chemical equation for the formation of prop-1-ene from a PRIMARY alcohol.

30.6 Name the type of elimination reaction that takes place.

QUESTION 31
A science educator finds a bottle containing an organic liquid in the laboratory. The label on the bottle is partially erased. From what is visible on the label, the educator concluded that the liquid must be either cyclohexane or cyclohexene.

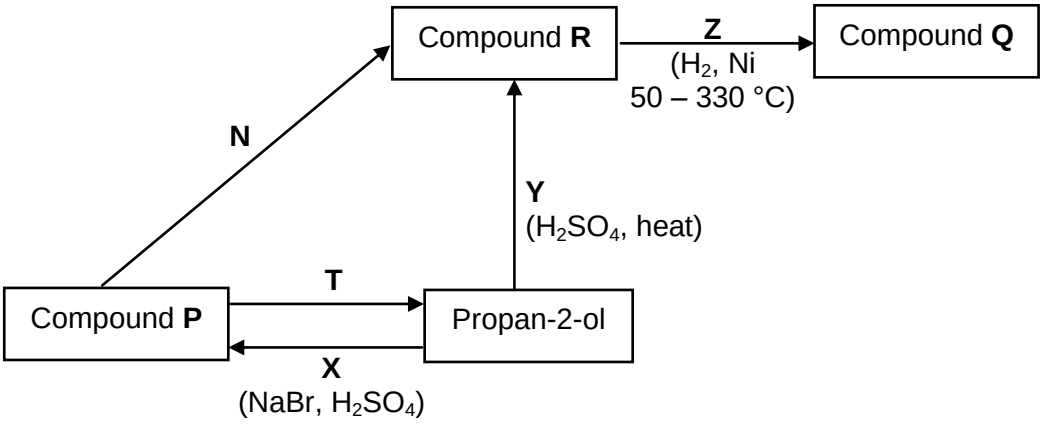
In order to identify the liquid, the educator performed an investigation. From the investigation the educator concluded that the liquid is unsaturated.

31.1 Identify the compound in the bottle.
31.2 Design an investigation that the educator could have performed to come to the above conclusion.
31.3 Use the following steps as guidelines in your design:
31.3.1 Apparatus needed
31.3.2 Chemicals needed
31.3.3 Method describing steps to be followed
31.4 What will be observed and how the results can be used to draw a conclusion
31.5 Draw the structural formula for cyclohexane.

QUESTION 32

Alcohols are very versatile compounds with a variety of uses. Hot and tired after a long day you can refresh yourself with a propan-2-ol massage. Some people will prefer to relax with a cool ethanol drink!

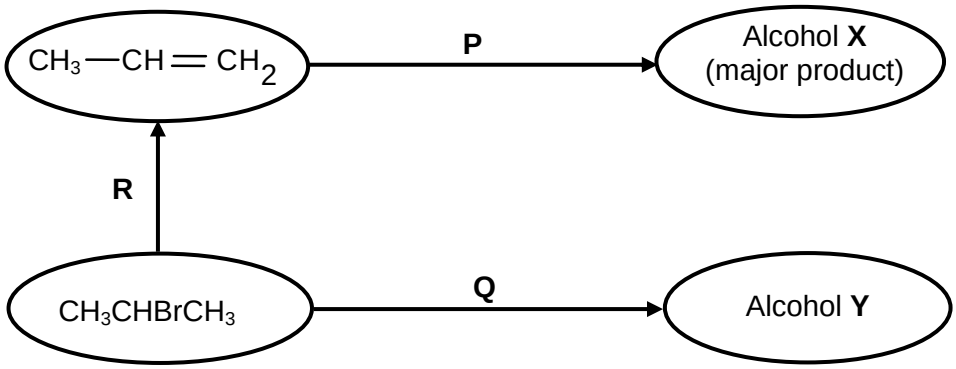
Apart from their uses, alcohols can be used to make several other kinds of organic compounds. The flow diagram below shows how propan-2-ol can be used as reagent for the preparation of three different compounds, **P, Q** and **R**.



32.1 Write down the structural formula for propan-2-ol.
32.2 Which one of propan-2-ol or propan-1-ol will have the higher vapour pressure? Refer to intermolecular forces to explain your answer.
32.3 Name the type of elimination reaction represented by **Y**.
32.4 Write down the structural formula and IUPAC name of compound **R**.
32.5 Compound **P** is prepared by the reaction of propan-2-ol with NaBr and H_2SO_4.
32.5.1 Write down the structural formula for compound **P**.
32.5.2 To which homologous series does compound **P** belong?
32.6 **T** represents the conversion of compound **P** into propan-2-ol. Briefly describe the reaction conditions needed for this conversion.
32.7 **N** represents an elimination reaction.
32.7.1 Name the type of elimination reaction represented by **N**.
32.7.2 Use condensed structural formulae to write a balanced equation for reaction **N**.
32.8 What type of reaction is represented by **Z**?
32.9 Use structural formulae to write a balanced equation for reaction **Z**.

QUESTION 33

In the flow diagram below **R**, **P** and **Q** represent different types of reactions.



33.1 Name the type of reaction represented by:
33.1.1 **P** 31.1.2 **Q** 31.1.3 **R**
33.2 Using structural formulae, write down a balanced equation for reaction **P**.
33.3 Write down the IUPAC name of alcohol **Y**.

33.4 Reaction **Q** takes place in the presence of a BASE. Write down TWO reaction conditions for this reaction.

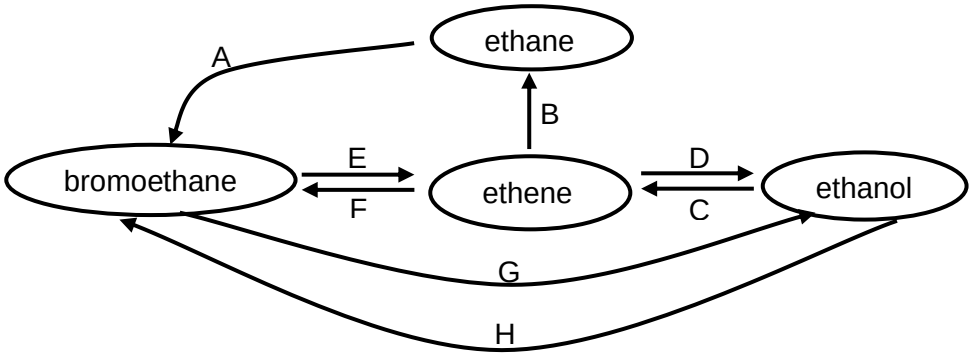
QUESTION 34

Ethene is a gaseous hormone associated with the ripening of fruit. It also contributes to the ageing and distortion of plants. In industry, the artificial ripening of fruit takes place when ethene is passed over the fruit in large rooms. After a while the ripening fruit releases its own ethene.

34.1 Write down the structural formula of ethene.

34.2 Why is it not advisable to place a banana that has been artificially ripened alongside a cabbage and lettuce?

34.3 In industry ethene is also used to synthesise a variety of organic compounds. The flow diagram below illustrates some of the many reactions ethene undergoes.



34.3.1 Write down the general formula for the homologous series to which ethene belongs.

34.3.2 Name the type of reaction represented by each of the letters **A**, **B**, **D** and **H**. Write down the letters **A**, **B**, **D** and **H** and next to each the type of reaction.

34.3.3 Use structural formulae to write down a balanced equation for reaction **B**.

34.3.4 Apart from ethene, which other reactant is needed for reaction **F**? Write down the FORMULA only.

34.3.5 Both reactions **E** and **G** occur in the presence of a base. Reaction E is an elimination reaction and reaction **G** is a substitution reaction.

(a) How is the base in reaction **E** different from the base in reaction **G**?

(b) Name the type of elimination reaction represented by **E**.

QUESTION 35

Petrol is a complex mixture of hydrocarbons such as hexane. Compounds such as 2,2,4-trimethylpentane are added to petrol to change its combustion properties.

35.1 Explain the term *hydrocarbon.*

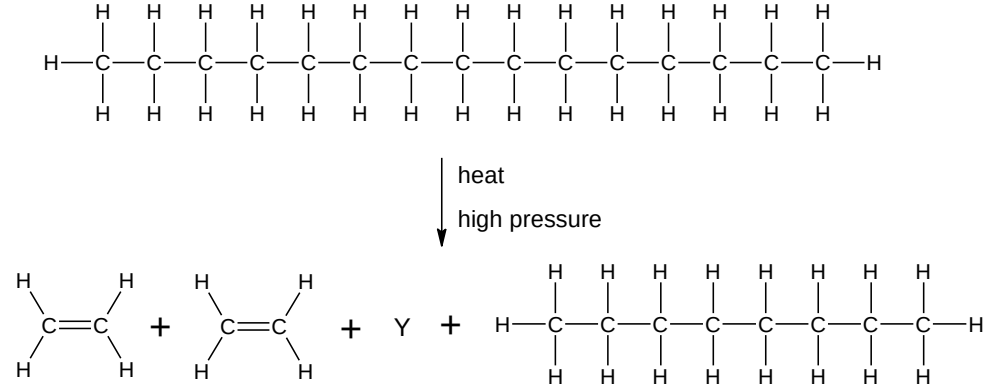
35.2 Complete the following equation that represents the complete combustion of hexane in a car engine. (Balancing of the equation is not required.)

$C_6H_{14} + O_2 \rightarrow ... + ...$

35.3 Write down the structural formula for 2,2,4-trimethylpentane.

35.4 Petrol requires alkanes in the range from C_5 to C_{10}. Cracking is the process that is used to convert longer chains into shorter chains.

The diagram below illustrates one of the possible cracking reactions of $C_{15}H_{32}$.



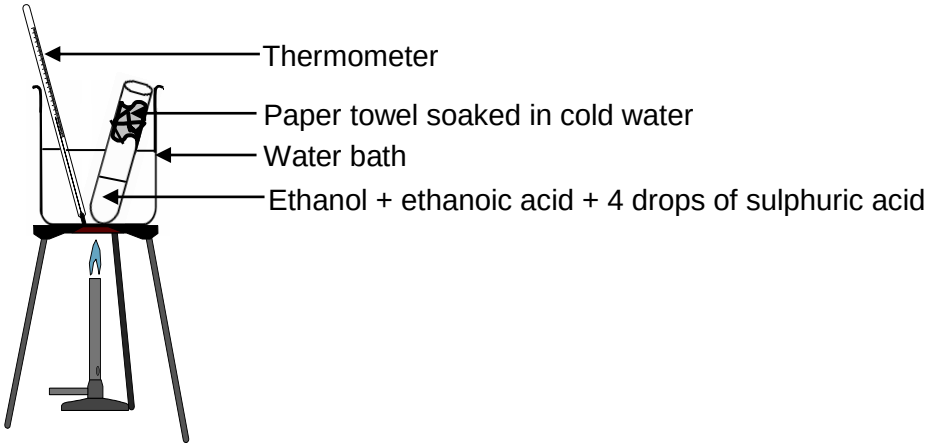
Write down the STRUCTURAL FORMULA and IUPAC NAME for the hydrocarbon represented by **Y**.

QUESTION 36

Many of the flavours and odours of fruits are esters. Ethyl ethanoate is the most common ester found in wines and contributes to the perception of the fruitiness of wine.

A learner wants to prepare ethyl ethanoate in the school laboratory. She follows the instructions below.

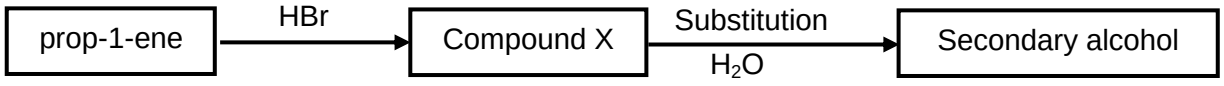
- Mix 1 cm^3 ethanoic acid and 1 cm^3 ethanol thoroughly in a test tube.
- Slowly add 4 drops of concentrated sulphuric acid while swirling the test tube.
- Soak a paper towel in cold water and fasten it around the test tube close to its mouth with an elastic band.
- Place the test tube in a water bath and heat the water with a flame to a temperature of about 60 °C.
- Leave the test tube in the hot water bath for about 15 minutes.
- Cool the test tube by placing it in a beaker of cold water.
- Smell the vapour in the test tube after 10 minutes.



36.1 To which homologous series does ethanol belong?
36.2 Use structural formulae to write a balanced equation for the reaction taking place in the test tube.
36.3 What is the function of the sulphuric acid in the above reaction?
36.4 Why does the method use a water bath instead of direct heating over an open flame?
36.5 State ONE function of the wet paper towel at the top of the test tube.
36.6 The learner finds it difficult to detect the smell of the ester due to the presence of sulphuric acid and unreacted ethanoic acid. A friend suggests that she must add 10 drops of a diluted sodium carbonate solution to the contents of the test tube. Briefly explain why this suggestion might be a solution to the problem.
36.7 Whilst several esters may be present in wine, the observed aroma is generally that of the smallest ester present in wine, namely ethyl ethanoate. State a physical property of ethyl ethanoate which is responsible for this.

QUESTION 37

The flow diagram below shows the conversion of prop-1-ene to a secondary alcohol.

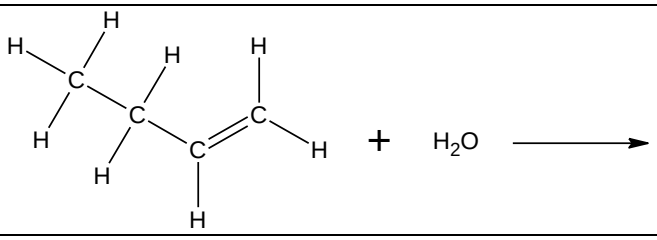
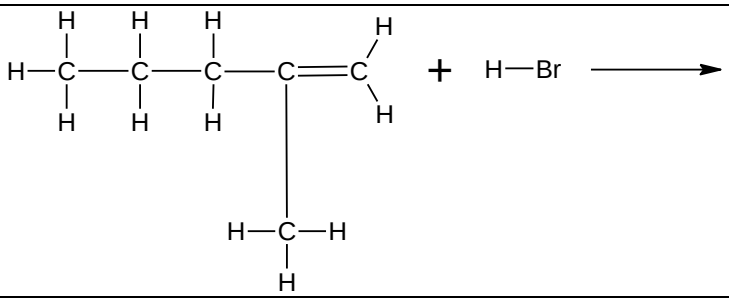
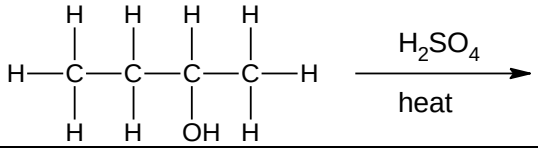


37.1 Give a reason why prop-1-ene is classified as an unsaturated organic compound.
37.2 Use structural formulae to write a balanced equation for the formation of compound **X**.
37.3 Name the type of reaction that takes place when prop-1-ene is converted to compound **X**.
37.4 Write down the structural formula and IUPAC name for the secondary alcohol that is formed.

37.5 Name the type of substitution reaction that takes place when compound **X** is converted to the secondary alcohol.
37.6 With the aid of a catalyst, prop-1-ene can be converted directly to the secondary alcohol, without the formation of the intermediate compound **X**.
37.6.1 Besides prop-1-ene, write down the NAME of the reactant needed for this direct conversion.
37.6.2 Write down the FORMULA of a catalyst that can be used.
37.6.3 Name the type of reaction that will take place during this direct conversion.
37.7 Instead of adding water to compound **X**, concentrated sodium hydroxide, in ethanol as solvent, is added and the mixture is heated.
37.7.1 Write down the IUPAC name of the organic product that is formed.
37.7.2 Name the type of reaction that takes place.

QUESTION 38

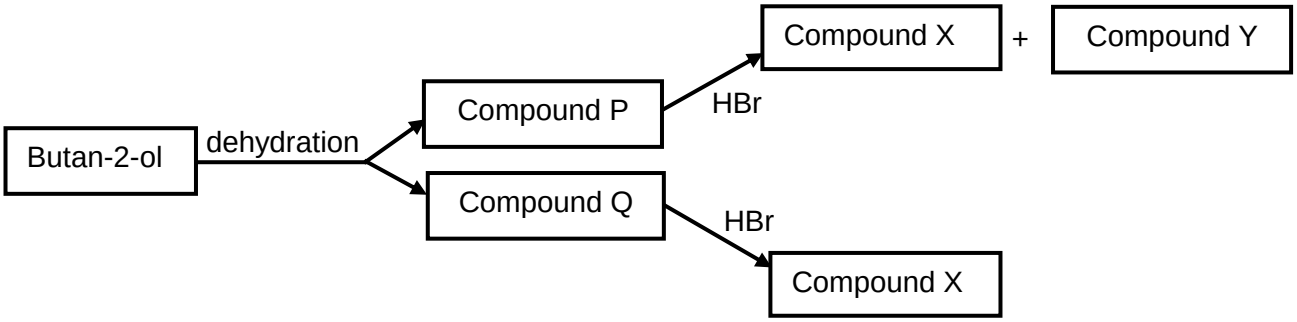
Most organic compounds can undergo substitution or addition or elimination reactions to produce a variety of organic compounds. Some incomplete organic reactions are represented below.

I	
II	
III	

38.1 Name the type of reaction represented by reaction III.
38.2 Both reactions I and II are examples of addition reactions. Name the type of addition that is represented by each reaction.
38.3 Write down the structural formula and IUPAC name of the major product formed in reaction I.
38.4 Reaction I only takes place in the presence of a catalyst. Write down the formula of the catalyst used in reaction I.
38.5 Write down the structural formula and IUPAC name of the major product formed in reaction II.
38.6 To which homologous series does the organic product formed in reaction III belong?

QUESTION 39

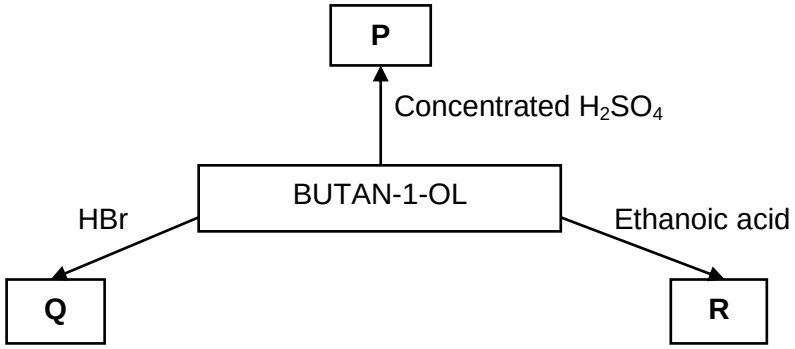
The flow diagram below shows the conversion of an alcohol into haloalkanes.



39.1 Name the type of organic reaction of which dehydration is an example.
39.2 To which homologous series do compounds **P** and **Q** belong?
39.3 What type of reaction takes place when compound P is converted to compounds **X** and **Y** as illustrated above?
39.4 Use structural formulae to write a balanced equation for the preparation of compound **Q** as illustrated above.
39.5 Which compound, **P** or **Q**, will be the major product? Give a reason for your answer.
39.6 Write down the structural formula and the IUPAC name for compound **X**.
39.7 A learner indicates that he can convert butan-2-ol directly into compound **X**. Name the type of reaction that will take place during a direct conversion.

QUESTION 40

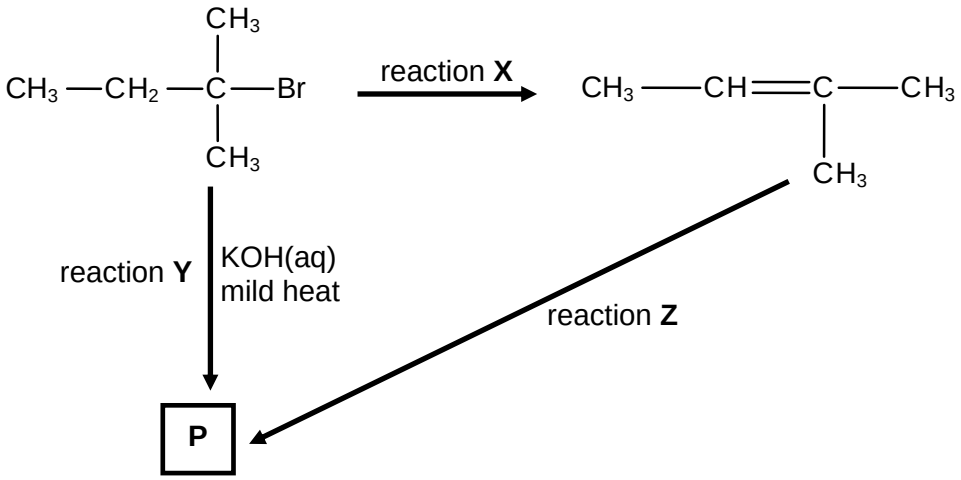
Some of the reactions of BUTAN-1-OL are represented in the flow diagram below. **P**, **Q** and **R** represent the organic products formed.



40.1 Is butan-1-ol a PRIMARY, SECONDARY or TERTIARY alcohol?
40.2 Product **P** is formed when butan-1-ol is heated in the presence of concentrated sulphuric acid. Write down the:
40.2.1 Name of the type of reaction that takes place
40.2.2 Balanced equation for the reaction that takes place using structural formulae
40.3 Product **R** is formed when butan-1-ol reacts with ethanoic acid in the presence of an acid catalyst. Write down the:
40.3.1 Name of the type of reaction that takes place
40.3.2 Structural formula of the organic product formed
40.4 When HBr reacts with butan-1-ol, compound **Q**, a haloalkane, is formed. Write down the:
40.4.1 Name of the type of reaction that takes place
40.4.2 IUPAC name of the haloalkane formed

QUESTION 41

The flow diagram below, **X**, **Y** and **Z** represent three different types of organic reactions. **P** represents an organic compound.



41.1

41.1.1 Name the type of reaction represented by **X**.

41.1.2 State TWO reaction conditions needed for reaction **X**.

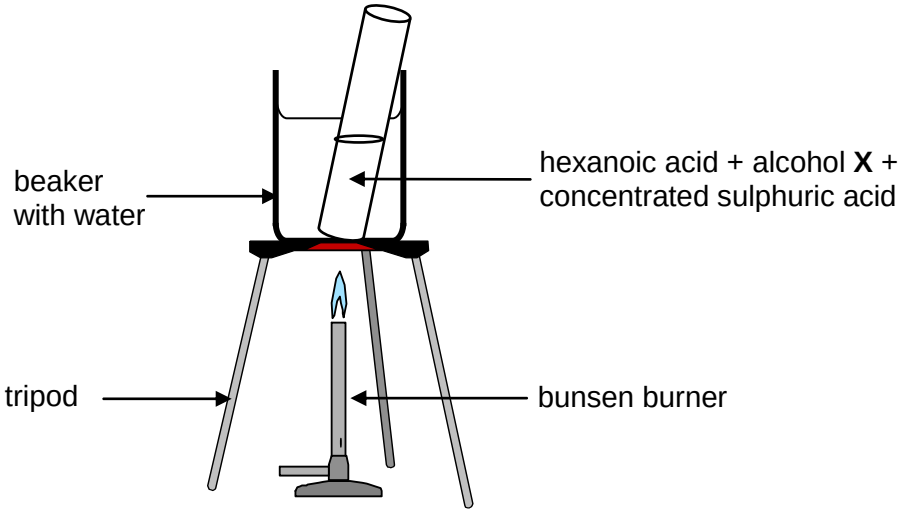
41.1.3 Reaction **Y** represents a substitution reaction. Write down the structural formula of compound **P** formed in this reaction.

41.1.4 Apart from the organic reactant, write down the NAME or FORMULA of the other reactant needed in reaction **Z**.

41.1.5 Name the type of reaction represented by **Z**.

41.2 Hexanoic acid is responsible for the unique odour associated with goats. When it reacts with alcohol **X**, ethyl hexanoate, which is used commercially as a fruit flavour, is formed.

Learners set up the apparatus shown below to prepare ethyl hexanoate in a laboratory.



41.2.1 Write down the IUPAC name of alcohol **X**.

41.2.2 What is the role of the sulphuric acid in the above reaction?

41.2.3 Use structural formulae to write down a balanced equation for the preparation of ethyl hexanoate.

41.2.4 Give a reason why the test tube and its contents are heated in a water bath and not directly over the flame.

41.2.5 Write down ONE use of esters in the food manufacturing industry.

QUESTION 42

Prop-1-ene, an UNSATURATED hydrocarbon, and compound **X**, a SATURATED hydrocarbon, react with chlorine, as represented by the incomplete equations below.

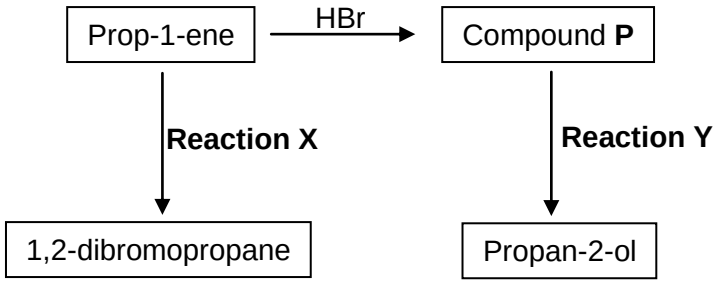
Reaction **I**: Prop-1-ene + $C\ell_2$ →

Reaction **II**: **X** + $C\ell_2$ → 2-chlorobutane + **Y**

42.1.1 Give a reason why prop-1-ene is classified as unsaturated.
42.1.2 What type of reaction (ADDITION or SUBSTITUTION) takes place in the following:
(a) Reaction **I** (b) Reaction **II**
42.1.3 Write down the structural formula of the product formed in Reaction **I**.
42.1.4 Write down the reaction condition necessary for Reaction **II** to take place.
42.1.5 Write down the IUPAC name of reactant **X**.
42.1.6 Write down the name or formula of product **Y**.
42.2 2-chlorobutane can either undergo ELIMINATION or SUBSTITUTION in the presence of a strong base such as sodium hydroxide.
42.2.1 Which reaction will preferably take place when 2-chlorobutane is heated in the presence of CONCENTRATED sodium hydroxide in ethanol? Write down only SUBSTITUTION or ELIMINATION.
42.2.2 Write down the IUPAC name of the major organic compound formed in QUESTION 42.2.1.
42.2.3 Use structural formulae to write down a balanced equation for the reaction that takes place when 2-chlorobutane reacts with a DILUTE sodium hydroxide solution.
42.2.4 Write down the name of the type of substitution reaction that takes place in QUESTION 42.2.3.
42.3 Haloalkanes are used in insecticides (insect killers).
42.3.1 Write down ONE POSITIVE impact of insecticides on human development.
42.3.2 Write down ONE NEGATIVE impact of insecticides on humans.

QUESTION 43

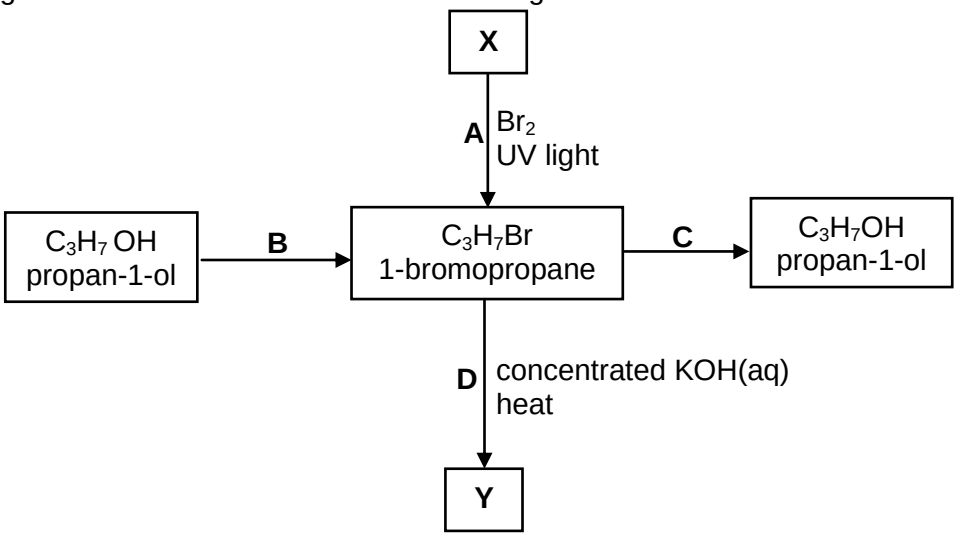
The flow diagram below illustrates how different organic compounds can be prepared from prop-1-ene.



43.1 Reaction **X** represents the conversion of prop-1-ene to 1,2-dibromopropane.
Write down:
43.1.1 The homologous series to which 1,2-dibromopropane belongs
43.1.2 The balanced equation for reaction **X**, using structural formulae
43.1.3 The type of reaction represented by **X**
Choose from ELIMINATION, ADDITION or SUBSTITUTION.
43.2 Write down the structural formula of compound **P**, the major product formed when prop-1-ene reacts with HBr.
43.3 Compound **P** is converted to propan-2-ol during reaction **Y** in the presence of a strong base.
43.3.1 Write down TWO reaction conditions needed for reaction **Y** to take place.
43.3.2 Classify propan-2-ol as a PRIMARY, SECONDARY or TERTIARY alcohol.
43.3.3 Write down the type of substitution reaction of which reaction **Y** is an example.
43.4 Propan-2-ol can be converted to prop-1-ene.
43.4.1 Write down the NAME or FORMULA of a reactant that can be used for this reaction.
43.4.2 What type of reaction takes place? Choose from HYDRATION, DEHYDRATION or HYDROLYSIS.

QUESTION 44

Some organic reactions are shown in the flow diagram below.



44.1 Name the type of reactions illustrated by **A**, **B**, **C** and **D**.

44.2 Use condensed structural formulae and write a balanced equation for reaction **C**.

44.3 Write down the structural formula for compound **X**.

44.4 In order to obtain product **Y**, C_3H_7Br is heated with a concentrated solution of KOH under reflux. Use condensed structural formulae to write a balanced equation for the reaction.

44.5 A group of learners decided to heat C_3H_7Br with dilute sodium hydroxide, instead of the concentrated potassium hydroxide, under reflux. Write down the IUPAC name of the organic compound that they will obtain.