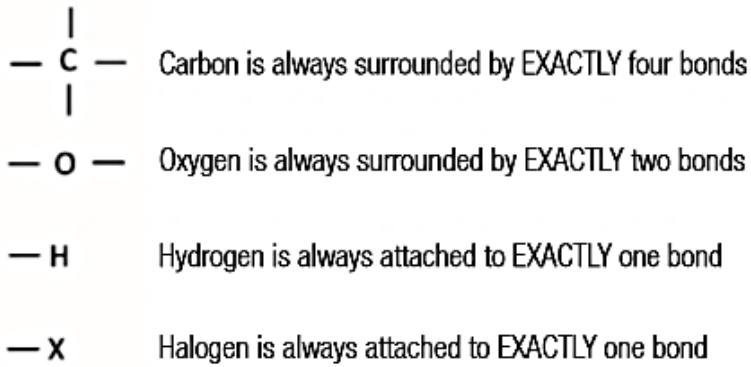
SUBJECT and GRADE	**Physical Sciences Grade 12**	
TERM 1	*Week 5*	
TOPIC	Organic Chemistry (Nomenclature/Naming)	
AIMS OF LESSON	The focus of this lesson will be on the following: • Define organic molecules, functional group, hydrocarbon, homologous series, saturated compounds, unsaturated compounds and structural isomer. • Write condensed, structural & molecular formulae (max 8 C atoms, 1 functional group per molecule) for alkanes (no rings), alkenes (no rings), alkynes, alcohols, haloalkanes (no rings), carboxylic acids, aldehydes, ketones, esters • Write IUPAC names for structural/ condensed structural formulae for compounds from above series. • Write IUPAC names from structural or condensed structural formulae for compounds listed (one functional group per molecule, max. two functional groups for haloalkanes). • Identify alkyl substituents (methyl- and ethyl-); max. THREE alkyl substituents. • Identify compounds that are saturated, unsaturated, structural isomers (chain, positional, functional)	
RESOURCES	***Paper based resources***	***Digital resources***
	Learners are referred to the: • *Organic Chemistry topic in the textbook or study guides (e.g. Answer Series) that learners will have on hand.* • *Examination Guideline (page 15-17)* • *Mind the Gap Chemistry book (pages 1-15)*	*Refer to the relevant digital resources:* • *WCED ePortal* https://wcedeportal.co.za • *Past NSC Examination papers (Paper 2 refer to question 2)* https://wcedonline.westerncape.gov.za/grade-12-question-papers • *Telematics* https://wcedonline.westercape.gov.za/edumedia/revision-dvds-telematics • *Mind the Gap* https://wcedonline.westercape.gov.za/mind-gap • *HeyScience App for Physical Sciences on Play Store*

	• *Past NSC Examination papers (refer to Paper 2 question 2)*	
INTRODUCTION	• Organic chemistry is the chemistry of carbon compounds in living and non-living systems. Organic molecules are molecules containing carbon atoms. Organic compounds typically have a backbone (chain) of linked carbon atoms that other atoms attach to. • The organic compounds that we study consist of Carbon, Hydrogen, Oxygen atoms and the Halogens (-Br, -Cl, -I), which are often represented collectively as –X).  	
CONCEPTS AND SKILLS	• Define **organic molecules** as molecules containing carbon atoms. (as per examination guideline page 15) • **Hydrocarbon:** Organic compounds that consist of hydrogen and carbon only. • **Homologous series:** A series of organic compounds that can be described by the same general formula OR in which one member differs from the next with a CH_2 group. **Organic molecular structures – functional groups, saturated and unsaturated structures, isomers** • Write down condensed structural formulae, structural formulae and molecular formulae (up to 8 carbon atoms, one functional group per molecule) for: o Alkanes (no ring structures) o Alkenes (no ring structures) o Alkynes	

- o Halo-alkanes (primary, secondary and tertiary haloalkanes; no ring structures)
- o Alcohols (primary, secondary and tertiary alcohols)
- o Carboxylic acids
- o Esters
- o Aldehydes
- o Ketones

The following table contains the systematic names for the first eight straight chain alkanes. It will be important to familiarize yourself with these names because they will be the basis for naming many other organic molecules throughout:

Table 1:

Number of carbon atoms	**Name of alkane**
1	Methane
2	Ethane
3	Propane
4	Butane
5	Pentane
6	Hexane
7	Heptane
8	Octane

<u>Alkanes example:</u>

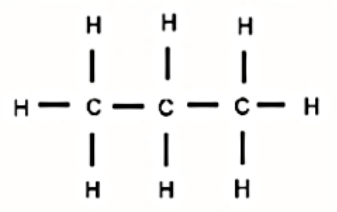
Alkanes have the general formula C_nH_{2n+2}

In propane n = 3 and therefore the general formula is $C_3H_{2(3)+2} = C_3H_8$

In a **structural formula** all the bonds in the compound are shown.

If any of these bonds are omitted, it is called a **condensed structural formula**.

E.g. **structural formula** for propane



possible **condensed structural formula** for propane

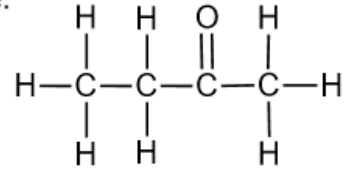
$CH_3 - CH_2 - CH_3$ or $CH_3CH_2CH_3$

Know the following definitions/terms:

Molecular formula: A chemical formula that indicates the type of atoms and the correct number of each in a molecule. Example: C_4H_8O

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

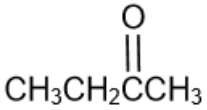
Example:



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

Example:

$CH_3CH_2COCH_3$ OR



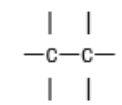
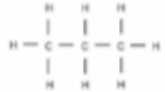
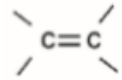
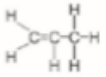
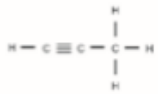
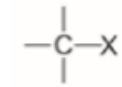
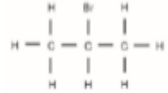
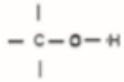
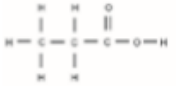
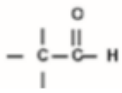
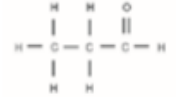
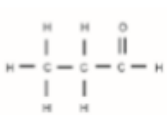
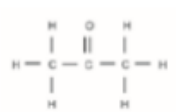
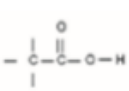
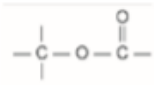
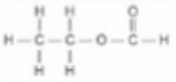
Homologous series		General formula	Functional Group	Suffix	Example name	Structural formula	Condensed structural formula	Molecular formula
Hydrocarbons	Alkanes	C_nH_{2n+2}		-ane	propane		$CH_3CH_2CH_3$	C_3H_8
	Alkenes	C_nH_{2n}		-ene	propene		$CH_2=CHCH_3$	C_3H_6
	Alkynes	C_nH_{2n-2}		-yne	propyne		$CH{\equiv}CCH_3$	C_3H_4
Haloalkanes/ alkyl halides		$C_nH_{2n+1}X$ (X = F, Cℓ, Br, I)		-ane	2-bromopropane		$CH_3CHBrCH_3$	C_3H_7Br
Alcohols		$C_nH_{2n+1}OH$		-ol	propan-2-ol		$CH_3CHOHCH_3$	C_3H_7OH
Aldehydes		$C_nH_{2n}O$ n =1, 2, ...		-al	propanal		CH_3CH_2CHO	C_3H_6O
Ketones		$C_nH_{2n}O$ n = 3, 4, ...		-one	propanone		CH_3COCH_3	C_3H_6O
Carboxylic acids		$C_nH_{2n}O_2$ n = 1, 2, ...		-oic acid	propanoic acid		CH_3CH_2COOH	$C_3H_6O_2$
Esters		$C_nH_{2n}O_2$ n = 2, 3, ...		-oate	ethyl methanoate		CH_3CH_2OOCH	$C_3H_6O_2$

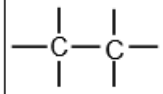
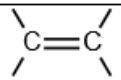
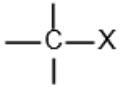
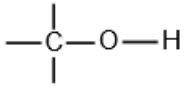
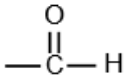
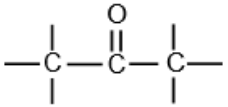
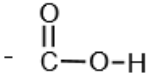
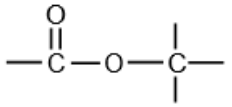
Table 2:

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

Unsaturated compounds: Compounds with one or more multiple bonds between C atoms in their hydrocarbon chains. E.g. Alkenes and alkynes

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.

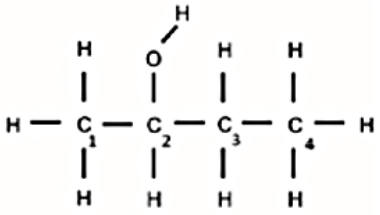
Table 3:

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

IUPAC naming and formulae

Organic compounds are named according to the IUPAC (international union of Pure and Applied Chemistry) system. Each IUPAC name consists of three parts: prefix, root, suffix.

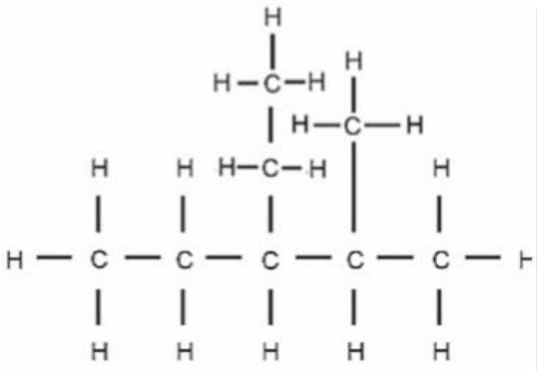
Table 4:

Prefix	**Root**	**Suffix**
Position and names of substituents (side chains), listed alphabetically. *Example:* The numbering of the carbon chain:  In the naming of the organic compound, the longest carbon chain is numbered in such a way that the–OH functional group is attached to the carbon that is assigned the smallest number. Therefore, in this example, the organic compound is called butan-**2**-ol.	Number of C-atoms in the main C-chain. Determine the root of the name from the number of C-atoms in the longest (main) C-chain. 1 = meth- 2 = eth- 3 = prop- 4 = but- 5 = pent- 6 = hex- 7 = hept- 8 = oct- 9 = non-	Determined by the homologous series. (Refer to **Table 2**) *Suffix* Alkanes -ane Alkenes -ene Alkynes -yne Haloalkanes -ane Alcohols -ol Aldehydes -al Ketones -one Carboxylic acids -oic acid Esters -oate

You must be able to:

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

Example: Give the IUPAC name of the following organic compound



Step 1: Identify the functional group, and the homologous series to which this compound belongs.

ALKANES

Step 2: Find the longest C-chain and count the C-atoms in it, starting at the side closest to the functional group. we start numbering from the side closest to a substituent.

We start numbering from the side closest to a substituent

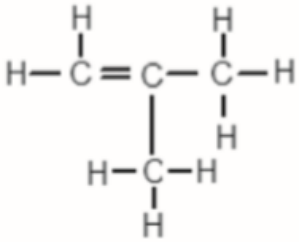
Step 3: Look at the substituents. Count the C-atoms in each substituent, determine the prefix and end it on –yl. (Identify alkyl substituents (methyl- and ethyl-) in a chain to a maximum of THREE alkyl substituents on the parent chain.)

The alkyl groups must be listed alphabetically, so we write the ethyl before the methyl.

IUPAC name: 3-ethyl-2-methylpentane

- Write down the structural formula when given the IUPAC name for a given homologous series.

Example: Write down the structural formula of 2-methylprop-1-ene



Step 1: Identify the functional group, and the homologous series to which this compound belongs.

Homologous series: ALKENES

Functional group: double bond between carbons (prop-1-1-ene)

Step 2: Write the longest C-chain and place the double bond between C-atoms 1 and 2.

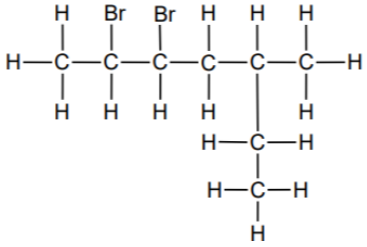
Step 3: Place the methyl substituent on the second carbon (*2-methyl)*

Please take note of the following:

- When naming haloalkanes, the halogen atoms do not get preference over alkyl groups – numbering should start from the end nearest to the first substituent, either the alkyl group or the halogen. In haloalkanes, where e.g. a Br and a Cℓ have the same number when numbered from different ends of chain, Br gets alphabetical preference.

- When writing IUPAC names, substituents appear as prefixes written alphabetically (bromo, chloro, ethyl, methyl), ignoring the prefixes di- and tri.

Example: Write down the IUPAC name of the following organic compound



IUPAC name: *2,2-dibromo-5-methylheptane*

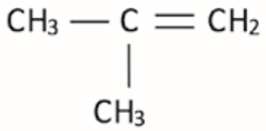
Key points to consider when studying this topic:

<u>General steps for the IUPAC naming of all organic compounds</u>

<u>Step 1:</u>

- Identify the functional group in the compound and the homologous series it belongs to. This determines the suffix (ending).

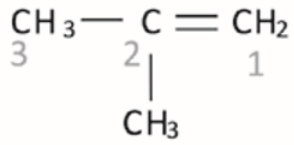
Example: Naming of 2-methylprop-1-ene



- In this case there are only carbons and hydrogens, with a double bond between the carbons. This indicates that this compound is an alkene and will end with the suffix -ene

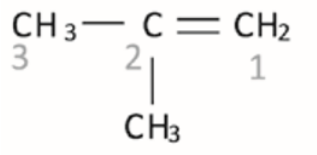
<u>Step 2:</u>

- Find the longest chain of carbon atoms. It must include the functional group and need not be in a straight line.
- Number the carbon atoms in this chain from the side nearest to the functional group e.g. a double or triple bond, a hydroxyl group, a carbonyl group or a carboxyl group.
- In the case of alkanes or haloalkanes, start numbering from the carbon nearest to a substituent (side chain) e.g. an alkyl group or halogen atom.
- Indicate the position of the functional group (except in the case of the alkanes). For alkenes and alkynes, give the smaller of the numbers of the C-atoms between which the double or triple bond exists. example: Naming of 2-methylprop-1-ene



Step 3:

- Determine whether there are any substituents.
- Count the number of C-atoms in the substituent to determine the prefix and end it on –yl.
- Write the number of the C-atom on the main chain where the alkyl group is attached, in front of the alkyl name.
- Separate the number and the name with a hyphen, e.g. 2-methyl.
- If a substituent occurs more than once, use the appropriate prefix: twice – di; three times – tri; four times – tetra e.g. 3,4-dimethyl
- If there is more than one substituent, write their names and positions in alphabetical order.



The methyl group is attached to the second carbon, hence the name 2-methyl prop-1-ene

Step 4:

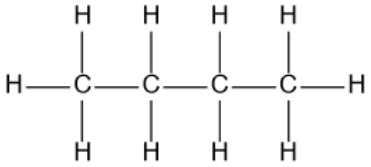
- Naming the organic compound with substituent(s) in front of the parent chain. Example: the IUPAC name of the compound discussed above is 2-methylprop-1-ene

STRUCTURAL ISOMER: Organic molecules with the same molecular formula, but different structural formulae.

In isomers, the same atoms are used in different compounds, but they are assembled or connected in different ways. There are different kinds of isomers in organic chemistry. Structural isomers refer to the order in which different atoms in a compound are combined.

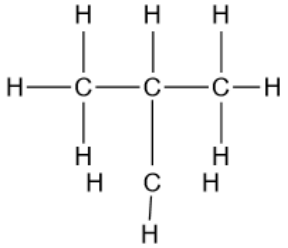
- We focus on three types of structural isomers: chain isomers, positional isomers and functional isomers. (Identify compounds (up to 8 carbon atoms) that are saturated, unsaturated and are structural isomers.)

- **Chain isomers:** Same molecular formula, but different types of chains, e.g. butane and 2-methylpropane.



Butane

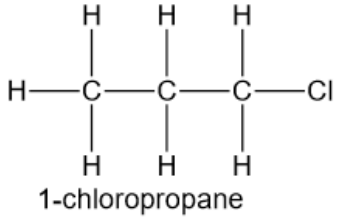
C_4H_{10}



2-methylpropane

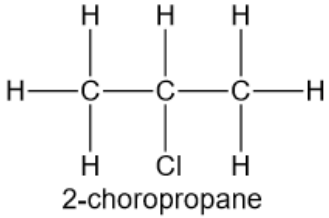
C_4H_{10}

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



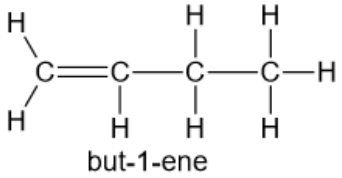
1-chloropropane

C_3H_7Cl



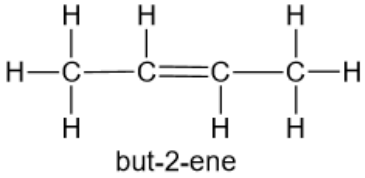
2-choropropane

C_3H_7Cl



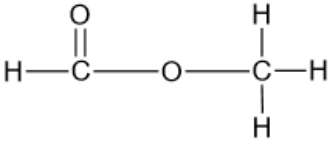
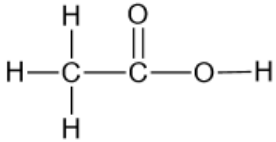
but-1-ene

C_4H_8



but-2-ene

C_4H_8

	o **Functional isomers:** Same molecular formula, but different functional groups, e.g. methyl methanoate and ethanoic acid.  methyl methanoate $C_2H_4O_2$  ethanoic acid $C_2H_4O_2$ ***Please remember the following:*** • Numbers and letters of the alphabet are separated by a hyphen. (e.g. 2-methylpropane) • Numbers are separated by the comma, and no space between the substituent(s) and the parent chain. (e.g. 2,2-dichloropentane) • When naming haloalkanes, the halogen atoms do not get preference over alkyl groups – numbering should start from the side nearest to the first substituent, either the alkyl group or the halogen. In haloalkanes, where e.g. a Br and a Cℓ have the same number when numbered from different sides of the chain, Br gets alphabetical preference. • When writing IUPAC names, substituents appear as prefixes written alphabetically (bromo, chloro, ethyl, methyl), but the prefixes di- and tri- should not be used to determine the alphabetical order. • In molecules where the functional group is ALWAYS on the first carbon (such as in the case of carboxylic acids, aldehydes there is NO number added to indicate the position of the functional group. (e.g. Ethanoic acid or pentanal.)
ACTIVITIES/ ASSESSMENT	Learners are referred to *Organic Chemistry activities/assessment* that they can complete/do in their *Physical Sciences textbooks or Study guides.* *Informal assessment activities in Mind the Gap:* • Structural Isomers: Activity 1 (page 4) • IUPAC naming: Activity 2 (page 12-13) • Structural isomers and IUPAC naming: Activity 3 and 4 (pages 13-15)
CONSOLIDATION	In this topic we have introduced the naming of organic compounds (of various homologous series). We have also looked at the three different types of structural isomers e.g. chain, positional and functional isomers. Consolidation activities are included below.

VALUES	The increasingly large number of organic compounds identified with each passing day, together with the fact that many of these compounds are isomers of other compounds, required that a systematic nomenclature system be developed. The purpose of the IUPAC system of nomenclature is to establish an international standard of naming compounds to facilitate communication. The goal of the system is to give each structure a unique and unambiguous name, and to correlate each name with a unique and unambiguous structure. Just as each distinct compound has a unique molecular structure which can be designated by a structural formula, each compound must be given a characteristic and unique name.

CONSOLIDATION ACTIVITY

QUESTION 1

1.1 Define the term functional group of organic compounds. (2)

1.2 Write down the:

1.2.1 Structural formula of the functional group of aldehydes (1)

1.2.2 Name of the functional group of carboxylic acids (1)

1.3 The IUPAC name of an organic compound is 2,4-dimethylhexan-3-one.

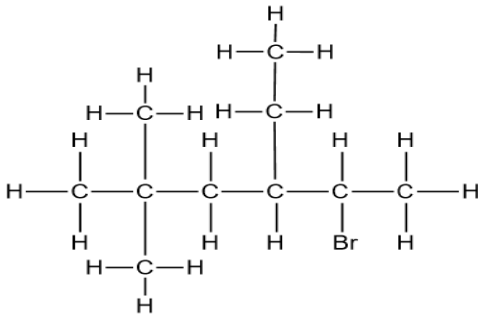
For this compound, write down the:

1.3.1 Homologous series to which it belongs (1)

1.3.2 Structural formula (3)

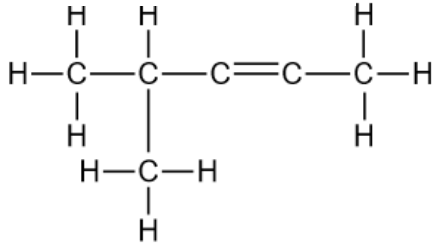
1.4 Write down the IUPAC names of the following compounds:

1.4.1



(3)

1.4.2

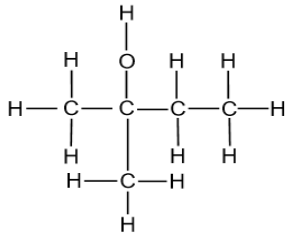
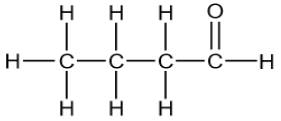
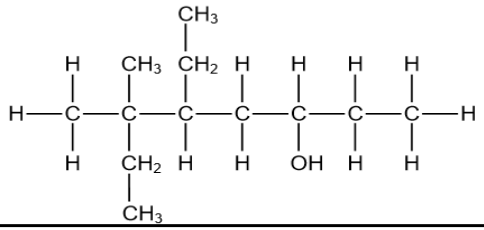


(2)

[13]

QUESTION 2

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

A		**B**	
C	Butan-1-ol	**D**	Butan-2-one
E			

2.1 Write down the LETTER that represents EACH of the following:

2.1.1 A tertiary alcohol (1)

2.1.2 An aldehyde (1)

2.1.3 A ketone (1)

2.1.4 A functional isomer of compound B (1)

2.2 Write down the IUPAC name of:

2.2.1 Compound B (1)

2.2.2 Compound E (4)

2.3 Define positional isomers. (2)

2.4 Write down the STRUCTURAL FORMULA of:

2.4.1 A positional isomer of compound C (2)

2.4.2 Compound D (2)

2.4.3 The organic acid that will react with compound C to form butyl propanoate (2)

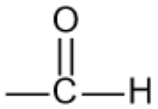
[17]

CONSOLIDATION ACTIVITY MARKING GUIDELINE

QUESTION 1

1.1 A bond / an atom / a group of atoms that determine(s) the (physical and chemical) properties of a group of organic compounds. ✓✓

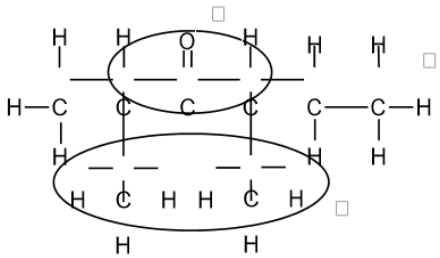
(2)

1.2.1  ✓

(1)

1.2.2 Carboxyl (group) ✓ (1)

1.3.1 Ketones ✓ (1)

1.3.2  ✓✓✓

1.4.1 5-bromo-4-ethyl-2,2-dimethylhexane✓✓✓ (3)

1.4.2 4-methylpent-2-yne ✓✓ (2)

[13]

QUESTION 2

2.1.1 A ✓ (1)

2.1.2 B ✓ (1)

2.1.3 D ✓ (1)

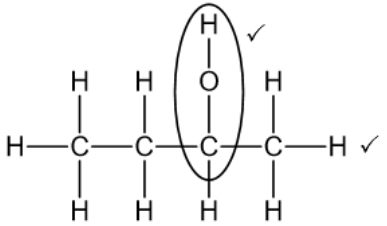
2.1.4 D ✓ (1)

2.2.1 Butanal✓ (1)

2.2.2 5-ethyl-6,6-dimethyloctan-3-ol/5-etiel-6,6-dimetieloktan-3-ol ✓✓✓✓ (4)

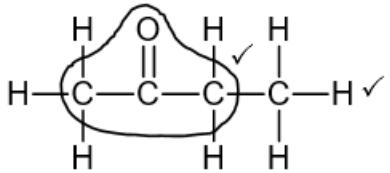
2.3 Compounds with the same molecular formula, but different positions of the side chain/substituents/functional groups on parent chain. ✓✓ (2)

2.4.1



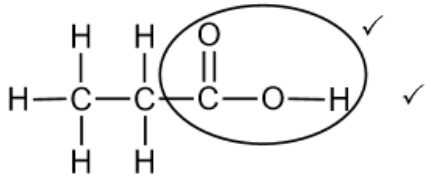
(2)

2.4.2



(2)

2.4.3



(2)

[17]