PHYSICAL SCIENCES

MATERIAL FOR GRADE 12

FIRST TERM

ORGANIC CHEMISTRY

QUESTIONS

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➢ TERMS AND DEFINITIONS

❖ MATTER AND MATERIALS: ORGANIC MOLECULES

Addition reaction: A reaction in which a double bond in the starting material is broken and elements are added to it.

Addition polymer: A polymer formed when monomers (usually containing a double bond) combine through an addition reaction.

Addition polymerisation: A reaction in which small molecules join to form very large molecules by adding on double bonds.

Alcohol: An organic compound in which H atoms in an alkane have been substituted with hydroxyl groups (-OH groups).

General formula: $C_nH_{2n+1}OH$

Aldehydes: Organic compounds having the general structure RCHO where R = H or alkyl.

General formula: RCHO (R = alkyl group)

Alkane: An organic compound containing only C-H and C-C single bonds.

General formula: C_nH_{2n+2}

Alkene: A compound of carbon and hydrogen that contains a carbon-carbon double bond. General formula: C_nH_{2n}

Alkyl group: A group formed by removing one H atom from an alkane.

Alkyne: A compound of carbon and hydrogen that contains a carbon-carbon triple bond.

Boiling point: The temperature at which the vapour pressure of a liquid equals atmospheric pressure.

Carbonyl group: Functional group of ketones (> C = O)

Carboxyl group: Functional group of carboxylic acids (-COOH)

Carboxylic acid: An organic compound containing a carboxyl group (-COOH group).

General formula: $C_nH_{2n+1}COOH$ (or RCOOH)

Chain isomers: Compounds with the same molecular formula, but different types of chains.

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

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Condensation polymerisation: Molecules of two monomers with different functional groups undergo condensation reactions with the loss of small molecules, usually water

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

Cracking: The chemical process in which longer chain hydrocarbon molecules are broken down to shorter more useful molecules.

Dehydration: Elimination of water from a compound usually such as an alcohol.

Dehydrohalogenation: The elimination of hydrogen and a halogen from a haloalkane.

Dipole-dipole force: Intermolecular forces found between polar molecules i.e. molecules in which there is an uneven distribution of charge so that the molecule has a positive and a negative side.

Elimination reaction: A reaction in which elements of the starting material are "lost" and a double bond is formed.

Esterification: The preparation of an ester from the reaction of a carboxylic acid with an alcohol.

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

Functional isomers: Compounds with the same molecular formula, but different functional groups.

Haloalkane (Alkyl halide): An organic compound in which one or more H atoms in an alkane have been replaced with halogen atoms.

General formula: $C_nH_{2\,n+1}X$ (X = F, Cℓ, Br or I)

Halogenation: The reaction of a halogen (Br2, Cℓ2) with a compound.

Homologous series: A series of organic compounds that can be described by the same general formula.

OR A series of organic compounds in which one member differs from the next with a CH_2 group.

Hydration: The addition of water to a compound.

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

Hydrogenation: The addition of hydrogen to an alkene

Hydrogen bond: A strong intermolecular force found between molecules in which an H atom is covalently bonded to wither an N, O or F atom.

Hydrohalogenation: The addition of a hydrogen halide to an alkene.

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Hydrolysis: The reaction of a compound with water.

Intermolecular force: Forces between molecules that determine physical properties of compounds.

IUPAC name: A chemical nomenclature (set of rules) created and developed by the International Union of Pure and Applied Chemistry (IUPAC) to generate systematic names for chemical compounds.

London force: A weak intermolecular force between non-polar molecules.

Macromolecule: A molecule that consists of a large number of atoms.

Melting point: The temperature at which the solid and liquid phases of a substance are at equilibrium.

Molecular formula: A chemical formula that indicates the type of atoms and the correct number of each in a molecule, e.g. CH4.

Monomer: Small organic molecules that can be covalently bonded to each other in a repeating pattern.

Organic chemistry: Chemistry of carbon compounds.

Polymer: A large molecule composed of smaller monomer units covalently bonded to each other in a repeating pattern

Polymerisation: A chemical reaction in which monomer molecules join to form a polymer

Positional isomer: Compounds with the same molecular formula, but different positions of the side chain, substituents or functional groups on the parent chain.

Primary alcohol: One C atom is bonded to the C atom bonded to hydroxyl group.

Primary haloalkane: One C atom is bonded to the C atom bonded to the halogen.

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

Secondary alcohol: Two C atoms bonded to the C atom that is bonded to hydroxyl group.

Secondary haloalkane: Two C atoms bonded to the C atom bonded to the halogen.

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

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

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Substituent (branch): A group or branch attached to the longest continuous chain of C atoms in an organic compound.

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.

Tertiary alcohol: Three C atoms bonded to carbon that is bonded to hydroxyl group.

Tertiary haloalkane: Three C atoms bonded to the C atom bonded to the halogen.

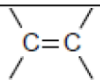
Unsaturated compounds: Compounds in which there are multiple bonds (double or triple bonds) between C atoms in their hydrocarbon chains.

Van der Waals forces: A combined name used for the different types of intermolecular forces.

Vapour pressure: The pressure exerted by a vapour at equilibrium with its liquid in a closed system.

➢ ORGANIC FUNCTIONAL GROUPS

Organic Functional Group List

Functional Group	Compound	Prefix/Suffix	Example	IUPAC Name (Common Name)
R-H	alkane	-ane	CH_3CH_3	ethane
	alkene	-ene	$H_2C{=}CH_2$	ethene (ethylene)
—C≡C—	alkyne	-yne	HC≡CH	ethyne (acetylene)
R-X	haloalkane	halo-	CH_3Cl	chloromethane
R-OH	alcohol	-ol (hydroxy-)	CH_3OH	methanol

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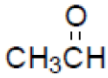
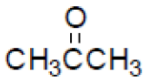
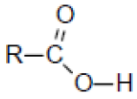
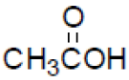
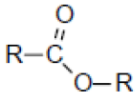
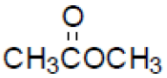
R-O-R	ether	ether (alkoxy-)	CH_3OCH_3	dimethyl ether
	aldehyde	-al		ethanal (acetaldeyde)
	ketone	-one		propanone (acetone)
	carboxylic acid	-oic acid		ethanoic acid (acetic acid)
	ester	-oate		methyl ethanoate (methyl acetate)

➢ ORGANIC CHEMISTRY- NOMENCLATURE

❖ Drawing of structural formulae of organic compounds

- ✓ All bonds must be shown as short vertical or horizontal line. No part of the structure should be condensed because the bonds between t shown.
- ✓ Even the bond between O and H must be shown i.e. -O-H not –OH.
- ✓ All H atoms should be shown around C atoms. Marks are deducted if only bonds shown and not the H atoms.

❖ Writing of IUPAC names of organic compounds

- ✓ Hyphens are used between a word and a number e.g 2-methylbutane.
- ✓ Commas are used between numbers e.g. 2,3-dimethylbutane.
- ✓ Marks are deducted if hyphens and / or commas are omitted.
- ✓ Hyphens should NOT be used between words.
- ✓ All IUPAC names are written as one word, except esters and carboxylic acids.

Examples:

Propanoic acid (two words)

Ethyl propanoate (two words)

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➢ IUPAC NAMING AND FORMULAE

- ✓ Write down the IUPAC name when given the structural formula or condensed structural formula for compounds from the homologous series above, restricted to one functional group per compound, except for haloalkanes. For haloalkanes, maximum two functional groups per molecule.
- ✓ Write down the structural formula when given the IUPAC name for the above homologous series.

➢ ORGANIC CHEMISTRY- PROPERTIES

- ✓ Specify the type of van der Waals force and relate them with Boiling Point , Melting Point and Vapour pressure .
- ✓ Describe the trend in the boiling points / Melting Point and Vapour pressure of the compounds.
- ✓ Give an explanation for the trend. In your explanation make reference to INTERMOLECULAR FORCES and the ENERGY needed.

- ✓ **THE BOILING POINT INCREASES:**
  - ❖ As the molecular mass/size of the molecule increases.
  - ❖ As the Carbon chain/ surface area increases
  - ❖ The strength of the London/dipole-dipole forces increases.
  - ❖ Hence more energy is needed to overcome the Intermolecular forces
  - ❖ Thus the boiling points/ Melting points increase but Vapour pressure.

❖ STRONG VS WEAK INTERMOLECULAR FORCES

➢ NON – POLAR MOLECULES

- ✓ Weak Van Der Waals
- ✓ London / dispersion / induced dipole
- ✓ Weak forces: less energy needed to break bonds
- ✓ Lower boiling point/melting point
- ✓ High vapour pressure

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➢ POLAR MOLECULES

- ✓ Strong Van Der Waals
- ✓ Dipole-dipole force
- ✓ More energy needed to break bonds
- ✓ High boiling point/melting point
- ✓ Lower vapour pressure

➢ ALCOHOL

- ✓ Strong hydrogen bond
- ✓ More energy needed to break bonds.
- ✓ High boiling point/melting point
- ✓ Lower vapour pressure
- ✓ Has one site of hydroxyl group.

➢ CARBOXYLIC ACIDS

- ✓ Strong hydrogen bond
- ✓ More energy needed to break bonds
- ✓ High boiling point/melting point
- ✓ Lower vapour pressure.
- ✓ Two site of hydroxyl group

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VAN DER WAALS FORCES		**HYDROGEN BONDS**
➢ **London forces**	➢ **Dipole-dipole**	
✓ very weak ✓ found between non-polar molecules	✓ slightly stronger than London forces ✓ found between slightly polar molecules	✓ strongest intermolecular force ✓ found in strongly polar molecules
EXAMPLES		
Alkanes	Aldehydes	Alcohols
Alkenes	Ketones	Carboxylic acids
Alkynes	Esters	
	Alkyl halides	

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WHEN ANSWERING A QUESTION RELATING TO INTERMOLECULAR FORCES, THE LEARNER MUST:

- ✓ Mention and specify the type of intermolecular force.
- ✓ Mention the amount of energy required to break the intermolecular forces.
- ✓ Mention the structure of the molecule.

➢ NUMBER OF FUNCTIONAL GROUPS

An increase in functional groups increase the IMF:

- ✓ Increasing IMF
- ✓ More energy required to overcome the bonds

➢ CHAIN LENGTH: MOLECULAR MASS

The greater the number of carbon atoms in the chain, the greater the molecular mass. An increase in molecular mass increases the IMF:

- ✓ Increasing IMF
- ✓ More energy required to overcome the bonds

➢ CHAIN LENGTH: BRANCHES

More branching results in a smaller surface area and lower the strength of the IMF:

- ✓ Decreasing IMF
- ✓ Less energy required to overcome the bonds

➢ ORGANIC REACTIONS

A. ADDITION REACTIONS (UNSATURATED → SATURATED)

- ✓ Addition reactions are reactions where atoms are added to an organic molecule.
- ✓ The double or triple bonds break open and the new atoms are added to the carbon atoms on either side of the double or triple bond

1. Hydrogenation – add H_2

Hydrogen + Alkene / Alkyne → Alkane

Reaction conditions: The alkene needs to be dissolved in a non-polar solvent and needs to have a catalyst present eg. Pt, Ni or Pd

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2. **Halogenation – add X (X = Halogen: F_2, Cl_2, Br_2, I_2)**

Halogen + Alkene / Alkyne → Haloalkane

Reaction conditions: No water to be present if it is to take place

3. **Hydrohalogenation – add HX (X = Halogen: F_2, Cl_2, Br_2, I_2)**

Hydrogen Halide + Alkene / Alkyne → Haloalkane

Reaction conditions: No water to be present if it is to take place.

Markovnikov's rule: The H atom will bond to the carbon atom which has the greater number of H atoms bonded to it. (Form biggest H groups)

4. **Hydration – add of H_2O**

Water (H_2O) + Alkene / Alkyne → Alcohol

Reaction conditions: Strong but dilute acid catalyst e.g. H_2SO_4 or H_3PO_4. Heat in the form of steam (H_2O) reactant.

Markovnikov's rule: The H atom will bond to the carbon atom which has the greater number of H atoms bonded to it. (Form biggest H groups)

B. ELIMINATION REACTIONS (SATURATED → UNSATURATED)

- ✓ An elimination reaction is a reaction where atoms or groups of atoms are removed from an organic molecule to form either a double or triple bonded compound.

1. **Dehydrogenation – remove H_2**

Alkane → Alkene + Hydrogen

Reaction conditions: The alkane needs to be in the presence of a catalyst eg. Pt, Ni or Pd

2. **Dehalogenation – remove X (X = Halogen: F_2, Cl_2, Br_2, I_2)**

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Haloalkane → Alkene + Halogen

Reaction conditions: Takes place in an unreactive solvent

3. Dehydrohalogenation – remove HX (X = Halogen: F_2, Cl_2, Br_2, I_2)

Haloalkane → Hydrogen halide + Alkene

Reaction conditions: Takes place in the presence of concentrated NaOH / KOH in ethanol as the solvent. Heat

Zaitzev's rule: H atom is removed from the carbon atom with the least number of H atoms.

(Keeps biggest H groups)

4. Dehydration – remove H_2O

Alcohol → Water (H_2O) + Alkene

Reaction conditions: Requires the heating of an alcohol with concentrated acid catalyst eg. H_2SO_4 or H_3PO_4. The acid should be in excess. Sulphuric acid is known as a dehydrating agent.

Zaitzev's rule: H atom is removed from the carbon atom with the least number of H atoms.

(Keeps biggest H groups)

C. SUBSTITUTION REACTIONS (SATURATED → SATURATED)

- ✓ Substitution reactions: is when an atom or group of atoms in an organic molecule are replaced or swopped/exchanged for another atom or group of atoms.
- ✓ Substitution reactions take place between compounds that are saturated alkanes, haloalkanes and alcohols.

1. Alkanes: Halogenation- Substitute X2 (X = Halogen: F_2, Cl_2, Br_2, I_2)

Alkane + Halogen → Haloalkane + Hydrogen Halide

Reaction conditions: Reaction takes place in the presence of **sunlight/heat**

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2. **Haloalkanes: Hydration- Substitute H_2O**

Haloalkane + H2O/NaOH/KOH → alcohol + HX / NaX / KX

Reaction conditions: The haloalkane is dissolved in an ethanol solution and treated with hot aqueous NaOH / KOH solution

3. **Alcohols: Hydrohalogenation- Substitute HX (X = Halogen: F_2, Cl_2, Br_2, I_2)**

- ✓ **Tertiary alcohol**

Alcohol + Hydrogen Halide → Haloalkane + Water

Reaction conditions: Require HX present at room temperature.

- ✓ **Primary and secondary alcohol**

Alcohol + Hydrogen Halide → Haloalkane + WaterR

Reaction conditions: High temperatures and need to be treated with NaBr and concentrated H_2SO_4.

D. COMBUSTION REACTION

- ✓ Hydrocarbons are the main source of fuel in the world at the moment.
- ✓ They are used in the production of electrical energy and as fuel for various engines.
- ✓ When hydrocarbons and alcohols react with oxygen they form water and carbon dioxide.
- ✓ These reactions are exothermic and produce large quantities of heat.

1. COMPLETE COMBUSTION

- ✓ **excess oxygen**
- ✓ **RECTION:** $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$ + energy

2. INCOMPLETE COMBUSTION

- ✓ **insufficient oxygen**
- ✓ **REACTION:** $2C_3H_8 + 7O_2 \rightarrow 6CO + 8H_2O$ + energy

BALANCING: C → H → O

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E. CRACKING

- ✓ Hydrocarbons can be made up of very long chains of hundreds of carbons.
- ✓ Crude oil is a mixture of many large hydrocarbons and each source of crude oil is different resulting in different types and amounts of hydrocarbons.
- ✓ Shorter chain hydrocarbons are more useful to use as fuels as they burn more readily and are more flammable.
- ✓ Cracking is the breaking up of long hydrocarbon chains into smaller more useful hydrocarbons. An alkene and alkane will be the products as a result of cracking.
- ✓ Cracking is a type of elimination reaction.

1. Thermal cracking

- ✓ This method makes use of high pressures and high temperatures to crack the long hydrocarbon chains with no catalyst.

2. Catalytic cracking

- ✓ This method uses a catalyst to crack long carbon chains at low pressure and low temperature.
- ✓ The heated crude oil is passed into a fractional distillation column and passed over a catalyst.
- ✓ The column is hottest at the bottom and coolest at the top.
- ✓ The crude oil separates according to boiling points and condenses as the gas rises up the column.
- ✓ The substances/chains with the longest chains will have higher boiling points and condense at the bottom and vice versa.

F. POLYMERS

- ✓ Polymers are very large organic molecules.
- ✓ They are made up of hundreds or thousands of atoms.
- ✓ Polymers are structured from repeated smaller units called monomers.

Monomer: Small organic molecules that can be covalently bonded to each other in a repeating pattern

Polymer: A large molecule composed of smaller monomer units covalently bonded to each other in a repeating pattern.

1. Condensation polymerization

- ✓ Occurs when two different monomers which have functional groups (alcohols and carboxylic acids) on both ends of their molecules react.
- ✓ In this reaction a water molecule is eliminated.

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2. **Addition polymers**

✓ Are made by joining two or more monomers which have double bonds- unsaturated molecules. (These are alkene's and alkyne's) and form long single bonded chains

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➢ HYDROLYSIS

✓ Is a substitution reaction.

✓ Product is alcohol.

➢ **Reaction conditions**

✓ NaOH and water

✓ Solution heated mildly

➢ HYDRATION

✓ Is an addition reaction.

✓ Product is alcohol.

➢ **Reaction condition**

✓ Conc. H_2 SO4 (catalyst) and water added

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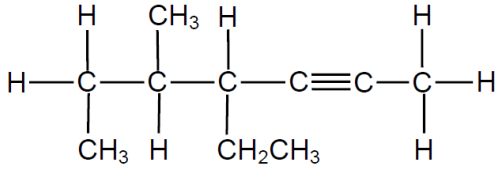
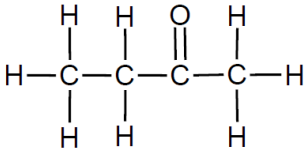
QUESTION 2 (Start on a new page.)

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

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

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

2.1 Write down the:

2.1.1 Letter that represents a ketone (1)

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

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

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

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

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

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

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

2.2.3 Is the isomer in QUESTION 2.2.2 a CHAIN, POSITIONAL or FUNCTIONAL isomer? (1)

2.3 Compound **D** reacts with bromine (Br_2) to form 2-bromobutane.

Write down the name of the:

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

2.3.2 Type of reaction that takes place (1)

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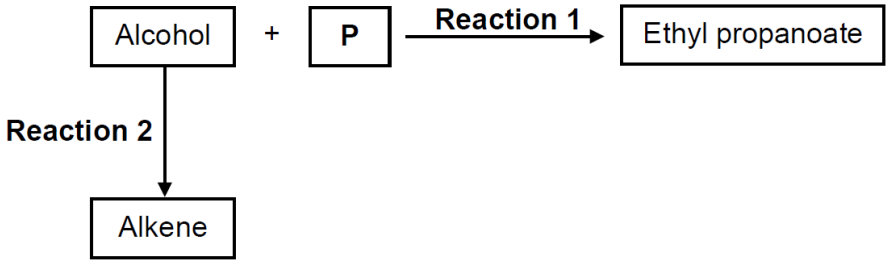
QUESTION 3 (Start on a new page.)

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



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

Write down the:

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

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

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

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

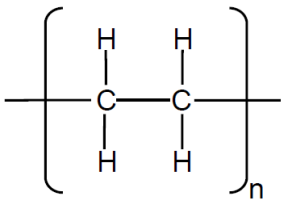
Write down the:

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

3.1.5 NAME or FORMULA of the acid catalyst (1)

3.1.6 STRUCTURAL FORMULA of the alkene (2)

3.2 The condensed formula of a polymer is shown below.



Write down the:

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

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

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QUESTION 4 (Start on a new page.)

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

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

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

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

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

4.2.2 Weakest intermolecular forces (1)

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

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

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

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

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

If the initial volume of the oxygen in the container was 60 cm^3, calculate the TOTAL volume of the gases that are present in the container at the end of the reaction. All the gases in the container are at the same temperature and pressure. (5)
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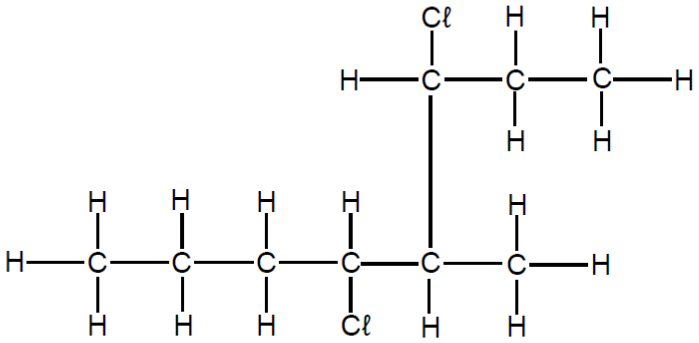
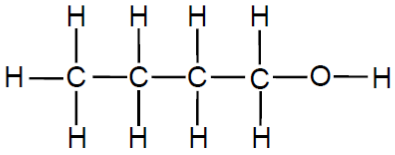
QUESTION 2 (Start on a new page.)

2.1 Consider the organic compounds represented by the letters **A** to **C** below.

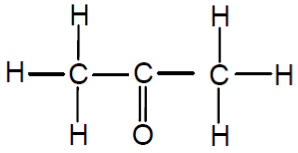
A



B



C



Write down the:

2.1.1 Name of the homologous series to which compound **C** belongs (1)

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

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

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

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

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

The ester contains 6,67% hydrogen (H), 40% carbon (C) and 53,33% oxygen (O). The molar mass of the ester is 60 $g \cdot mol^{-1}$.

Use a calculation to determine its:

2.2.3 Empirical formula (5)

2.2.4 Molecular formula (3)

Write down the:

2.2.5 Structural formula of methanoic acid (1)

2.2.6 IUPAC name of the ester (2)

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QUESTION 3 (Start on a new page.)

3.1 Define the term *boiling point.* (2)

3.2 What is the relationship between strength of intermolecular forces and boiling point? (1)

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

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

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

3.3.1 Compounds **A** and **B** (3)

3.3.2 Compounds **C** and **D** (3)

3.4 Is compound **B** a GAS or a LIQUID at room temperature? (1)
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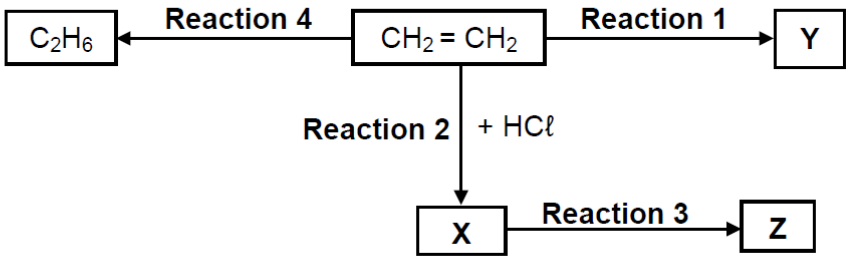
QUESTION 4 (Start on a new page.)

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



4.1 During **Reaction 1**, $CH_2 = CH_2$ undergoes polymerisation to form compound **Y**.

For this reaction, write down the:

4.1.1 Type of polymerisation (1)

4.1.2 NAME of compound **Y** (1)

4.2 For **Reaction 2**, write down the:

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

4.2.2 Type of addition reaction of which this is an example (1)

4.3 During **Reaction 3**, compound **X** reacts with excess hot water.

Write down the:

4.3.1 STRUCTURAL FORMULA of compound **Z** (2)

4.3.2 NAME or FORMULA of the INORGANIC product (1)

4.4 **Reaction 4** is an addition reaction.

4.4.1 Is C_2H_6 a SATURATED or an UNSATURATED compound? Give a reason for the answer. (2)

4.4.2 Write down the NAME or FORMULA of the INORGANIC reactant needed for this reaction. (1)

4.4.3 Using molecular formulae, write down a balanced equation for the complete combustion of C_2H_6. (3)

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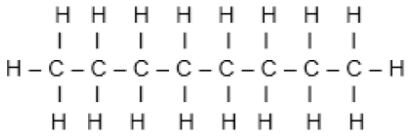
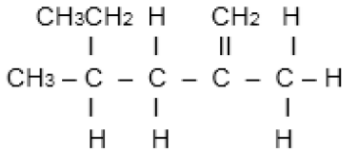
QUESTION 2 (Start on a NEW PAGE.)

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

A		**B**	
C	$C_3H_7C\ell$	**D**	Propanoic acid
E	Polyethene	**F**	$C_nH_{2n}O_2$

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

2.1 Write down the letter of the compound that …

2.1.1 has a carboxyl group. (1)

2.1.2 is used to make plastic. (1)

2.2 Write down the …

2.2.1 IUPAC name of compound **B**. (2)

2.2.2 STRUCTURAL FORMULA of the monomer of compound **E**. (2)

2.3 Compound **A** is an alkane.

Write down the …

2.3.1 GENERAL FORMULA for alkanes. (1)

2.3.2 MOLECULAR FORMULAE of each of the two products obtained during the complete combustion of compound **A**. (2)

2.4 Compound **C** is a primary haloalkane:

2.4.1 Write down the STRUCTURAL FORMULA and IUPAC name of a STRUCTURAL ISOMER of compound **C**. (4)

2.4.2 Classify the isomer in QUESTION 2.4.1 as CHAIN, POSITIONAL or FUNCTIONAL. (1)

2.5 Chemical analysis of compound **F** shows that it has the following percentage composition: **x%** carbon (C), **y%** hydrogen (H) and **12,5%** oxygen (O).

Use a calculation to determine the value of **x**. (4)

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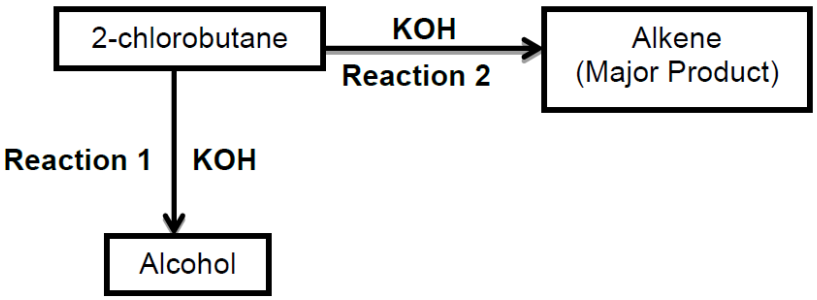
QUESTION 3 (Start on a NEW PAGE.)

3.1 The flow diagram below shows two organic reactions in which 2-chlorobutane reacts with potassium hydroxide (KOH) under different reaction conditions.



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

3.1.1 Write down the …

(a) type of reaction of which **Reaction 1** is an example. (1)

(b) IUPAC name of the alcohol. (2)

3.1.2 Which ONE of the reactions, **1** or **2**, uses concentrated potassium hydroxide? (1)

3.1.3 Write down the STRUCTURAL FORMULA of the alkene. (2)

3.2 A small sample of propyl methanoate is prepared in a school laboratory using an alcohol and a carboxylic acid in the presence of a catalyst. The reaction mixture is heated in a water bath.

Write down the …

3.2.1 reason why the reaction mixture is heated in a water bath instead of heating directly. (1)

3.2.2 STRUCTURAL FORMULA of the alcohol. (2)

3.2.3 IUPAC name of the carboxylic acid. (1)

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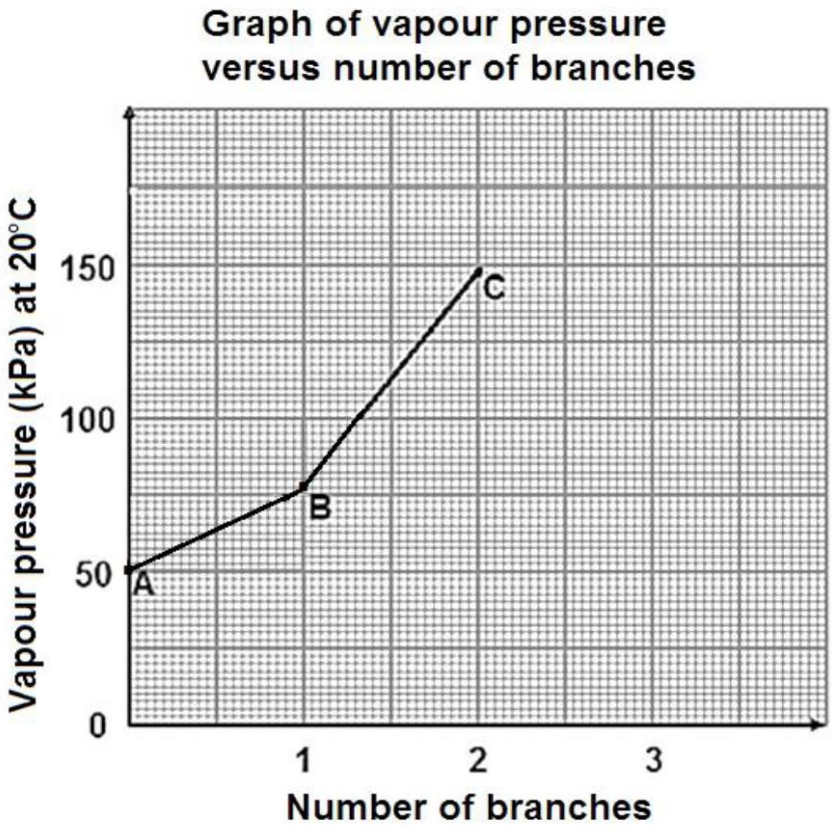
QUESTION 4 (Start on a NEW PAGE.)

There are three chain isomers having the molecular formula, C_5H_{12}. In a practical investigation, vapour pressure data for the three chain isomers **A**, **B** and **C** is collected and plotted on a graph as shown below.



4.1 Define the term *chain isomer*. (2)

4.2 Use the graph to estimate the vapour pressure of the straight chain isomer of C_5H_{12} at 20 °C. (1)

4.3 Write down the STRUCTURAL FORMULA of compound **C**. (2)

4.4 Explain the difference in the vapour pressure of compound **A** and **B**. In your explanation refer to the STRUCTURE of the molecules, the TYPE and STRENGTH of the INTERMOLECULAR FORCE(S). (3)

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4.5 The learners also collected boiling point data for compounds **D**, **E** and **F** as shown in the table below.

Compound	Condensed Structural Formula	Boiling point (°C)
D	CH_3OH	78
E	$CH_3CH_2CH_2OH$	97
F	$CH_3C\ell_2$	39,6

4.5.1 Write down the NAME of the type of intermolecular force that is responsible for the difference in the boiling points of compound **D** and **E**. (2)

4.5.2 Explain the difference in the boiling points of compounds **D** and **F** by referring to the TYPE and STRENGTH of intermolecular forces. (3)

Compound **F** is prepared at standard conditions (STP) by the reaction between methane and chlorine as shown by the equation:

$$CH_4(g) + C\ell_2(g) \rightarrow CH_2C\ell_2(g) + H_2(g)$$

4.5.3 Write down the NAME of the type of reaction that leads to the formation of compound **F**. (1)

4.5.4 In the reaction 21,88 dm^3 of CH_4 produces 0,043 kg of $CH_2C\ell_2$. Calculate the percentage yield in this reaction. (5)

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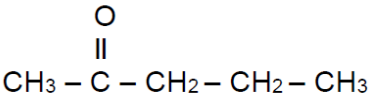
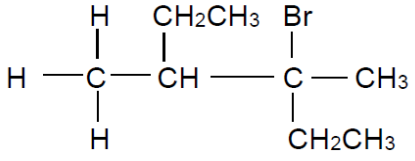
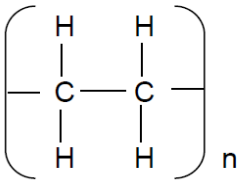
QUESTION 2 (Start on a new page.)

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

1

A	Hexane	**B**	
C	$C_3H_6O_2$	**D**	Propanoic acid
E		**F**	

Use the information in the table to answer the QUESTIONS 2.1 to 2.5.

2.1 Write down the LETTER that represents a compound that is:

2.1.1 A ketone (1)

2.1.2 A large molecule composed of smaller monomer units covalently bonded to each other in a repeating pattern (1)

2.2 Write down the IUPAC name of:

2.2.1 Compound **B** (2)

2.2.2 Compound **E** (3)

2.3 Compound **C** is prepared by the reaction of methanol with a carboxylic acid in the presence of concentrated sulphuric acid.

Write down the:

2.3.1 Name of the homologous series to which compound **C** belongs (1)

2.3.2 STRUCTURAL FORMULA of the carboxylic acid used (2)

2.3.3 STRUCTURAL FORMULA of compound **C** (2)

2.4 Compound **D** is one of the STRUCTURAL ISOMERS of compound **C**.

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

2.4.2 Write down the IUPAC name of another STRUCTURAL ISOMER of compound **C**, other than compound **D**. (2)

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2.5 Compound **A** undergoes a cracking process in which shorter chain hydrocarbons **X** and **Y** are produced according to the equation:

$$\textbf{Hexane} \xrightarrow[\text{High Temperature}]{\text{High Pressure}} \textbf{Y} + \textbf{X}$$

2.5.1 Classify the cracking process as CATALYTIC or THERMAL. (1)

'Shorter chain' hydrocarbon **X** is a monomer of compound **F** shown in the table.

2.5.2 Write down the MOLECULAR FORMULA of compound **Y.** (1)
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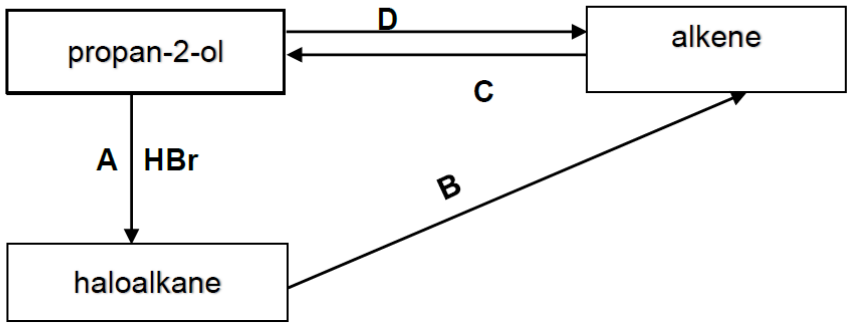
QUESTION 3 (Start on a new page.)

The flow diagram below shows various organic reactions.



3.1 Is propan-2-ol a PRIMARY, SECONDARY or TERTIARY alcohol? (1)

3.2 NAME the type of reaction represented by:

3.2.1 **A** (1)

3.2.2 **B** (1)

3.2.3 **C** (1)

3.3 Write down the STRUCTURAL FORMULA of the haloalkane. (2)

3.4 Use STRUCTURAL FORMULAE to write down a balanced equation for reaction **C.** (5)

3.5 Reaction **B** takes place in the presence of a strong base.

Is the base used in reaction **B** DILUTE or CONCENTRATED? (1)

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QUESTION 4 (Start on a new page.)

4.1 Vapour pressure values for compounds **E** and **F** are shown in the table below. The data was obtained at the <u>same temperature</u> of 20 °C using <u>equal volumes</u> of the compounds **E** and **F**.

COMPOUND		**VAPOUR PRESSURE (in kPa at 20 °C)**
E	Ethanoic acid	0,5
F	Propan-1-ol	2

4.1.1 Define the term *vapour pressure.* (2)

4.1.2 Besides the two control variables underlined above, write down another control variable for this comparison. (1)

4.1.3 Give a reason why hydrogen bonds in compound **E** are stronger, than in compound **F**. (1)

4.2 Learners carried out an investigation into the factors that affect the boiling points of compounds **A** to **D** shown in the table below.

The results of the investigation are shown in the table below.

COMPOUND	**NUMBER OF METHYL SIDE CHAINS (BRANCHES) IN ISOMER**	**BOILING POINT (°C)**
A	$CH_3CH_2CH_2CH_2CH_2CH_3$	68
B	$CH_3CHCH_2CH_2CH_3$ | CH_3	60
C	CH_3 | $CH_3CCH_2CH_3$ | CH_3	50
D	CH_3 | $CH_3CHCHCH_3$ | CH_3	57,9

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

The boiling points of compounds **C** and **D** are compared.

4.2.2 Write down the independent variable for this comparison. (1)

Compound **A** required exactly 96 dm^3 of oxygen at STP for complete combustion according to the reaction represented by the equation below.

$$2C_6H_{14} + 19O_2 \longrightarrow 12CO_2 + 14H_2O \qquad \Delta H = -4163 \text{ kJ/mol of } C_6H_{14}$$

4.2.3 Calculate the net energy released by the reaction. (4)

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QUESTION 2 (Start on a new page.)

2.1 The IUPAC name of an organic compound is 2,2,4-trimethylpentane.

For this compound write down:

2.1.1 The NAME of the homologous series to which it belongs (1)

2.1.2 Its STRUCTURAL formula (3)

2.1.3 The MOLECULAR formulae of the TWO products formed when the compound undergoes combustion in excess oxygen (2)

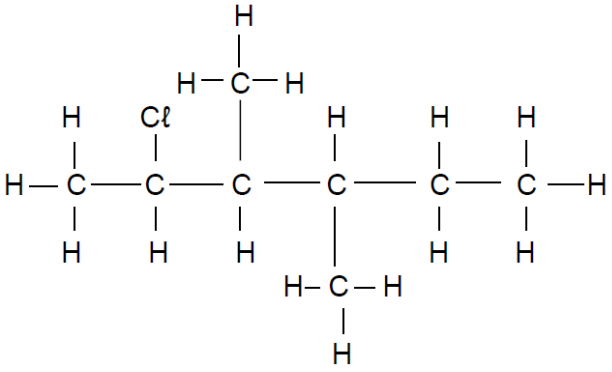
2.2 Study the condensed structural formulae for compounds **A** and **B** given below.

A. $(CH_3)_2CHC(=O)CH_2CH_3$ **B.** $(CH_3)_2CH_2CH_2C(=O)CH_3$

2.2.1 Give a reason why compounds **A** and **B** are said to be positional isomers. (2)

2.2.2 Write down the compound STRUCTURAL formula and IUPAC name of another positional isomer of compounds **A** and **B**. (4)

2.3 Consider the compound given below:



For this compound, write down the:

2.3.1 IUPAC name (3)

2.3.2 TYPE of halo-alkane. Choose from PRIMARY, SECONDARY or TERTIARY (1)

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QUESTION 3 (Start on a new page.)

The table below shows the vapour pressure values for the organic compounds **A** to **E**. The letters **X**, **Y** and **Z** represent vapour pressure values for compounds **A** to **C**.

COMPOUND	IUPAC NAME	VAPOUR PRESSURE (kPa) at 20 °C
A	Pentane	**X**
B	2-methyl butane	**Y**
C	2,2-dimethyl propane	**Z**
D	Ethanol	5,95
E	Methanoic acid	4,6

3.1 Give a reason why compounds **A**, **B** and **C** are said to be hydrocarbons. (2)

The values **X**, **Y** and **Z** are given in random order below.

Vapour pressure at 20 °C (kPa)	53,3	14,6	77

3.2 Choose the vapour pressure value that represents **Y**.

Fully explain the choice you made. (4)

3.3 Which ONE of the compound (**D** or **E**), has a HIGHER boiling point? (1)

Explain the answer by referring to:

3.3.1 Data in the table (1)

3.3.2 STRENGTH of the hydrogen bonds (2)

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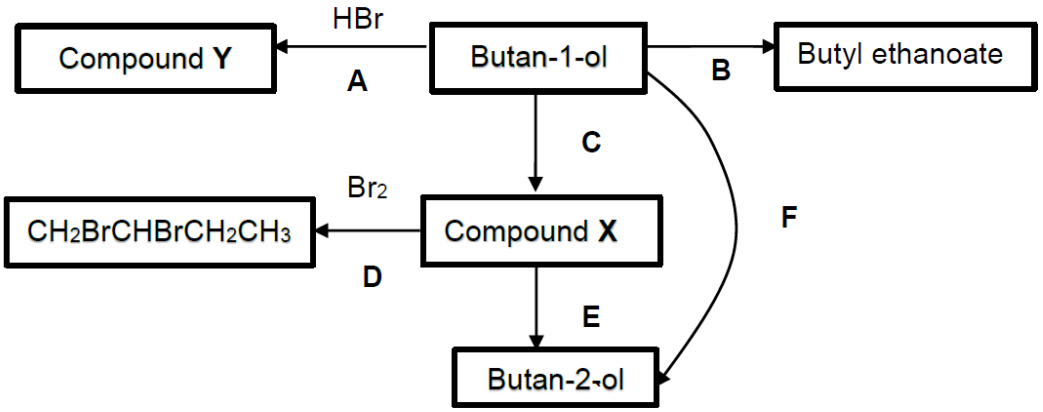
QUESTION 4 (Start on a new page.)

The flow diagram shows how an alcohol can be used to prepare other organic compounds. The letters **A, B, C, D, E** and **F** represent different organic reactions. **X** and **Y** are organic compounds.



4.1 Write down the type of reaction represented by reaction **A**. (1)

4.2 In reaction **B**, butan-1-ol reacts with a carboxylic acid in the presence of a catalyst to produce butyl ethanoate. Butyl ethanoate can be identified by its characteristic smell.

4.2.1 What safety precaution must be taken when smelling chemical compounds? (1)

For reaction **B** write down the:

4.2.2 Type of reaction (1)

4.2.3 IUPAC name of the carboxylic acid used (2)

4.2.4 STRUCTURAL formula of butyl ethanoate (2)

4.3 Use STRUCTURAL formulae to write down a balanced equation for reaction **A**. (4)

4.4 Reaction **F** involves two reactions (reaction **C** and reaction **E**). In reaction **F** butan-1-ol is converted to butan-2-ol through an intermediary, compound **X**.

Write down the:

4.4.1 STRUCTURAL formula of compound **X** produced in reaction **C** (2)

4.4.2 NAME or FORMULA of the inorganic reagent needed in reaction **C** (1)

4.4.3 Reaction condition needed for reaction **E** (1)

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