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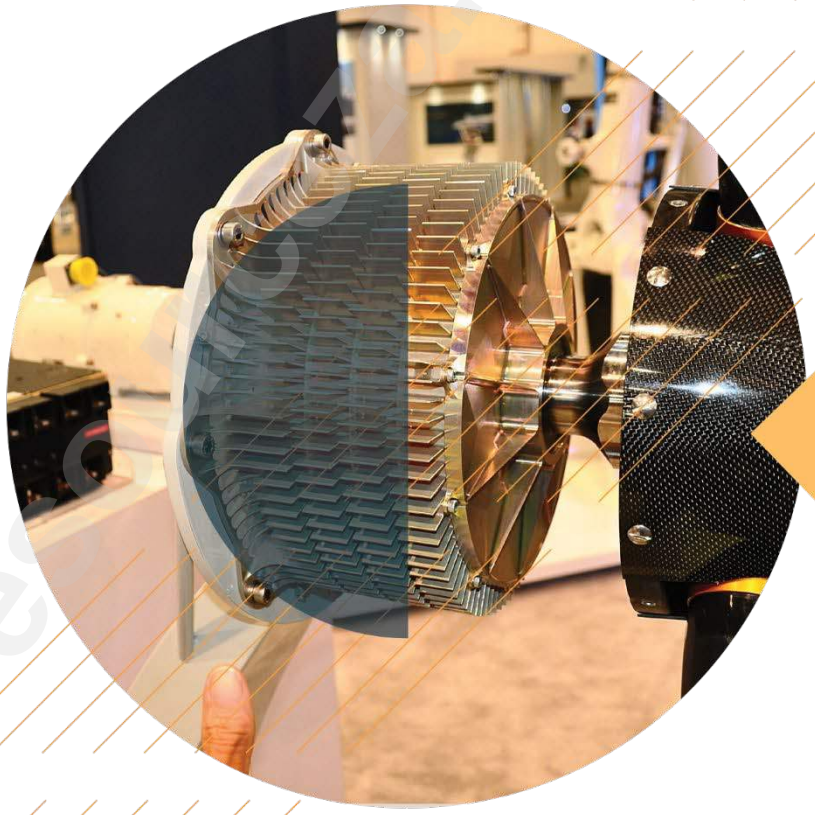
GRADE 12

Technical Sciences

SELF STUDY GUIDE BOOK 2

1. Organic Molecules and
2. Electrochemistry

DRAFT 2



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INTRODUCTION

The declaration of COVID-19 as a global pandemic by the World Health Organisation led to the disruption of effective teaching and learning in many schools in South Africa. The majority of learners in various grades spent less time in class due to the phased-in approach and rotational/ alternate attendance system that was implemented by various provinces. Consequently, the majority of schools were not able to complete all the relevant content designed for specific grades in accordance with the Curriculum and Assessment Policy Statements in most subjects.

As part of mitigating against the impact of COVID-19 on the current Grade 12, the Department of Basic Education (DBE) worked in collaboration with subject specialists from various Provincial Education Departments (PEDs) developed this Self-Study Guide. The Study Guide covers those topics, skills and concepts that are located in Grade 12, that are critical to lay the foundation for Grade 12. The main aim is to close the pre-existing content gaps in order to strengthen the mastery of subject knowledge in Grade 12. More importantly, the Study Guide will engender the attitudes in the learners to learning independently while mastering the core cross-cutting concepts.

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About the Study Guide

This document was developed to assist grade 12 learner who are studying remotely (at home).

This document forms part of the series to be distributed Department of Education Grade 12 learners who are currently taking Technical Sciences as one of their subjects.

The document deals with topics in Paper 2.

The topics are: Organic Chemistry and Electrochemistry.

What to find in this document?

Short notes with illustrations (images, pictures, diagrams).

- Definitions of terms
- Worked out examples – some of the examples are taken directly from previous formal assessment tasks (Common Assessment tasks) from different Provinces.
- Solutions with brief notes or explanations of what to do and how to obtain a correct answer.

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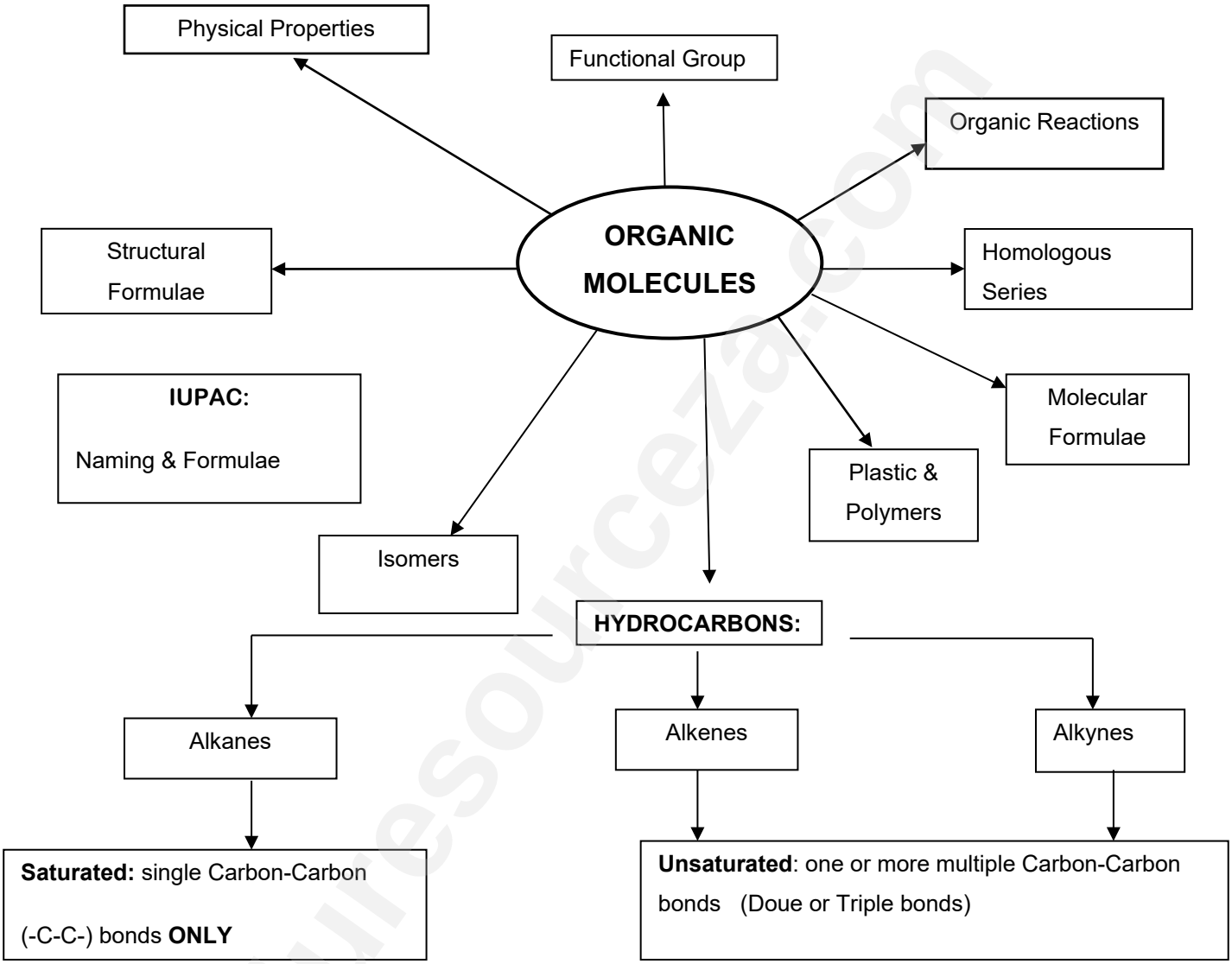
SECTION 1

Organic Molecules

Chapter Summary



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1.1 Definitions

Table 1: Definitions

Concept	Description /Explanation
• **Organic molecules**	are molecules containing carbon atoms.
• **Homologous series**	is a series of organic compounds that can be described by the same general formula and where each member differs from the next by a **-CH_2** group.
• **General formula**	is an expression used to indicate the distribution of atoms in an organic compound in a homologous series.
• **Functional group**	is an atom or a group of atoms that determine the chemistry of a molecule. **OR** an atom or a group of atoms that determine(s) the physical and chemical properties of a group of organic compounds.
• **Hydrocarbons**	are organic compounds containing **ONLY** hydrogen and carbon atoms only.
• **Unsaturated hydrocarbons**	contain covalent double or triple bonds between the carbon atoms
• **Saturated hydrocarbons**	contain only single covalent bonds between carbon atoms

Note:

- **Key words** should be taken into consideration in definitions.
- Definitions should be written as they appear in the **Examination Guidelines.**

How to represent Organic Molecules

- **Structural formulae** and /or **Molecular formulae** are used to represent Organic Molecules.

You must be able to write **Molecular** and **Structural Formulae** of Organic Molecules up to **Six** (6) **Carbon (C) atoms**

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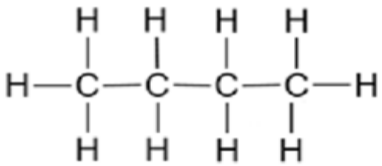
Table 2: Structural Formula & Molecular Formula

Structural formulae	**Molecular formulae**
• show which atoms are attached to which within the molecule.	• indicate the type of atoms and correct number of each in a molecule.
• atoms are represented by their chemical symbols • lines are used to represent **ALL** the bonds that hold the atoms together.	**Example:**
Example: Structural formula of **Butane** 	

Molecule	**Molecular Formula**
Butane	C_4H_{10}
Ethanoic acid	$C_2H_4O_2$

Tips on drawing/writing structural formulae.

- Make sure that carbon atom is surrounded by 4 bonds (**not more, not less**).
- All bonds must be drawn.
- Hydrogen atoms should not be omitted.
- Functional group should be placed at the correct position.
- Use a general formula to generate the molecular formula.

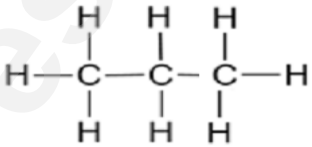
N.B:

- When asked to write molecular formula, do not draw the structural formula.
- Learners will be **penalized** if they write molecular formula instead of structural formula.

Worked Example

Write down whether the following examples are showing the molecular formula or the structural formula for the organic compound.

Table 3: Worked example on formulae.

A.		B.	C_5H_{12}

Solutions:

A. Structural formula- all the bonds are showing.
B. Molecular formula- only type of atoms and correct number of each in a molecule.

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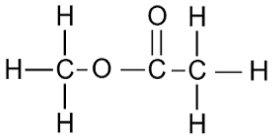
Test yourself

Write down whether the following examples are showing the molecular formula or the structural formula for the organic compound

Table 4: Test yourself on formulae

A.		B.	$C_3H_7C\ell$

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1.3. Homologous series

Homologous series is a series of organic compounds that have **the same general formula** and where each member differs from the next by **–CH_2** group.

There are **NINE** (9) Homologous series that we will focus on namely:

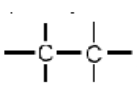
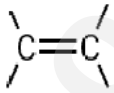
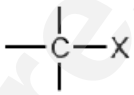
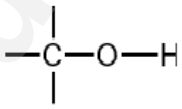
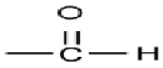
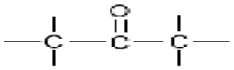
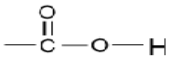
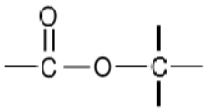
- Alkanes
- Alkenes
- Alkynes
- Haloalkanes
- Alcohols
- Aldehydes
- Ketones
- Carboxylic acids
- Esters

Functional group

Functional group Is an **atom or group** of atoms that **determine** the **chemistry of a molecule**.

N.B: The functional groups for all the homologous series must be identified FROM STRUCTURAL FORMULAE AND NAME of organic molecules.

Table 5: Homologous Series, Functional Groups and General Formulae.

Homologous series	**Functional group**		**General formula**
	Structure of functional group	**Name of functional group**	
Alkanes		Only C-H and C-C single bonds	C_nH_{2n+2}
Alkenes		Carbon-carbon double bond	C_nH_{2n}
Alkynes		Carbon-carbon triple bond	C_nH_{2n-2}
Haloalkanes (alkyl halides)	 (**X** = F, Cℓ, Br, I)	-	$C_nH_{2n+1}X$
Alcohols		Hydroxyl group	$C_nH_{2n+2}O$
Aldehydes		Formyl group	$C_nH_{2n}O$
Ketones		Carbonyl group	$C_nH_{2n}O$
Carboxylic acids		Carboxyl group	$C_nH_{2n}O_2$
Esters			$C_nH_{2n}O_2$

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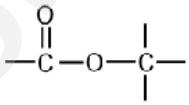
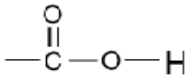
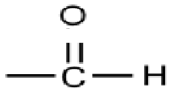
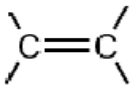
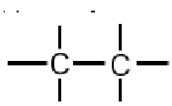
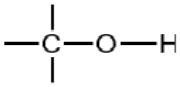
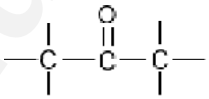
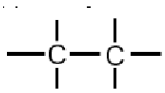
Worked example.

- Consider the table below and identify the homologous series in which each of the following Organic compounds belong (10)

Table 6: Solution to worked example

A		B	
	• **Alkyne** because it has **Carbon-carbon triple bond** as a functional group ✓		• **Ester** because it has as a functional group ✓
C		D	
	• **Carboxylic acid** because it has **carboxyl group** as a functional group✓		• **Aldehydes** because it has **Formyl group** as a functional group✓
E		F	
	• **Alkene** because it has **Carbon-carbon double bond** as a functional group ✓		• **Alkanes** because it has **Only C-H and C-C single bonds** as a functional group✓
G		H	
	• **Haloalkanes** because it has as a functional group✓		• Alcohol because it has **Hydroxyl group** as a functional group✓
I		J	
	• **Ketones** because it has **Carbonyl group** as a functional group ✓		• Alkanes because it has **Only C-H and C-C single bonds** as a functional group✓

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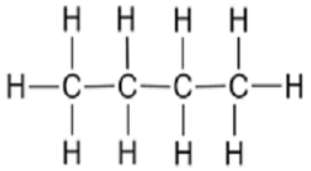
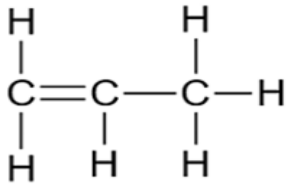
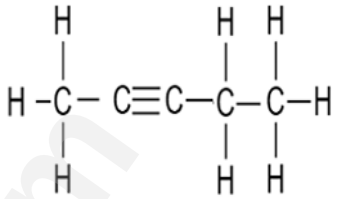
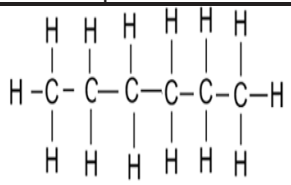
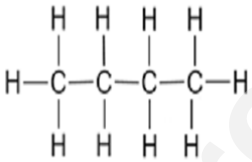
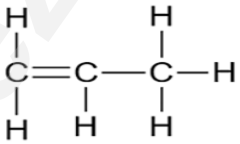
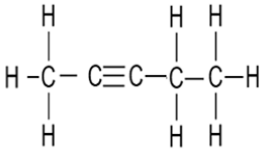
1.4 Hydrocarbons

1.4.1 **Hydrocarbons** are compounds that consist of Hydrogen **(H)** and Carbon **(C) atoms *ONLY.***

Table 7: Examples of Hydrocarbons

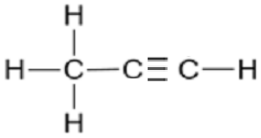
		

1.4.2 **Table 8:** Differences between **Saturated** and **Unsaturated** hydrocarbons

Saturated hydrocarbons		**Unsaturated** hydrocarbons	
• contain **ONLY single** covalent bonds between **carbon atoms**.		• contain covalent **double** or **triple** bonds between **the carbon atoms.**	
• Example:		• Example	
			

Worked Example

- Identify the following compound as saturated or unsaturated, support your answer.

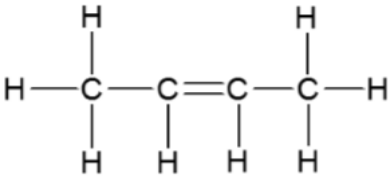


Solution

- **Unsaturated –** contain covalent triple bonds between the carbon atoms

Test Yourself

- Identify the following compound as saturated or unsaturated, and support your answer



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1.5 IUPAC Naming and Formulae

Table 9:RULES OF NAMING ORGANIC MOLECULES:

Step 1: Identify the **number of carbon atoms** in the **parent chain** of the organic compound.

- The following prefixes are used:

Number of Carbon atoms	Prefix
1	Meth-
2	Eth-
3	Prop-
4	But-
5	Pent-
6	Hex-

Parent chain: is the longest continuous chain of carbon atoms.

Step 2: Number the carbons in the **parent chain.**

- Start with the carbon at the end closest to the functional group.
- Functional group must have the lowest possible number.

Step 3: Identify the **functional group of a homologous series** in the compound.

- This will determine the **suffix** of the name.

Table 10: Suffixes.

Homologous series	Suffix
Alkanes	-ane
Alkenes	-ene
Alkynes	-yne
Alcohols	-ol
Aldehydes	-al
Ketones	-one
Carboxylic acids	-oic acid
Esters	-oate

Functional group: an atom or a group of atoms that determine

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Homologous Series: is a group of organic compounds that can e described by the same general formula and where each member differs from the next by a CH_2 group.

Table 11: Prefixes

Homologous series	prefix
Halo-alkane	• Bromo • Chloro • Fluoro
Ester	• Meth**yl-** • Eth**yl-** • Prop**yl-**

Step 4: Identify any branched groups: **alkyl groups.**

- Name the branched groups by counting the number of carbon atoms in the branched group, these groups will all end in **-yl. i.e. methyl and ethyl'**
- Note the position of the branched group on the main carbon chain.
- If there is more than one of the same type of branched group, then:
  - ✓ both numbers must be listed (e.g. 2,4 -) followed by **di** for two and **tri** for three.

NB: If the molecule is an ***alkane*** the branched group must be on the carbon with the lowest possible number.

- The branched groups must be listed before the name of the main chain in alphabetical order. (ignoring: di / tri / tetra).

1.6 **Naming of Haloalkanes**

Step 1: When naming Haloalkanes, the halogen atoms do not get preference over alkyl groups.

Step 2: Numbering should start from the end nearest to the first substituent, either the alkyl group or the halogen.

Step 3: In **Haloalkanes**, where for example, a **Br** and a **Cℓ** have the same number when numbered from different ends of chain, **Br** gets alphabetical preference.

Step 4: When an alkyl group is a substituent in a molecule, it should be treated as a substituent.

Table 12: Summary of naming organic compounds

Longest continuous carbon chain	Determines the name of the parent chain whether prop /but/ hex
Prefix	substituent/branch (position included where necessary)
suffix	Functional group
Repeating substituent	di/tri

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Worked Example:

Break down the following names using the summary table above.

a. 1,2-dibromobutane
b. Propanal

Table 13: Solution to worked example on naming using Table 12

a	Repeating substituent/branch	1,2-di-
	Prefix	- bromo
	Longest continuous chain	But-
	suffix	-ane

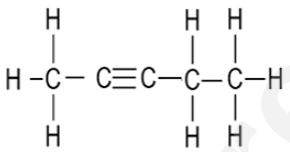
b	Repeating substituent/branch	None
	Prefix	
	Longest continuous chain	Prop-
	suffix	-al

NB: all the **saturated** compounds consist of **-an-** before the **suffix**. i.e. **ONLY** alkenes and alkynes **do not** contain **-an-.**

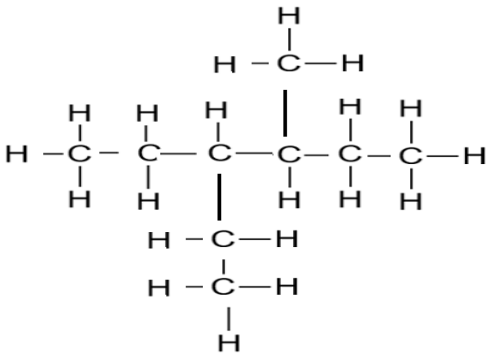
Table 14: Examples on IUPAC naming.

Write down the IUPAC names for the structures below:

1.



2.



Solutions

1. **But-2-yne/2-butyne**

USE IUPAC NAMING RULES TO SHOW HOW TO ARRIVE AT THE FINAL ANSWER

2. **3-ethyl-4-methylhexane**

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Test Yourself

Draw the structural formula of the following organic compounds:

a. Butan-2-ol
b. Hexan-3-one

1.7 Isomers

What are isomers?

- are organic molecules with the **same molecular formula** but with **different structural formula**

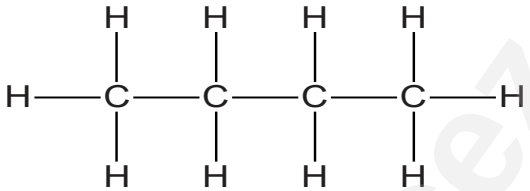
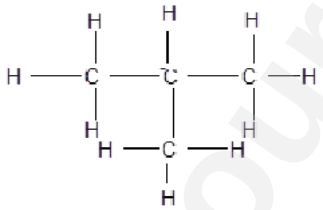
Types of Isomers

1.7.1 Chain Isomers

- have the **same molecular formula**, but **different types of chains**

Table 15: Chain isomers

Example 1

	Molecular Formula	Name of organic molecule
•		Butane
•		2-Methylpropane

Explanation:

- Both butane and 2-methylpropane have:
  - ✓ the same **molecular formulae** C_4H_{10}.
  - ✓ different **structural formulae.**
  - ✓ different **CHAIN LENGTHS.**

1.4.2 Positional Isomers

- have the **same molecular formula**, but **different positions** of the side chain, substituent, or functional groups on the **parent chain.**

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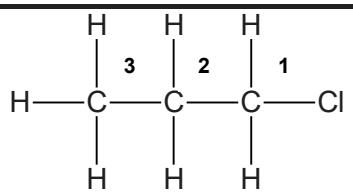
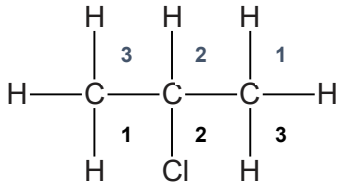
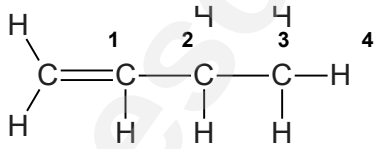
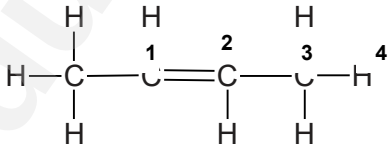
Table 16:
Example 2: Positional isomers.

	Molecular Formula	Name of organic molecule
•		1-chloropropane
•		2-chloropropane

Explanation:
- Both 1- chloropropane and 2-chloropropane have:
  - ✓ the same molecular formulae C_3H_7
  - ✓ different types of functional groups
  - ✓ different POSITIONS OF THE FUNCTIONAL GROUPS (chlorine atom)

Table 17: Example 3: positional isomers

Example 3

	Molecular Formula	Name of organic molecule
•		but-1-ene
•		but-2-ene

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Explanation:

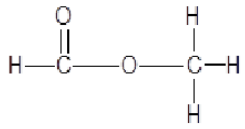
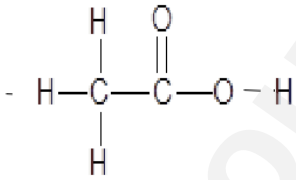
- Both but-1-ene and but-2-ene have:
  - ✓ the **same molecular** formulae C_4H_8.
  - ✓ different structural formulae
  - ✓ different POSITIONS OF THE FUNCTIONAL GROUPS (carbon – carbon double bond).

1.4.3 Functional Isomers

- the same molecular formula, but different functional groups

Table 17: Example 4: Functional isomers

Example 4

	Molecular Formula	Name of organic molecule
•		Methylmethanoate
•		Ethanoic acid

Explanation:

- Both Methylmethanoate and Ethanoic acid have:
  - ✓ the **same molecular** formulae C_2H_4
  - ✓ different structural formulae.
  - ✓ different TYPES OF FUNCTIONAL GROUP.

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Test Yourself

1. Complete the table below:

Table 18: Test Yourself 1

Homologous series	Structural Formula for the Functional Group	General Formula
Alkanes	1.1	1.10
Alkenes	1.2	1.11
Alkynes	1.3	1.12
Alkyl halides	1.4	1.13
Aldehydes	1.5	1.14
Ketones	1.6	1.15
Alcohols	1.7	1.16
Carboxylic acids	1.8	1.17
Esters	1.9	1.18
Marks	**2 x9 =18**	**1x9=9**

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2. Complete the table below:

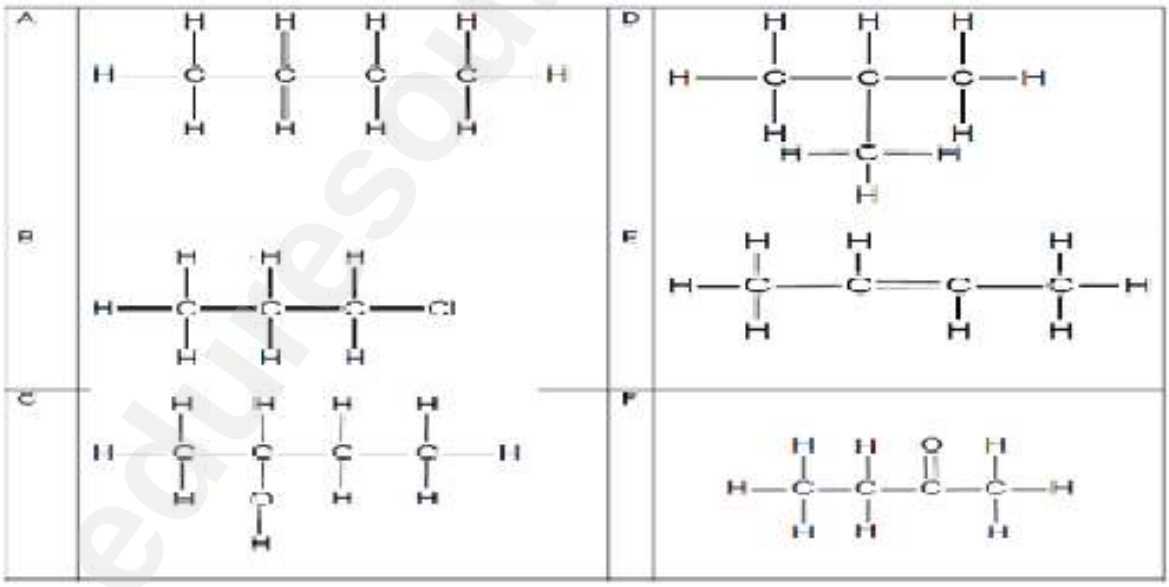
Table 19: Test Yourself 2

Name of organic compound	Structural Formula	Molecular Formula	Homologous Series
Butane	2.1	2.8	2.15
2-methylpropane	2.2	2.9	2.16
Hexane	2.3	2.10	2.17
Pentyne	2.4	2.11	2.18
Butylethanoate	2.5	2.12	2.19
Heptanal	2.6	2.13	2.20
2-methylpropan-ol	2.7	2.14	2.21
Marks	**2x7 = 14**	**1x7=7**	**1x7=7**

3. The table shows structures of 6 organic compounds study them and answer questions that follow.

Test yourself

Table 20: Test yourself 3



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3.1 Write down letters A-F and next to each the IUPAC name of the compound (6)

3.2 From the table, write down the letter which represent the following

3.2.1 Chain isomer of compound A (2)

3.2.2 Unsaturated Hydrocarbon (1)

3.2.3 The Ketone (1)

3.2.4 The compound with hydroxyl group (1)

3.2.5 The compound with carbonyl group (1)

3.3 Draw the structures of the following compounds

3.3.1 The **positional isomer** of compound **B** (2)

3.3.2 The **functional isomer** of compound **F** (2)

4.1 Define the following Terms / Concepts

4.1.1 Organic compound (2)

4.1.2 Homologous Series (2)

4.1.3 Hydrocarbon (2)

4.1.5 Functional group (2)

4.1.6 Chain isomer (2)

4.2 Distinguish between the following:

4.2.1 Saturated and unsaturated hydrocarbons (4)

4.2.2 Positional and functional isomer (4)

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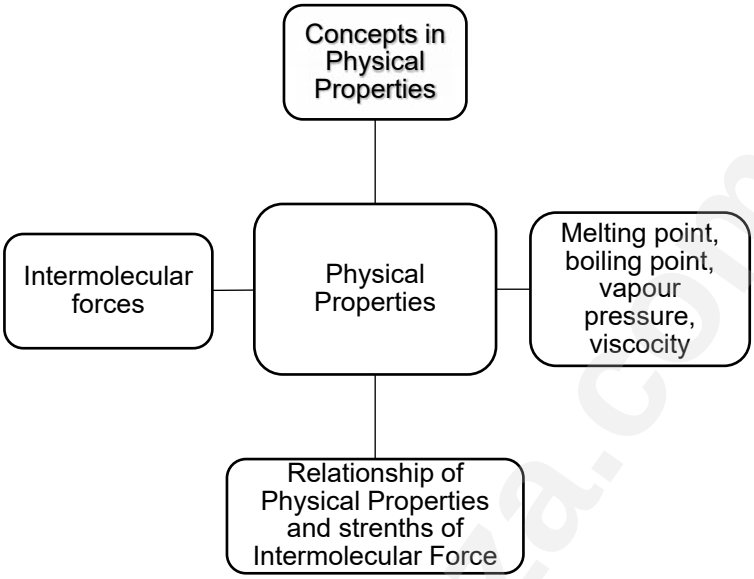
SECTION 2

Physical Properties of Organic Molecules



2.1 Boiling Point, Melting Point, Vapour Pressure and Viscosity.

Table 21: Definitions: Boiling Point, Melting Point, Vapour Pressure and Viscosity.

Concept		Description
•	Boiling point	is the **temperature** at which the **vapour pressure** is **equal** to the **atmospheric** pressure.
•	Melting point	Is the **temperature** at which the **solid and liquid phases** of a substance are **at equilibrium**.
•	Vapour pressure	Is the **pressure exerted** by a **vapour at equilibrium** with its **liquid** in a closed system
•	Viscosity	is the **resistance of a fluid (liquid or gas)** to flow

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2.2 Intermolecular Forces

- are electrostatic forces in between molecules which make substances.

Table 22: Types of intermolecular Forces

Induced dipole / Dispersion / London forces	**Induced dipole / Dispersion / London forces/Dipole-Dipole forces**	**Induced dipole / Dispersion / London forces/Dipole-Dipole forces/Hydrogen bond / London forces**
Alkanes	Halo-alkanes	Alcohols One **(1)** hydrogen bond site
Alkenes	Aldehydes	Carboxylic acids Two **(2)** hydrogen bond sites
Alkynes	Ketones	
	Esters	
Comparison of the strengths of the intermolecular forces		
London < Dipole-dipole<Hydrogen bond		
2.3	**Factors Affecting The Strength of Intermolecular Forces**	
	✓	**Chain Length**: the longer the chain the stronger the **London forces** or the shorter the chain the weaker the **London forces.**
	✓	**Branched chains**: the more the branches the weaker the intermolecular forces – **same homologous series.**
	✓	**Number and Type of intermolecular forces**: Hydrogen Bonds are stronger than Dipole-dipole and London Forces. Dipole- dipole are stronger than London forces. **Different homologous series.**

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2.4 Relationship between Physical Properties And Intermolecular Forces

Table 23: Relationship Between Physical Properties and Intermolecular Forces

	Physical Properties	Relationship to intermolecular forces
•	BOILING POINT	increases with increase in strength of Intermolecular forces. **Or** decreases with decreasestrength of Intermolecular forces
•	MELTING POINT	increases with increase instrength of Intermolecular forces. **Or** decreases with decrease in strength of Intermolecular forces
•	VISCOSITY	increases with increase in strength of Intermolecular forces. **Or** decreases with decrease in strength of Intermolecular forces
•	VAPOUR PRESSURE	increases with decrease in strength of Intermolecular forces. **Or** decreases with increase in strength of Intermolecular forces

Tips on explaining the relationship between physical properties and intermolecular forces

Compare the structures – Chain Length, number of branches or Type and number of intermolecular forces.

Compare the strengths of Intermolecular Forces.

Compare Energy needed to overcome the intermolecular forces.

Conclude on the physical property (higher/lower).

Mention the compounds and intermolecular forces of the compounds in question.

Comparative words to use when the relationship between the strength of intermolecular forces and the Physical properties.

Longer / shorter than (chain length).

More /less branched (chain).

Stronger /weaker than (intermolecular forces).

More/ less (energy needed to overcome intermolecular forces).

Higher /lower than (boiling point/meting point/ vapour pressure/viscosity).

Tips the trends in **Boiling points**/ **Melting points** / **Vapour pressure** / **Viscosity.**

The longer the chain, the higher the melting point.

Carboxylic have more sites of hydrogen bond than alcohols.

The stronger the intermolecular forces, the higher the boiling point.

The weaker the intermolecular forces, the stronger the vapour pressure.

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Worked example 1: Physical properties

The boiling points of straight chain alkanes are invetigated and results are recorded in the table below:

Table 24: Worked example 1 on Physical properties.

	Compounds	**Boiling point (ºC)**
A	Methane	-162
B	Ethane	-89
C	Propane	-42

1.1 Which of the compounds in the table has the longest chain length? (1)

1.2 Explain the increase in boiling points of alkanes, as indicated in the table, by referring to INTERMOLECULAR FORCES. (3)

1.3 Which ONE of COMPOUNDS **A to C** has the HIGHEST VAPOUR PRESSURE? Give a reason for the answer, using the data in the table. (2)

1.4 Which ONE of COMPOUNDS **A to C** has the HIGHEST Viscosity? (2)

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Solutions to worked example

1.1 Alkanes ✓ (1)

1.2 FROM compound A to C

• Chain length/molecular mass INCREASES✓

• STRENGTH of intermolecular forces/London //Dispersion /Induced dipole forces increases. ✓

• More energy is needed to break the Intermolecular forces. ✓

• Therefore the stronger the intermolecular forces the higher the boiling point. (3)

1.3 A ✓LOWEST boiling point.✓ (2)

1.4 C✓ longest chain length ✓ (2)

2. Three compounds are used to investigate **ONE** of the factors that influences boiling point. The results obtained are shown in the table below

	COMPOUND	**Molecular mass(g.mol^{-1})**	**Boiling point(°C)**
A	Butane	58	-0,5
B	Propan-1-ol	60	98
C	Ethanoic acid	60	118

2.1 Write down the type of intermolecular force found in each of the compounds, A-C. (3)

2.2 Which ONE of compounds **A, B** or **C** has the HIGHEST vapour pressure?
Give a reason for the answer by refering to the given data in the table. (2)

2.3 Which ONE of compounds **A, B** and **C** has the HIGHEST boiling point? Explain the answer by refering to intermolecular forces present in EACH compound. (4)

2.4 Which compound, BUTANE and BUTANAL has the higher Melting point?
Explain the answer by refering to the intermolecular forces. (4)

SOLUTIONS TO WORKED EXAMPLES

2.1 A- Dispersion/London/induced dipole intermolecular forces✓
B- Hydrogen Bond ✓
C- Hydrogen Bond ✓ (3)

2.2 A ✓/ Butane.
Lowest boiling point✓/Weakest intermolecular forces. (2)

From A to C

- Compound **A / Butane** consist of LONDON forces/ DISPERSION forces/ INDUCED-DIPOLE FORCES.✓
- Compound **B/propan-1-ol** consist of ONE site for hydrogen bonding.✓
- Compound **C/ ethanoic acid** consist of TWO sites for hydrogen bonding.✓
- Strength of intermolecular forces INCREASE from **A to C.**✓

OR

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- Intermolecular forces in compound **A/butane** are the WEAKEST and intermolecular forces in compound **C/ethanoic acid** are the STRONGEST.✓
- MORE energy is needed to overcome intermolecular forces in compound **C/ethanoic acid**.✓

2.3
- **Butane** consist of LONDON forces/ DISPERSION forces/ INDUCED-DIPOLE FORCES.✓
- **Butanal** consist of DIPOLE-DIPOLE forces.✓
- **DIPOLE - DIPOLE forces** are STRONGER than London forces/ Dispersion forces/Induced-Dipole forces.✓
- **MORE** energy needed to overcome intermolecular forces in **Butanal.**✓ (4)

Table 25: Worked example2 on Physical properties.

ACTIVITY 1

Learners investigate which factor influence the boiling points of **straight-chain alkanes**.
The results are shown in the table below are are given in the table below

Table 26: Activity on Physical properties

	Number of carbon atom	**Boiling point (^{0}C)**
A	1	-162
B	2	-89
C	3	-42
D	4	-0,5

1.1 Which compound (A-D) has the highest vapour pressure? Use the data in the table to explain the answer. (2)

1.2 Explain the **trend** in boiling point of compounds **A to D** by refering to the intermolecular forces. (4)

1.3 Write down the **STRUCTURAL FORMULA** of the CHAIN isomer of compound **D.** (2)

1.4 How will the boiling point of 2-methyl propane compare to that of 2-methyl butane?
Explain the answer by refering to intermolecular forces. (2)

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Activity 2

Three compounds are used to investigate ONE of the factors that influence boiling point. The results are obtained are shown in the table below:

Table 26: Activity 2 on Physical properties

	Compounds	Boiling point(°C)
A	Butane	-0,5
B	Butan-1-ol	117,7
C	Butanoic acid	164

2.1 Is compound **B** a PRIMARY, SECONDARY or TERTIARY alcohol? Give a reason for the answer. (2)

2.2 Write down the NAME and FORMULA for the functional group of

2.2.1 Butanol (2)

2.2.2 Butanoic acid (2)

2.3 Write down the STRUCTURAL FORMULA of a POSITIONAL ISOMER of compound **B.** (2)

2.4 The boiling points increases from compound **A to C**.

Fully explain this trend by refeing to the intermolecular forces present in **EACH** compound. (5)

2.5 Which compound, BUTANE or BUTANONE, has the higher boiling point? Explain the answer by refering to intermolecular forces (4)

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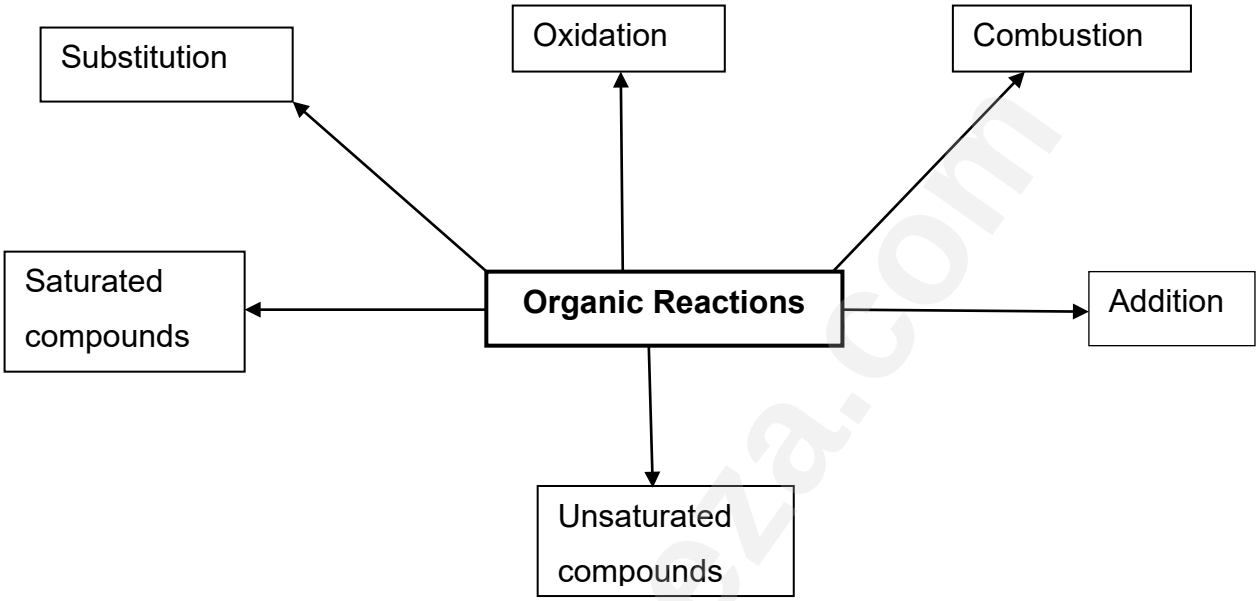
Section 3

Organic Reactions and reaction conditions



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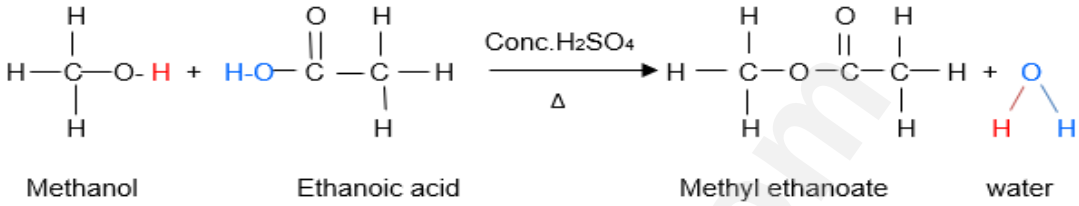
3.1 **FORMATION OF AN ESTER:** Reaction where **an alcohol** and a **carboxylic acid** are heated in the presence of concentrated sulphuric acid (H_2SO_4).

Alcohol + Carboxylic Acid ⟶ Ester + water



Reaction conditions: Concentrated **H_2SO_4**and **Heat**

NOTE! Name of ESTER = First part come from **alcohol** + Second part come from **carboxylic acid**

ABOVE example:

ALCOHOL + CARBOXYLIC ACID → ESTER

Methanol + Ethanoic acid ⟶ Methylethanoate

Explanation / Discussion

- The part of Carbon (**C**) - chain attached to the Oxygen (**O**) represent alcohol.
- The part of **C**-chain attached to **C= O** part, represent the carboxylic acid side

Why do we use a water bath instead of direct heat?

➢ Because **ALCOHOL** is **HIGHLY FLAMMABLE.**

3.2 **Combustion / Oxidation Reactions of Hydrocarbons (alkanes, alkenes, alkynes)**

Hydrocarbon **+** O_2 ⟶ CO_2 **+** H_2O

Examples:

- $2\ C_3H_6 + 9\ O_2 \longrightarrow 6\ CO_2 + 6\ H_2O$
- $2\ C_4H_{10} + 13\ O_2 \longrightarrow 4CO_2 + 5\ H_2O$

3.3 **SUBSTITUTION REACTIONS**

3.3.1 **Halogenation**

Alkane + Halogen $\xrightarrow{hf,\ \Delta}$ Haloalkane + HX

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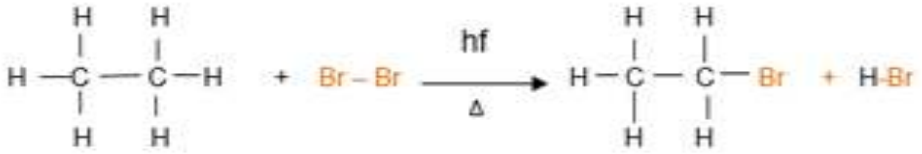
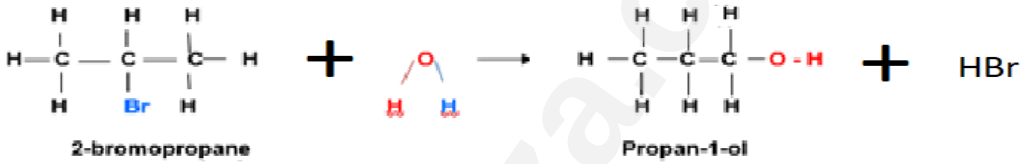
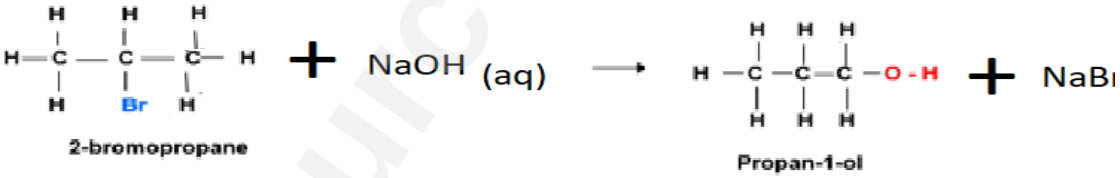
Example



Reaction condition: Uv – light / sunlight / heat / hf / Δ

3.3.2 Hydrolysis of haloalkanes – replace halogen atom with -O-H to form alcohol.





Reaction conditions: High temperatures

3.4 ADDITION REACTIONS

- unsaturated organic compound becomes Saturated organic compounds.
- reactions where atoms are added to an organic molecule.
- the double bonds break open and the new atoms are added to the carbon atoms on either side of the double bond
- **hydrogen (H_2),** a **halogen** (Group 7 – e.g. Cl_2), a **Hydrogen halide** or **water H_2O** are added to **unsaturated hydrocarbons (alkenes).**

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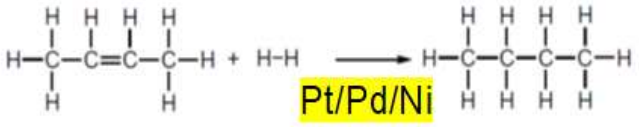
3.4.1 **Hydrogenation –** Addition of **hydrogen (H_2)**

$$\text{Alkene} + H_2 \xrightarrow{Pt\ \Delta} \text{Alkane}$$



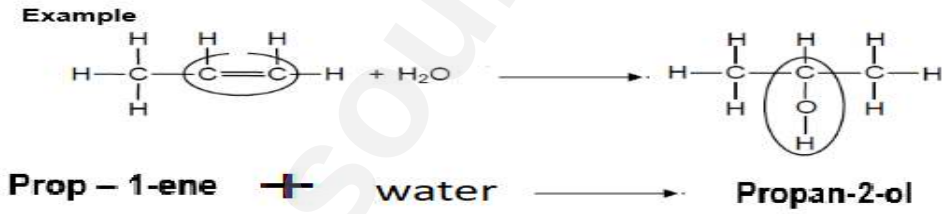
But-2-ene + Hydrogen ⟶ ane

Reaction conditions: Needs **heat** and a **catalyst**(Platinum (Pt) / Nickel (Ni) / Paladium(Pd)

3.4.2 **Hydration** –Addition of water (H_2O)

$$\text{Alkene} + H_2O \xrightarrow{\text{Conc. } H_2SO_4} \text{Alcohol}$$

Example



Reaction conditions:

- (**Excess) water** / H_2O in conc H_2SO_4.
- **Diluted** Sulphuric acid / H_2SO_4.

NB: Sulphuric acid **(H_2SO_4)** acts as a catalyst.

- The **DOUBLE BOND** between C atoms split to form **A SINGLE BOND.**
- Each of these TWO C-atoms gain a BOND.
- The H^+ will bond to the C atom with the **MOST H's.**
- The OH will bond with C with the LEAST H's.

3.4.3 **Halogenation**- addition of two of the same halogen atoms eg. Cl_2 or Br_2.

$$\text{Alkene} + X_2 \longrightarrow \text{Haloalkane}$$

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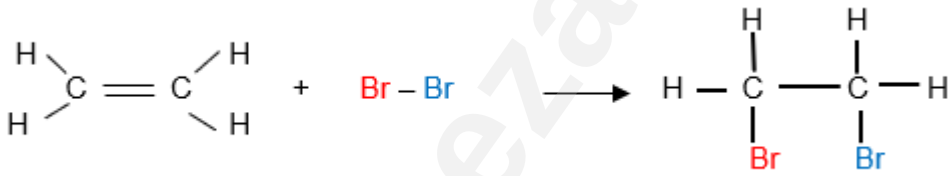
3.4.4 Hydrohalogenation– Addition of a **halogen atom attached to a hydrogen atom.**

Alkene + HX ⟶ Haloalkane

Ethene + Hydrogen bromide ⟶ 1- Bromoethene

Reaction conditions: NO water / H_2O

Example:



Reaction conditions: NO water/ Non- Polar solvent

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SECTION 4: PLASTIC AND POLYMERS

4.1 DEFINITIONS

	TERMS / CONCEPTS	DESCRIPTION / EXPLANATION
•	Macromolecule	a **molecule** that consists of a **large number of atoms**
•	Polymer	a **large molecule** composed of **smaller monomer units covalently bonded** to each other in a **repeating pattern**
•	Monomer	**small organic molecules** that can be **covalently bonded** to each other in a **repeating pattern**
•	Plastics	**synthetic materials** derived from **organic compounds.**
•	Polymerisation	a **chemical reaction** in which **monomer molecules join** to form a **polymer**

4.2 **Industry uses of Polythene**

- Polythene is used for manufacture:
  - ✓ Plastic bags
  - ✓ Plastic Squeeze bottles
  - ✓ Cling wrap
  - ✓ Bullet proof vests

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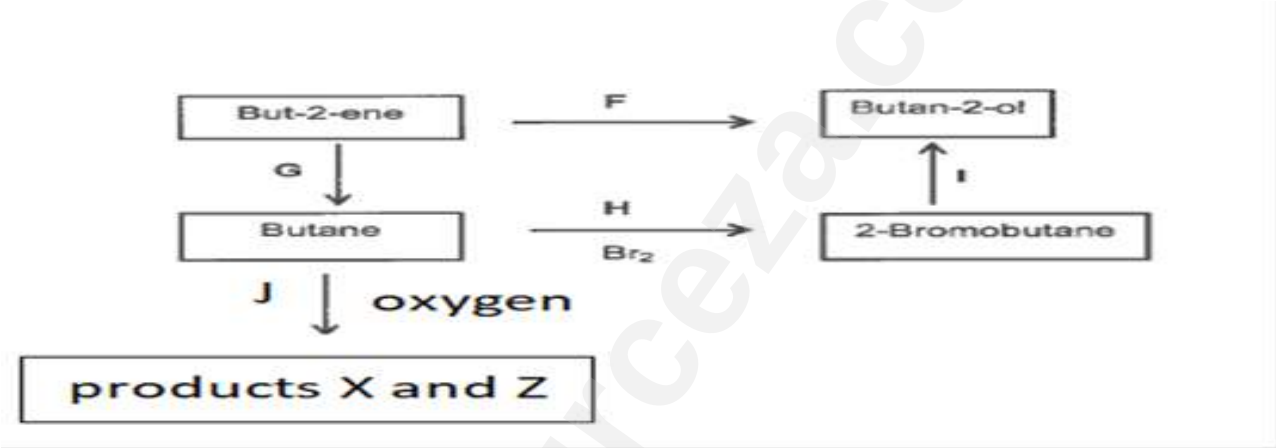
Worked Example

Refer to both the passage and flow diagram to answer the questions that follow:

Fossil fuel is a general term for buried combustibles geologic deposits of organic materials. These deposits are formed from decayed plants and animals that have been converted to crude oil, coal, natural gas, or heavy oils by exposure to heat and pressure in earths 's crust over hundreds of millions of years. Alkanes are the most important fossil fuels. Some countries like Canada produce 18.3 billion cubic feet of natural gas per day. Propane is produced as a by-product of two other processes, natural gas processing and petroleum refining. Propane is a cleaner-burning alternative fuel. Butane is another gaseous fuel derived from petroleum. The reactions that are undergone by propane are summarized in the flow diagram below.



1.1 In which phase does butane occur at room temperature? (1)

1.2 Draw the structural formula of propane (2)

1.3 Give one important use of Alkanes (1)

1.4 Write down the type of reactions represented by

1.4.1 F (1)

1.4.2 G (1)

1.4.3 H (1)

1.5 During reaction, **I**, the Haloalkane reacts in the presence of a base to form an alcohol.

Write down:

1.5.1 the **Name** of the suitable base used in the reaction. (1)

1.5.2 the reaction conditions required in required in the reaction. (2)

1.6 With the use of molecular formulae write down a balance chemical reaction for reaction **J.** (3)

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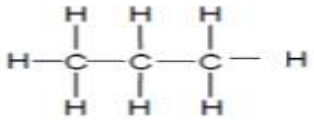
SOLUTIONS TO WORKED EXAMPLES

1.1 Gas ✓ (1)

1.2



✓✓ (2)

1.3 Used as fossil fuels✓ (1)

1.4.1 Addition -Hydration✓ (1)

1.4.2 Addition- hydrogenation✓ (1)

1.4.3 Substitution - halogenation✓ (1)

1.4.4 Substitution - Hydrolysis✓ (1)

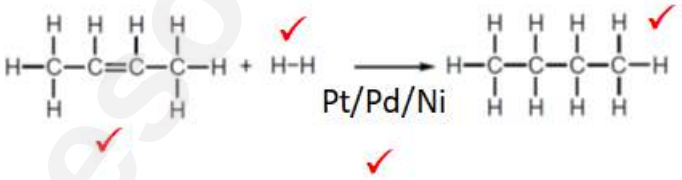
1.4.5 Combustion/ oxidation✓ (1)

1.5.1 Sodium hydroxide/Potassium hydroxide ✓**(Penalize if chemical formula is written).** (1)

1.5.2 A dilute strong base✓ and **mild** heat ✓**(Penalize if only heat is written.)** (2)

1.6 $2C_4H_{10} + 13O_2$✓ $\longrightarrow$ $8CO_2$✓ $+ 10H_2O$ ✓ (3)

2.1



(4)

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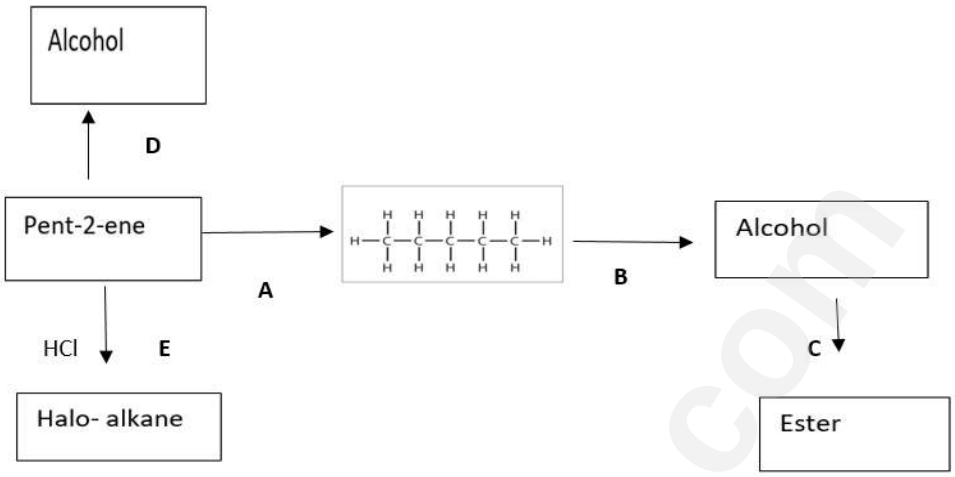
ACTIVITY 2

Consider the flow diagram below and answer questions that follow



1.1 What type of reaction is represented by each of the following:

1.1.1 A (1)

1.1.2 B (1)

1.1.3 C (1)

1.1.4 D (1)

1.2 Both reaction B and D produce alcohol as the product through different reaction types.

1.2.1 Explain the difference in these reactions. Refer to **SATURATED/UNSATURATED** status of hydrocarbons, **REACTION TYPE(S)** in each reaction and **REACTION CONDITIONS** required. (3)

1.3 Give the IUPAC name of the alcohol(s) formed in reaction

1.3.1 D (1)

1.3.2 B (1)

1.4 Draw the structural formula of halo-alkane formed in reaction E (2)

1.4.1 Is the Haloalkane formed a major or a minor product? (1)

1.5 Use structural formula to write down a balanced equation between methanoic acid and alcohol formed in reaction **B. NOTE: Both alcohol and carboxylic acid must be correctly oriented.** (4)

1.5.1 What type of alcohol is formed in reaction **D**?

Write only primary/secondary/tertiary (1)

1.6 Write down the formula for the inorganic product formed in reaction **C** (2)

1.7 What is type of reaction is reaction **C**? (1)

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2.1 Write down the reaction conditions for the following Reactions

2.1.1 **B** (1)

2.1.2 **C** (1)

2.1.3 **D** (1)

2.1.4 **E** (1)

2.2 Write down one use of alcohols. (1)

ACTIVITY 3

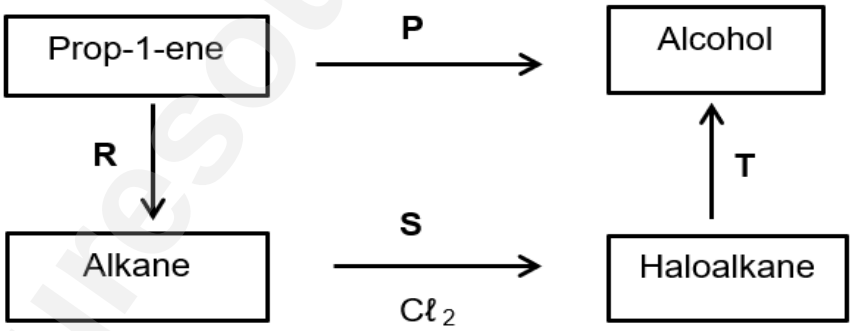
Fossil fuels are formed by the natural process of decomposition of organisms under heat and pressure. They contain a high percentage of carbon and include fuels such as coal, petrol, and natural gases. Alkanes are the most important fossil fuel. The combustion of alkanes (also known as oxidation) is highly exothermic.

3.1 Why are alkanes referred to as organic compounds (1)

3.2 Write down the reaction condition for the complete combustion/oxidation of alkanes (1)

3.3 Write a balanced equation using molecular formulae to show the complete combustion reaction of propane. (3)

3.4 Prop-1-ene can be converted to other compounds by means of different organic reactions represented by **P**, **R**, **S** and **T**, as shown below.



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3.4.1 Why is propene referred to as a hydrocarbon? (1)

3.4.2 Is propene as saturated or an unsaturated hydrocarbon? (1)

3.4.3 Explain your answer in 2.4. (1)

4.5 Write down the TYPE of the reaction represented by

4.5.1 P (1)

4.5.2 S (1)

4.5.3 R (1)

4.6 Using structural formulae, write down structural balanced equation for reaction **P** (3)

4.7 What are the reaction conditions for reaction **S**? (1)

4.8 Write down the IUPAC name for:

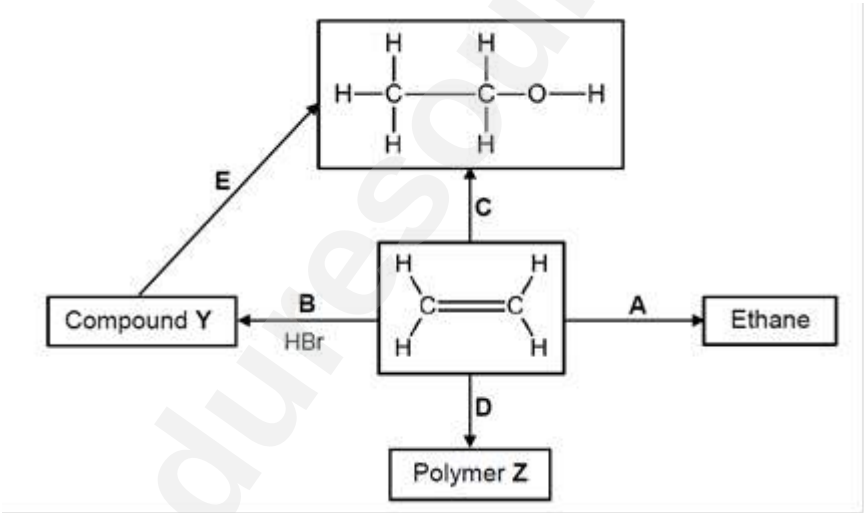
4.8.1 The Haloalkane formed in reaction **S** (1)

4.8.2 The alcohol formed in reaction **T** (1)

4.9 Draw the structural formula for the alcohol mentioned in 4.8.2 above (2)

ACTIVITY 4

The diagram below shows how ETHENE can be converted into other organic compounds. The letters **A, B, C, D** and **E** represent different organic reactions



3.1 Reaction E and C produce an alcohol; classify the alcohol as **Primary / secondary/ tertiary**.

3.1.1 **C** (1)

3.1.2 **E** (1)

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3.2 Write down the type of addition reaction represented by:

3.2.1 **A** (1)

3.2.2 **B** (1)

3.3 Consider reaction **A**. Write down the NAME or FORMULA of the:

3.3.1 Inorganic reactant needed. (1)

3.3.2 Catalyst needed. (1)

3.4 Write down:

3.4.1 the **structural FORMULA** of the **functional group** of compound **Y**. (2)

3.4.2 The IUPAC name of compound **Y**. (2)

3.4.3 Two reaction conditions for reaction E (2)

3.5 Use structural formulae to write down the balanced equation for reaction **C**. (3)

3.6 Reaction **D** represents a Polymerization reaction

3.6.1 Define Polymerization (2)

3.6.2 Distinguish between a polymer and a monomer. (4)

3.7 Write down

3.7.1 the IUPAC name of the MONOMER used in reaction **D**. (1)

3.7.2 the IUPAC name of polymer **Z** (1)

3.8 Define plastics. (2)

3.9 Give two industrial uses of Polyethene (2)

[29]

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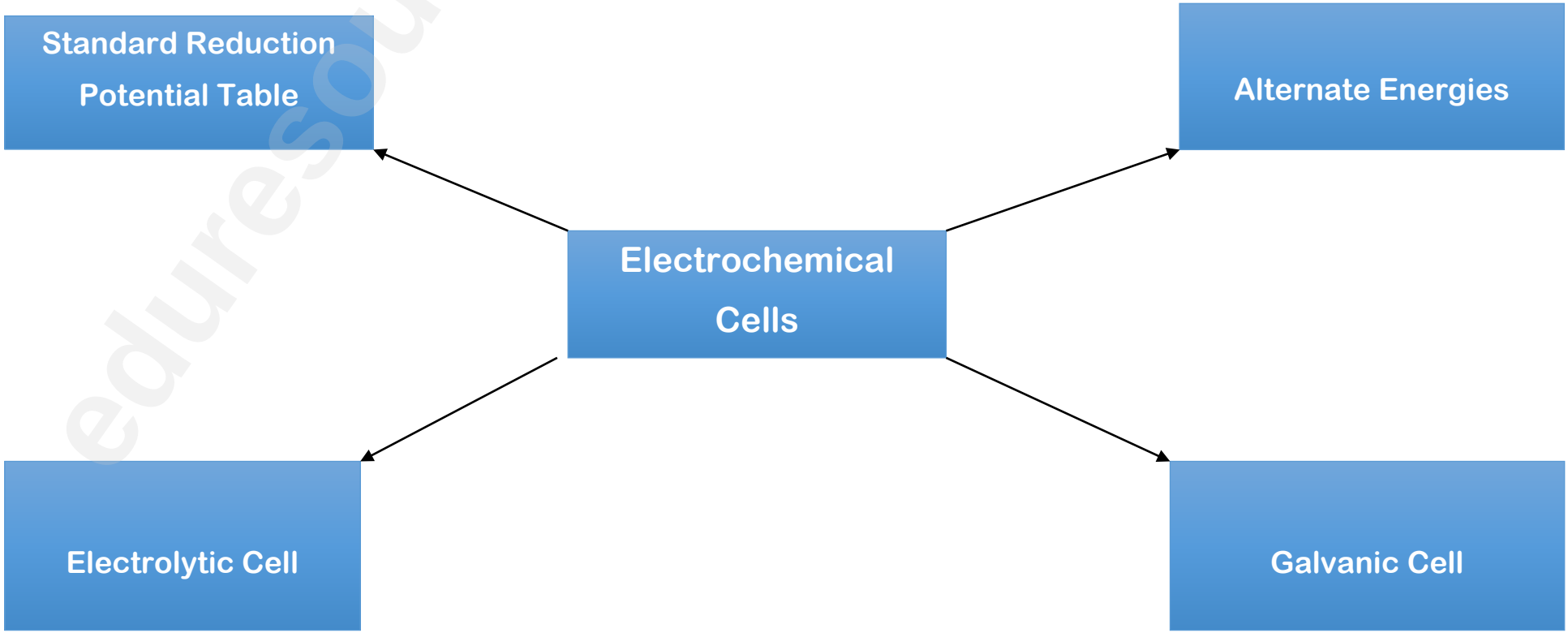
ELECTROCHEMICAL CELLS

Outline of Electrochemical Cells



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Unit 1

	Concept	Description /Explanation
1.1	Oxidation	is the loss of electrons.
1.2	Reduction	is the gain of electrons.
1.3	Oxidizing agent	is a substance that is reduced/ gains electrons OR substance that undergoes reduction.
1.4	An electrolyte	is a substance that contains free ions, and which therefore behaves as an electrical conductor.
1.5	Electrolysis	is the decomposition of a substance when electric current is passed through it. **OR** is the chemical process in which electrical energy is converted to chemical energy. **OR** is the use of electrical energy to produce chemical change.
1.6	An electrode	is an electrical conductor that is used to contact a metallic part of a circuit.
1.7	An anode	is an electrode where **oxidation** takes place.
1.8	A cathode	is an electrode where **reduction** takes place.
1.9	An anion	is a negative ion.
1.10	A cation	is a positive ion.

Unit 2
Standard Reduction Potential Table

Section of the TABLE OF STANDARD REDUCTION POTENTIALS (4B)

Most negative reduction potential
Weakest oxidising agent

Most negative reduction potential
Strongest reducing agent

$Ni^{2+} + 2e^-$	⇌	Ni	− 0,27
$Sn^{2+} + 2e^-$	⇌	Sn	− 0,14
$Pb^{2+} + 2e^-$	⇌	Pb	− 0,13
$Fe^{3+} + 3e^-$	⇌	Fe	− 0,06
$2H^+ + 2e^-$	⇌	$H_2(g)$	0,00
$S + 2H^+ + 2e^-$	⇌	$H_2S(g)$	+ 0,14
$Sn^{4+} + 2e^-$	⇌	Sn^{2+}	+ 0,15
$Cu^{2+} + e^-$	⇌	Cu^+	+ 0,16
$SO_4^{2-} + 4H^+ + 2e^-$	⇌	$SO_2(g) + 2H_2O$	+ 0,17
$Cu^{2+} + 2e^-$	⇌	Cu	+ 0,34
$2H_2O + O_2 + 4e^-$	⇌	$4OH^-$	+ 0,40
$SO_2 + 4H^+ + 4e^-$	⇌	$S + 2H_2O$	+ 0,45

Most positive reduction potential
Strongest oxidising agent

Most positive reduction potential
Weakest reducing

Adapted from 2019 Physical Sciences National Diagnostic Report

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2.1 Standard Reduction Potential Table

Standard Reduction Potential Table: is a table lists the standard electrode potentials (E^{θ} values) for various compounds.

- standard potentials are listed as **Reduction Potentials.**
- substances are written as atoms, ions, or gasses in the table.

Reduction Potential: is an ability of a substance to undergo reduction.

- is measured under **Standard Conditions**.

Standard conditions for measuring Standard Reduction potential

- **Temperature:** 298 K (25°)
- **Concentration of electrolytes**: 1 mol·dm^{-3}
- **Pressure:** 101,3 kPa (1 atmosphere) **(ONLY** where gases are involved**)**

The tables of Standard Reduction Potentials can be used to:

- identify oxidizing and reducing agents.
- write balanced redox reaction equations.
- predict whether a redox reaction takes place spontaneously or not.
- calculate the ***emf*** of a cell.

NB: All half-reactions are written as reductions when proceeding from left to right.

- **Oxidising agents** are on the left-hand side of Tables 4A and 4B e.g. Li^+, H^+, F_2
- **Reducing agents** are on the right-hand side of Table 4A and 4B. e.g. Li, H_2, F^-.
- ***Reduction Potential Tables 4A and 4B*** *are attached as part of the data sheets*

2.2 Standard Hydrogen electrode

- Standard Hydrogen electrode (0,00V) is the **reference** electrode.

2.3 Oxidising agents and Reducing agents:

2.3.1 Oxidising agents

- Li^+ is the **weakest** oxidising agent.
- F_2 is the **strongest** oxidising agent.
- the one with a **higher** reduction potential between the two will **readily undergo reduction** and will be an **oxidising agent**.

2.3.2 Reducing agents

- F^- is the weakest reducing agent.
- Li is the strongest reducing agent.
- the one with a **lower** reduction potential between the two will **readily undergo oxidation** and will be a **reducing agent**.

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Oxidising agents are **reduced** – undergo **reduction** – **GAIN** ELECTRONS
Reducing agents are **oxidised** – undergo **oxidation** – **LOSE** ELECTRONS

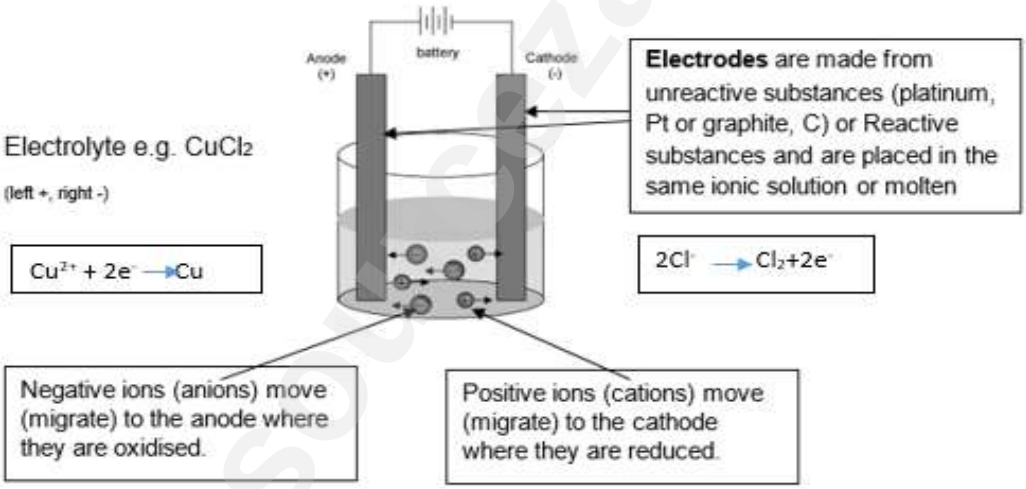
2.4. Summary

- A redox reaction will always take place between an **oxidising** agent and a **reducing** agent.
- Species on the **left** of Table **4A** or **4B** will react with species on the **right.**
- **Spontaneous Reaction** will always take place between the **stronger reducing** agent and the **stronger oxidising** agent.

Unit 3: Electrolytic Cell

An **electrolytic cell** is a cell in which electrical energy is converted into chemical energy. (Nonspontaneous cell).

3.1 Components of and Electrolytic Cell



3.2. Anode and Cathode

Anode	Cathode
• **Oxidation half-reaction** at the **anode** (e^- are given off).	• **Reduction half-reaction** at the **cathode** (e^- are taken in) written as is from the SRP table.
• The anode **decreases** in mass. Solid will **corrode.**	• The cathode **increases** in mass Solid will be **deposited.**
• Anions migrate towards the anode	• Cations migrate towards the cathode.
• **Positive** electrode.	• **Negative** electrode.
• **Reducing Agent is found at anode**	• **Oxidising Agent is found at anode**

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3.6 Tips on answering questions

- ✓ Use single arrow when writing equations.
- ✓ Do not omit charges in ions and electrons.
- ✓ When writing a formula for a two letter compound the first letter must be a capital letter and the second one a small letter e.g. CL is not correct, but Cl is correct.
- ✓ Pay attention to the suffixes of ions e.g. Cl^- is called a chloride ion not a chlorine ion.
- ✓ When writing a reduction reaction, you only remove the arrow pointing backwards and write the equation as it is from the Standard Reduction Potential table.

Worked examples

QUESTION 1

1.1 An ionic solution that conducts electricity

A Electrical conductor

B Galvanic cell

C Electrolytic cell

D Electrolyte (2)

1.2 The reactant that donates electrons during a redox reaction

A Oxidising agent

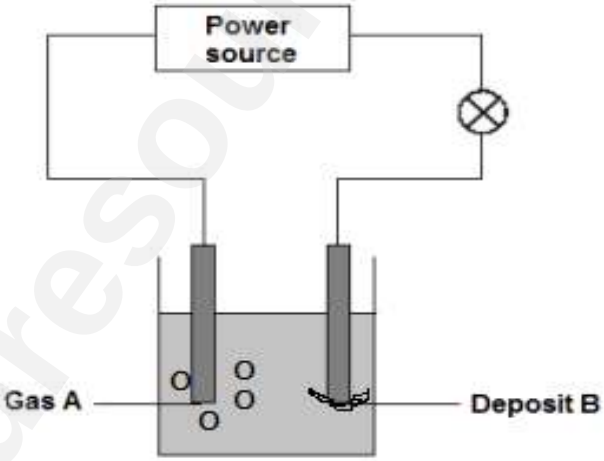
B Reducing agent

C Electrode

D Salt bridge (2)

QUESTION 2

Consider the diagram below and answer the questions below



2.1. Define the term electrolysis (2)

2.2. What ion is responsible for the blue colour of the copper chloride solution. (1)

2.3 Write down the

2.3.1 Name gas A (1)

2.3.2 Name of the deposit B (1)

2.4 Give one industrial application of electrolysis. (1)

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2.5 Write down the half reaction that occurs at the:
2.5.1 Cathode (2)
2.5.2 Anode (2)
2.6 Use the half reactions in question 2.5.1 and 2.5.2 to write down the net ionic equation for the reaction. (2)
2.7. Name the energy conversion that takes place in an electrolytic cell. (2)
2.8 What type of energy source is used in and electrolytic cell? Write AC or DC. (1)
2.9 Explain the answer in 2.8. (2)

Solutions

1.1 D ✓✓ (2)

1.2 B ✓✓ (2)

2.1 A process whereby electrical energy is converted into chemical energy✓✓ (2)

2.2 Cu^{2+}✓ (1)

2.3.1 Chlorine✓ (1)

2.3.2 Copper✓ (1)

2.4

- Appearance Decorations
- Protection against corrosion.
- Special surface properties

✓ any one (1)

2.5.1 $Cu^{2+} + 2e^- \rightarrow Cu$ ✓✓ (2)

2.5.2 $2\ Cl^- \rightarrow Cl_2 + 2e^-$ ✓✓ (2)

2.6 $Cu^{2+} + 2\ Cl^- \rightarrow Cl_2 + Cu$ ✓✓ (2)

2.7 Electrical energy is converted to Chemical energy✓ (1)

2.8 DC✓ (1)

2.9 So that electrons can flow in only one direction✓ (1)

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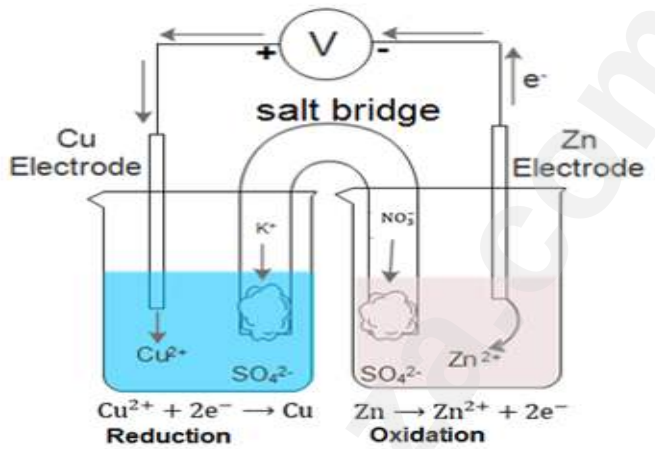
Unit 4: Galvanic Cell

A **galvanic (voltaic) cell** as an electrochemical cell that converts chemical energy to electrical energy. (**Spontaneous cell**).

4.1. Components of a Galvanic Cell



Explanation

- In the zinc-copper cell, the copper and zinc plates are called the **electrodes.**
- The electrode where **oxidation** occurs is called the **anode**, and the electrode where **reduction** takes place is called the **cathode**.
- In the zinc-copper cell, the zinc plate is the anode and the copper plate is the cathode.
- Two half cells are connected to an external wire (electrons flow towards the cathode) AND a salt bridge (anions migrate towards the anode and the cations migrate towards the cathode)

4.2 Functions of a Salt Bridge:

- ✓ Completes the circuit.
- ✓ Ensures electrical neutrality(Allows movement of ions between the electrolytes, i.e. it acts as an ion exchanger)
- ✓ Keeps the two electrolytes in the two half-cells separate so that they do not mix.

4.3 Reduction and Oxidation half reactions

- A redox reaction can be broken up into an oxidation half-reaction and a reduction half-reaction.
- The one half-reaction must show a gain of electrons and the other reaction must show a loss of electrons.
- For every oxidation, there has to be a reduction, and vice versa.
- A half-reaction cannot occur on its own.

In a Zinc/copper cell:

The half-reaction that takes place at the zinc plate is:

$Zn \rightarrow Zn^{2+} + 2e^-$ (**Oxidation half reaction**)

The half-reaction that takes place at the copper plate is:

$Cu^{2+} + 2e^- \rightarrow Cu$ (**Reduction half reaction**)

The overall reaction is:

$Zn + Cu^{2+} + 2e- \rightarrow Zn^{2+} + Cu + 2e^-$ or, if we cancel the electrons:

$Zn + Cu^{2+} \rightarrow Zn^{2+} + Cu$

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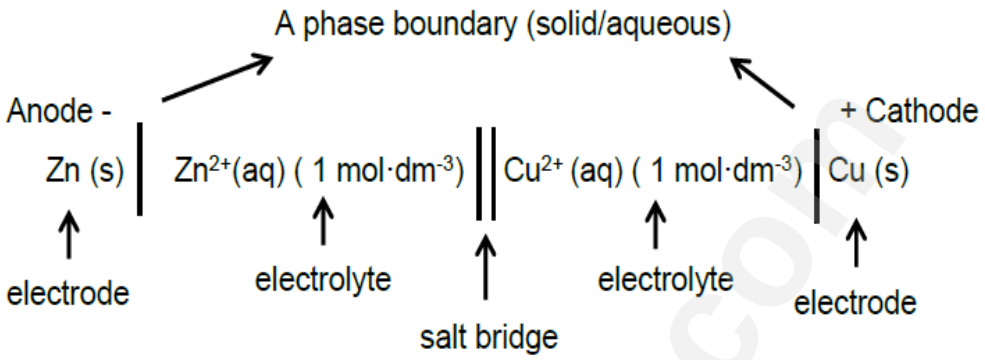
4.4. Standard cell notation

For this electrochemical cell, the standard notation is:



4.5 Standard conditions

- The emf of the cell or cell potential is a maximum under **standard conditions.**

Standard Conditions:

- ✓ Temperature 298 K/ 25^0 C
- ✓ Pressure of 101,3 Pa (applies when gases are involved)
- ✓ Concentration of electrolyte of 1 mol.dm^{-3}

4.6. Emf of a cell

$$E^0_{cell} = E^0_{cathode} - E^0_{anode}$$

For example, in the case of Zn-Cu cell, the half equations that represent the correspondent reactions are the following:

$Cu^{2+}_{(aq)} + 2e^- \rightleftharpoons Cu_{(s)}$ $E^0 = +0,34$ V

$Zn^{2+}_{(aq)} + 2e^- \rightleftharpoons Zn_{(s)}$ $E^0 = -0,76$ V

$E_0 = +0,34 - (-0,76)$

= + 1,1 V

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4.7. Summary

Anode	Cathode
Oxidation half-reaction at the anode (electrons are given off).	**Reduction half-reaction** at the **cathode** – written as is from the Standard Reduction Potential table
always the negative electrode	always the **positive** electrode.
Lower Reduction potential	**Higher Reduction potential**
Anions migrate towards the anode	Cations migrate towards the cathode
The anode decreases in mass. Solid will corrode	The cathode **increases** in mass Solid will be **deposited**
Negative electrode	Positive electrode
Reducing Agent is found at Anode	Oxidising Agent is found at Anode

4.8. Question structure and tips

- ✓ Energy conversion
- ✓ Functions of a salt bridge
- ✓ Movement of cat ions OR an ions
- ✓ Standard conditions
- ✓ Identify anode and cathode
- ✓ Identify oxidising agent and a reducing agent
- ✓ Write half reactions at anode and cathode
- ✓ Write net reaction
- ✓ Calculate emf of a cell

4.9. Exam tips

- ✓ Use single arrow when writing equations
- ✓ Do not omit charges in ions and electrons
- ✓ When writing a formula for a two letter compound the first letter must be a capital letter and the second one a small letter e.g. CL is not correct, but Cl is correct.
- ✓ When writing a reduction reaction you only remove the arrow pointing backwards and write the equation as it is from the Standard Reduction Potential table.
- ✓ Solutions in your half cells must be of the same anions eg in a zinc/copper cell $ZnSO_4$ must go with $CuSO_4$ OR $ZnCl_2$ must go with Cu Cl_2

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Worked examples.

MULTIPLE-CHOICE QUESTIONS

1.1 In an electrochemical cell, what relationship must be TRUE about the values of $E^{\ominus}_{oxidising\ agent}$ and $E^{\ominus}_{reducing\ agent}$ for the reaction to occur spontaneously under standard conditions?

A. $E^{\ominus}_{reducing\ agent} > 0$ and $E^{\ominus}_{oxidising\ agent} > 0$

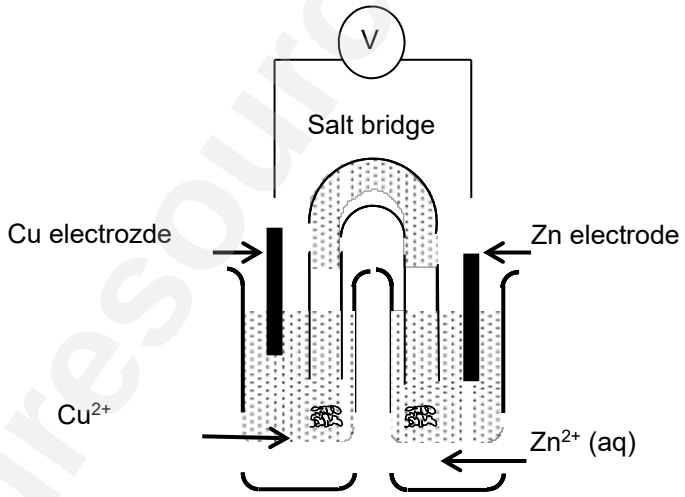
B. $E^{\ominus}_{reducing\ agent} < 0$ and $E^{\ominus}_{oxidising\ agent} < 0$

C. $E^{\ominus}_{reducing\ agent} > E^{\ominus}_{oxidising\ agent}$

D. $E^{\ominus}_{reducing\ agent} < 0$ and $E^{\ominus}_{oxidising\ agent} > 0$ (2)

QUESTION 6 (Start on a new page.)

6.1 A learner constructed an electrochemical cell using copper and zinc electrodes. The cell was set up as illustrated below.



6.1.1 Identify the type of electrochemical cell shown in the diagram above. (1)

6.1.2 Which energy conversion occurs in this cell? (2)
6.1.3 Write down TWO functions of the salt bridge. (2)
6.1.4 What is the direction of electron flow? (2)
6.1.5 Why is KNO_3 the preferred electrolyte to be used in the salt bridge instead of $BaCl_2$? (2)

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6.2 For this cell:

6.2.1 Write down the net reaction. (2)

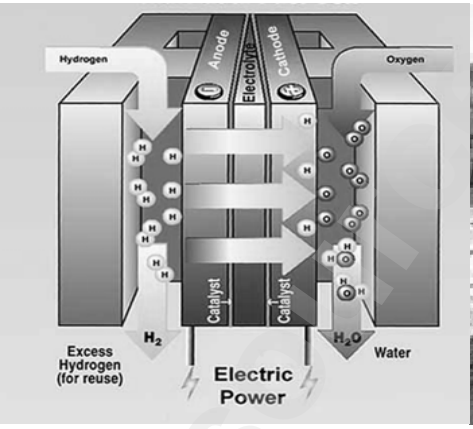
6.2.2 Give the standard conditions. (2)

6.2.3 Write down the cell notation. (3)

6.3 **HYDROGEN-FUELLED CAR**

The hydrogen car, developed in Norway, uses electric current and hydrogen gas instead of fossil fuels. The maintenance free batteries give the car a range of 125 km, which covers daily driving needs easily. The batteries can be charged using a plug or a hydrogen fuel cell while driving. The hydrogen tank doubles the driving range to 250 km and can be refilled in a few minutes. Finally, a zero-emissions vehicle is available.

[Source: http://www.pivco.no/content.php?id=40]



Individual fuel cell used in hydrogen-fuelled car

Hydrogen-fuelled car

6.3.1 Give TWO emissions that ordinary petrol-powered cars would produce? (2)

6.2 Give ONE:

6.2.1 Advantage of a hydrogen-fuelled car (1)

6.2.2 Disadvantage of a hydrogen-fuelled car (1)

[20]

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Solution

QUESTION 1

1.6 D ✓✓ (2)

QUESTION 6

6.1.1 Galvanic/Voltaic cell ✓ (1)

6.1.2 From chemical energy to electrical energy ✓✓ (2)

6.1.3
- Provides medium to allow for mobility of charge,i.e.allows charge to move through the cell effectively. ✓
- Maintains electrical neutrality in the cell.✓
- It completes the circuit ✓ (Any two) (2)

6.1.4 From the zinc (electrode) ✓to the copper (electrode) ✓

OR
From anode ✓ to cathode ✓

(Accept: From negative to positive electrode (2)

6.1.5 $BaSO_4$ will form a precipitate✓ and prevent the movement of ions✓ between the two half-cells. (2)

6.2.1 $Zn + Cu^{2+}$✓$\rightarrow Zn^{2+} + Cu$ ✓ (2)

6.2.2 Concentration (of electrolyte) = 1 mol·dm^{-3} ✓
Temperature = 25° C/298 K (2)

6.2.3 Zn (s)| $Zn^{2+}(1mol.dm^{-3})_{(aq)}$ ✓‖✓$Cu^{2+}(1mol.dm^{-3})_{(aq)}$| Cu (s) ✓
(Accept: Zn (s)| $Zn^{2}{}_{+(aq)}$ ✓‖✓$Cu^{2+}{}_{(aq)}$| Cu (s) ✓
(Do not penalise if phases are not included) (3)

6.3.1 CO_2, CO, NO, NO_2, SO_2 (ANY 2 gases) ✓✓ (2)

6.3.2 It does not produce harmful substances✓ (1)

6.3.3 *A car can travel a maximum of 250 km (before refilling).*✓ (1)

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Complete the table below to show the differences between Electrolytic cell and Galvanic cell.

	Electrolytic cell	Galvanic cell	Marks
Energy conversion			(4)
Spontaneous/ Non-spontaneous			(2)
Exothermic/Endothermic			(2)
Cathode (Positive/Negative)			(2)
Salt bridge/No salt bridge			(2)
Emf (Positive / Negative)			(2)
Power source (YES/NO)			(2)

Solutions

	Electrolytic cell	Galvanic cell
Energy conversion	Electrical energy is converted to Chemical energy✓✓	Chemical energy is converted to Electrical energy✓✓
Spontaneous/ Non-spontaneous	Non-spontaneous✓	Spontaneous✓
Exothermic/Endothermic	Endothermic✓	Exothermic✓
Cathode (Positive/Negative)	Negative✓	Positive✓
Salt bridge/No salt bridge	No salt bridge✓	Salt bridge✓
Emf (Positive / Negative)	Negative✓	Positive✓
Power source (YES/NO)	YES✓	NO✓

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ACTIVITIES
QUESTION 1: MULTIPLE-CHOICE QUESTIONS

Various options are provided as possible answers to the following questions. Choose the answer and write only the letter (A–D) next to the question number (1.1–1.10) in the ANSWER BOOK, for example 1.11 E.

1.1 The organic compound below is an example of a …

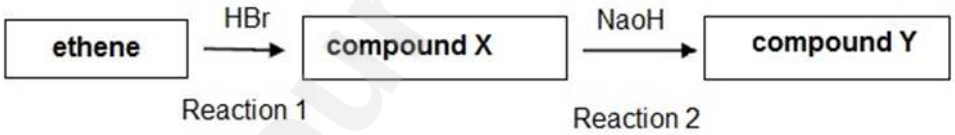
C_3H_7Cl

A haloalkane.
B alcohol
C aldehyde.
D alkane (2)

1.2 The IUPAC name of the following compound is …

A propanone
B propanal.
C propanoic acid.
D propanol. (2)

1.3 Ethene can be converted into other carbon-containing compounds using the reactants shown in the following flow chart.



Compounds **X** and **Y** are respectively:

	X	Y
A	bromoethane	methanol
B	bromoethane	ethanol
C	bromoethene	ethanoic acid
D	bromoethene	ethane hydroxide

(2)

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1.4 In which ONE of the following options are the three compounds listed in increasing order of vapour pressure?

A propanoic acid, pentane, butan-1-ol
B propanoic acid, butan-1-ol, pentane
C pentane, butan-1-ol, propanoic acid
D butan-1-ol, propanoic acid, pentane (2)

1.5 An electrochemical cell is to be set up to plate a nickel object with silver. Which ONE of the combinations below CORRECTLY shows the metal used for the positive electrode and the electrolytic solution in the electrochemical cell?

	METAL USED FOR POSITIVE ELECTRODE	ELECTROLYTE SOLUTION
A	silver	silver nitrate
B	silver	nickel sulphate
C	nickel	silver nitrate
D	nickel	nickel sulphate

(2)

1.6 The cell notation for a standard Zn–Cu electrochemical cell is:

A $Cu^{2+}(aq) / Cu(s)$ // $Zn(s) / Zn^{2+}(aq)$
B $Zn(s) / Zn^{2+}(aq)$ // $Cu^{2+}(aq) / Cu(s)$
C $Cu(s) / Zn^{2+}(aq)$ // $Cu^{2+}(aq) / Zn(s)$
D $Zn(s) / Zn^{2+}(aq)$ // $Cu(s) / Cu^{2+}(aq)$ (2)

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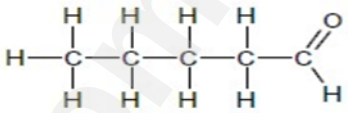
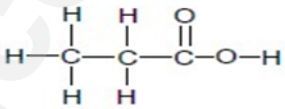
QUESTION 2

Organic chemistry is the chemistry of organic molecules divided into homologous series which are identified by the functional groups.

2.1 Define the term ***homologous series***. (2)

2.2 Study the organic molecules listed below.

A	hex-2-ene	B	
C	3-chlorobut-1-ene	D	

2.2.1 Define the term *isomers* in words. (2)

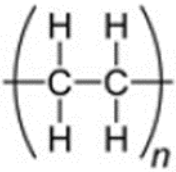
2.2.2 Draw the structural formula of a positional isomer of **A.** (2)

2.2.3 Write down the structural formula of the functional group of **B** and next to it write down the name of the homologous series to which **B** belongs. (2)

2.2.4 Draw the structural formula of compound **C**. (2)

2.2.5 Write down the structural formula of ONE functional isomer of compound **D**. (2)

2.3 The diagram below shows the structural formula for polyethylene. This is the industrial organic product used in the preparation of plastics.



2.3.1 Define the term *monomer*. (2)

2.3.2 Write down the IUPAC name of the monomer that formed polyethylene (2)

2.3.3 Give TWO uses of polyethylene. (2)

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QUESTION 3
The table below shows the vapour pressures of various organic compounds at 25 ˚C.

Compound	Molar mass (g mol^{-1})	Vapour pressure (X 10^2 Pa)
Pentane	72	573,0
Hexane	86	160,0
Heptane	100	48,0
Propan -1-ol	60	21,0
Propan -2 ol	60	44,0
Butan -1 ol	74	6,2
Butan -2 ol	74	18,3
Pentan -1-ol	88	2,2
Pentan -2- ol	88	8,04
Ethanoic acid	60	15,3
Propanone	58	240,0

3.1 Write down the general formula of the homologous series to which heptane belongs. (1)

3.2 Draw the structural formula of propanone. (2)
3.3 Give the IUPAC name of an isomer of propanone. (2)

3.4 From the table above, write down the name of the intermolecular forces involved in the following:
3.4.1 Alcohols (1)
3.4.2 Alkanes (1)

3.5 State and explain the relationship between vapour pressure and the strength of intermolecular forces. (2)

3.6 Which compound will have the higher boiling point? Ethanoic acid OR Propan-1-ol Refer to intermolecular forces and energy in giving reasons for your answer to this difference. (4)

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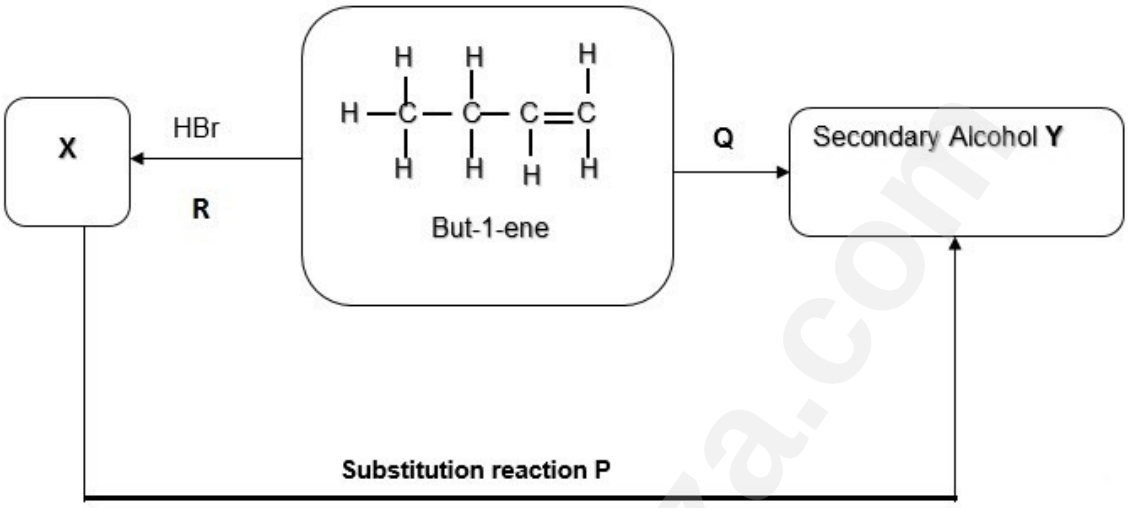
QUESTION 4

The flow diagram below represents a series of organic reactions that took place.



4.1 Name the type of organic reaction represented by **reaction Q** in the diagram. (1)

4.2 Give the reaction condition(s) required for **reaction P** which is the hydrohalogenation reaction that forms compound **X** to take place. (2)

4.3 Write down the IUPAC name of compound **X.** (2)

4.4 Using structural formulae, write down an equation that represents **reaction R** which is **hydrohalogenation**. (3)

4.5 Draw the structural formula of the product **Y** and give its IUPAC name. (3)

4.6 Write down a balanced equation for the complete combustion of butene (C_4H_8) in oxygen. (3)

4.7 Give the name of the substitution reaction represented as **reaction P**. (2)

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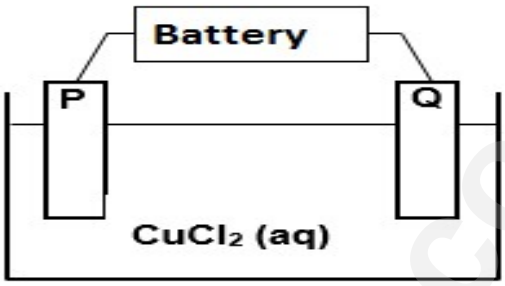
QUESTION 5

In the electrolytic cell, represented below, two CARBON RODS are used as electrodes and a concentrated copper (II) chloride solution is used as an **electrolyte**.



When the cell is functioning, a gas is released at electrode **P**, whilst electrode **Q** is coated with a reddish brown layer.

5.1 Define the term *electrolyte.* (2)

5.2 Give TWO standard conditions for the electrolytic cell when it is in operation. (2)

5.3 Write down a half-reaction to explain the observation made at:

5.3.1 Electrode **P** (2)

5.3.2 Electrode **Q** (2)

5.4 What energy conversion is taking place in this cell? (2)

5.5 Which electrode, **P** or **Q**, is the cathode? Give a reason for the answer. (2)

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5.6 The carbon rods in the above cell are now replaced with COPPER RODS.

The following observations are made at electrode **P**:

- No gas is released
- Its surface appears rough and eroded

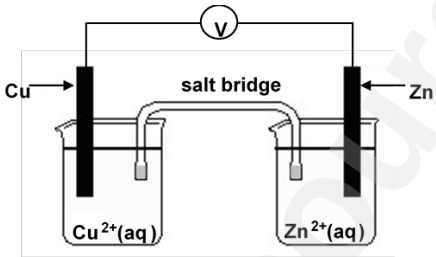
5.6.1 Refer to the RELATIVE STRENGTHS OF REDUCING AGENTS to explain this observation. (3)

5.6.2 Will this electrolytic cell operation be a "***spontaneous***" *or* ***"non-spontaneous"*** *process?* (1)

QUESTION 6

The potential difference of a galvanic cell is measured experimentally by learners. Learners decided to further COMPARE the experimental as well as the calculated potential difference value**.**

They set up the galvanic cell shown below.



The voltmeter measures an initial reading of 0,9 V.

6.1 Write down the energy conversion that takes place in this cell. (2)

6.2 Which section of the cell will be responsible for electron flow when the cell is in operation? (2)

6.3 State ONE function of the salt bridge other than completing the circuit. (2)

6.4 Write down the half-reaction that takes place at the anode. (2)

6.5 In which direction will the electrons in the external circuit flow when this cell delivers a current? Write down only from Cu to Zn or from Zn to Cu. (1)

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6.6 Write down the balanced net (overall) cell reaction. (3)

6.7 Use the Table of Standard Reduction Potential to calculate the initial potential difference (emf) of the above cell at STANDARD CONDITIONS. (4)

6.8 From the results obtained the learners conclude that the measured potential difference differs from the calculated potential difference.

Give possible reasons for this difference in values. (3)

6.9 South Africa is experiencing an electricity crisis. There is an alarming shortage of coal which used to be a traditional source of electricity generation in the country. Eskom's grid is on the law and hence the alternative forms of energy. There are noticeable wind farms in most parts of the country as a form of renewable energy. The most popular type of these forms of renewable energy is **photo-voltaic** which uses silicon cells that traps radiant energy from the sun hence they are commonly known as solar panels. Global warming is also another universal crisis that can be addressed by use of renewable energies as form of electricity.

(2)

6.9.1 Explain TWO environmental threats when solar panels are installed during the construction stage.

6.9.2 What are the economic advantages of using solar panels? (2)

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November 2019
QUESTION 1: MULTIPLE-CHOICE QUESTIONS

Various options are provided as possible answers to the following questions. Choose the answer and write only the letter (A–D) next to the question numbers (1.1 to 1.10) in the ANSWER BOOK, e.g. 1.11 D.

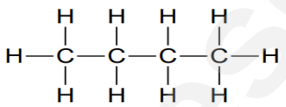
1.1 Which ONE of the following organic molecules consists of single bonds only?

A Propene
B Propanol
C Propanoic acid
D Propylmethanoate (2)

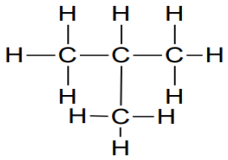
1.2 Which ONE of the following organic molecules is used as fuels?

A Carboxylic acids
B Aldehydes
C Alkanes
D Esters (2)

1.3 Consider the two structural formulae given below.



and



The two structures represent … isomers.

A chain
B positional
C functional
D unsaturated (2)

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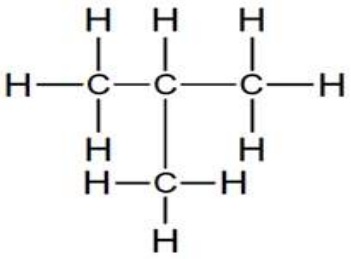
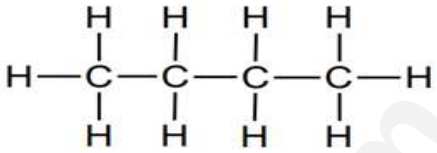
1.4 Identify the product formed during the addition reaction of but-2-ene.

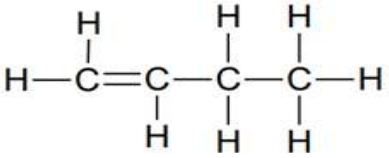
A



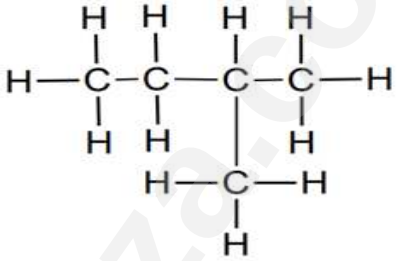
B



C



D



(2)

1.5 In which ONE of the following is chemical energy converted to electrical energy?

A Oxidation reaction
B Electrolytic cell
C Galvanic cell
D Electrolysis (2)

1.6 What is the oxidation number of chlorine in $CuC\ell_2$?

A +2
B -2
C +1
D -1 (2)

Organic molecules are used in a variety of industries including food, pharmaceuticals, fuels and construction. They include homologous series such as alkanes, alkenes, alkynes, haloalkanes, alcohols, carboxylic acids, ketones, aldehydes and esters.

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2.1 Define the term *homologous series.* (2)

2.2 Identify any ONE homologous series that is a hydrocarbon in the list above. (1)

2.3 Hydrocarbons can either be saturated or unsaturated. Distinguish between *saturated* and *unsaturated hydrocarbons*. (2)

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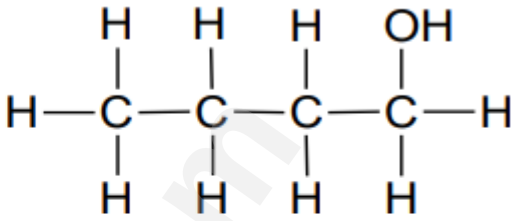
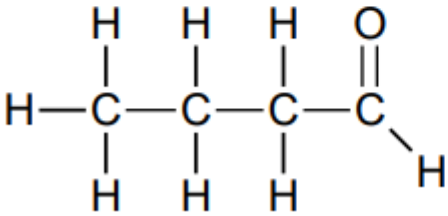
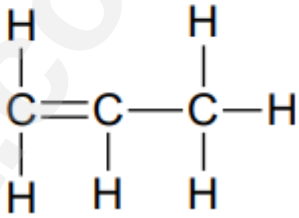
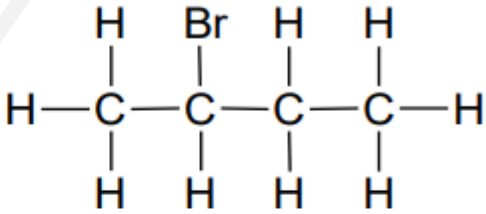
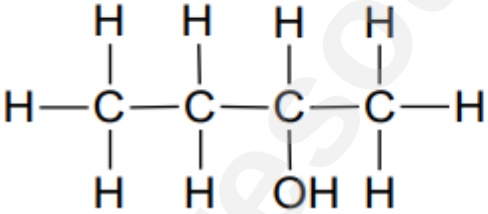
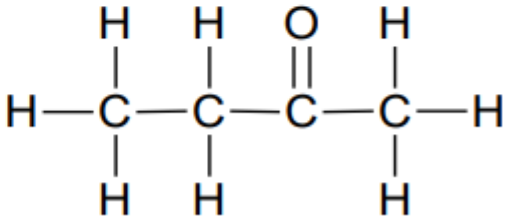
2.4 The table below represents organic compounds with different functional groups.

A	Methyl ethanoate	B	
C		D	
E	Butane	F	
G		H	

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2.4.1 Define the term *functional group.* (2)

2.4.2 Refer to the table of organic compounds on the previous page.

Write down the letter/letters that represent(s) the following:

2. 4.2.1 Haloalkane (1)

2. 4.2.2 Ester (1)

2. 4.2.3 Molecule with a general formula, C_nH_{2n} (1)

2. 4.2.4 TWO pairs of organic molecules that are isomers (2)

2.5. Rewrite the identified pairs of isomers in QUESTION 2. 4.2.4 and next to each, write down the TYPE of isomer to which each pair belongs. (2)

2.6 Write down the structural formulae of:

2.6.1 Compound **E** (2)

2.6.2 A functional group of compound **A** (2)

2.7 Write down the IUPAC names of the compounds represented by the following letters:

2.7.1 **F** (2)

2.7.2 **H** (2)

2.8 Polymers are organic molecules used in everyday life.

2.8.1 Define the term *polymer*. (2)

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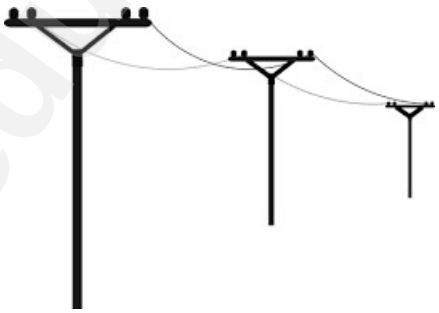
2.8.2 Identify TWO objects in the pictures below that are made from polymers.

Balloons	Pine furniture
Paper	Plastic bottles
Wooden telephone poles	Cardboard boxes
	

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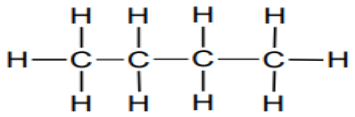
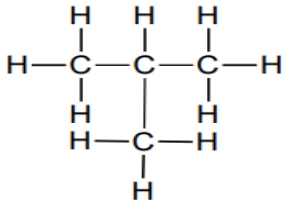
QUESTION 3 (Start on a new page.)

The table below shows TWO organic compounds with their corresponding boiling points.

ORGANIC COMPOUNDS	BOILING POINT
A 	-0,5 °C
B 	-11,7 °C

3.1 Identify the TYPE of intermolecular force of the compounds in the table above. (1)

3.2 Explain the difference in the boiling points of **A** and **B**. Refer to CHAIN LENGTH, STRENGTH OF INTERMOLECULAR FORCES and ENERGY. (3)

3.3 Define the term *melting point*. (2)

3.4 Which ONE of the two compounds in the table has a higher melting point? (1)

3.5 Explain the answer in QUESTION 3.4. (2)

3.6 How does the vapour pressure of **A** compare to the vapour pressure of **B**?

Write only HIGHER THAN, LOWER THAN or THE SAME AS. (1)

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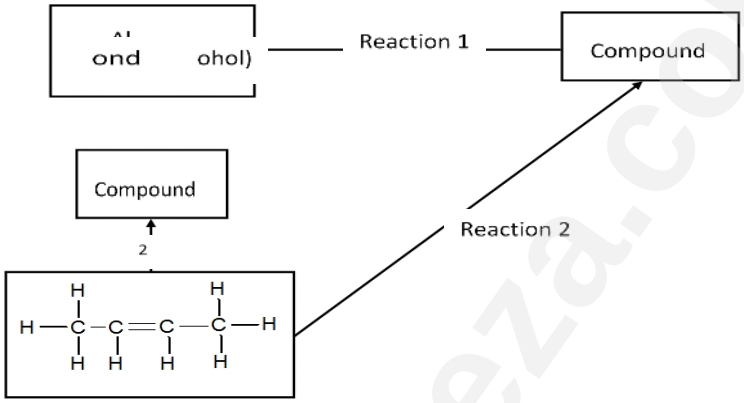
QUESTION 4 (Start on a new page.)

Butane can react with excess oxygen and is used as cigarettelighterfuel or in bottled gas for cooking.

4.1 Write down the TYPE of reaction that takes place when butane is used as a fuel. (1)

4.2 Consider the flow diagram below and answer the questions that follow.



Write down the NAME/TYPE of the following:

4.2.1 Reaction 1 (1)

4.2.2 Reaction 2 (1)

4.3 Write down the NAME of the following:

4.3.1 Compound **A** (2)

4.3.2 Alcohol **B** (2)

4.3.3 Compound **C** (2)

4.4 Name ONE reaction condition for reaction 1. (1)

[10]

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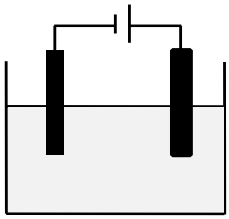
QUESTION 5 (Start on a new page.)

The diagram below represents an electrochemical cell used in the decomposition of copper(II)chloride.



5.1 Identify the TYPE of electrochemical cell represented in the diagram above. (1)

5.2 What energy conversion takes place in this cell? (2)

5.3 Define the term *electrolyte.* (2)

5.4 What type of ions are Cu^{2+} ? Write only ANIONS or CATIONS. (1)

5.5 Write down the balanced half reactions that occur at the:

5.5.1 Cathode (2)

5.5.2 Anode (2)

5.6 Define the term *oxidising agent*. (2)

5.7 Identify the reducing agent in this cell. (1)

5.8 In which direction will electrons flow in the external circuit? Write only FROM THE CATHODE TO THE ANODE or FROM THE ANODE TO THE CATHODE. (1)

5.9 Write down the overall net cell reaction. (3)

[17]

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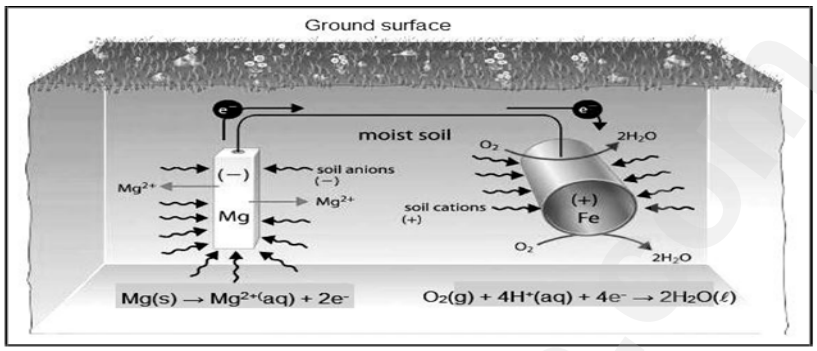
QUESTION 6 (Start on a new page.)

The picture below is a representation of an electrochemical process operating similarly to a galvanic cell, where an underground iron pipe is connected to the magnesium bar to prevent the iron pipe from rusting.



6.2 Which electrode is the anode? (1)

6.3 What substance in the picture acts as the salt bridge? (1)

6.4 Write down TWO functions of a salt bridge. (2)

6.5 What will happen to the mass of magnesium during the process? Write only INCREASES, DECREASES or STAYS THE SAME. (1)

6.6 Explain the answer to QUESTION 6.5. (2)

6.7 Write down the balanced net reaction. (3)

6.8 Calculate the emf of the cell. (4)

6.9 Eskom is the main supplier of electrical energy in South Africa.

Write down:

6.9.1 THREE alternative sources of energy used in South Africa (3)

6.9.2 THREE advantages of biodiesel (3)

[22]

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GAUTENG 2019

QUESTION 1: MULTIPLE-CHOICE QUESTIONS

Four options are provided as possible answers to the following questions. Each question has only ONE correct answer. Write only the letter (A – D) next to the question number (1.1 – 1.10) in the ANSWER BOOK.

1.1 To which functional group does methyl ethanoate belong?

A Esters

B Alcohols

C Aldehydes

D Carboxylic acids (2)

1.2 One of the four organic compounds below belong to carbonyl group …

A Pentane

B Pentanol

C Pentanone

D Pentanoic acid (2)

1.3 Which of the following lists the intermolecular forces from the lowest to the highest boiling point required to overcome them?

A Van der Waals, dipole-dipole, single hydrogen, double hydrogen

B Double hydrogen, single hydrogen, dipole-dipole, van der Waals

C Single hydrogen, double hydrogen, dipole-dipole, van der Waals

D Dipole-dipole, van der Waals, single hydrogen, double hydrogen (2)

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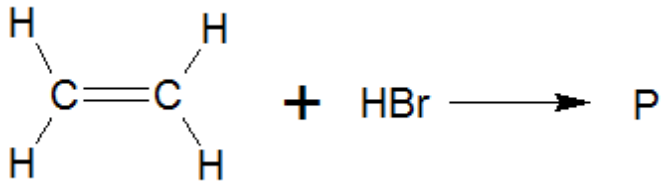
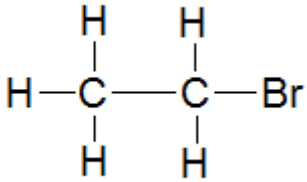
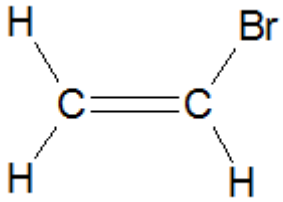
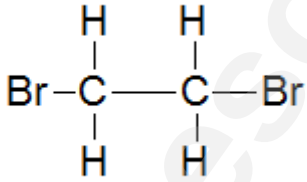
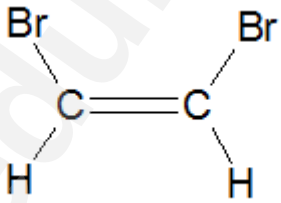
1.4 In the flow diagram below, the structural formula of P is …



A	
B	
C	
D	

(2)

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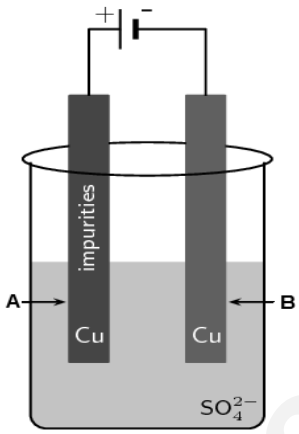
Questions 1.5 to 1.7 are based on the diagram below which represents the purification of copper.



1.5 The correct statement about the cell represented above is:

A It is an electrolytic cell and electrode B is the cathode.

B It is an electrolytic cell and electrode A is the anode.

C It is a galvanic cell and electrode A is the cathode.

D It is a galvanic cell and electrode B is the anode. (2)

1.6 Which ONE of the following statements is CORRECT for this process?

A Cu is oxidised to copper ions at B.

B Cu is reduced to copper ions at B.

C Cu^{2+} ions are reduced to copper at B.

D Cu^{2+} ions are oxidised to copper at A.

(2)

1.7 The most suitable electrolyte to be used in this reaction is…

A Zinc Sulphate

B Copper Sulphate

C Magnesium Sulphate

D Aluminium Sulphate (2)

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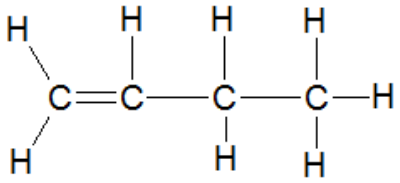
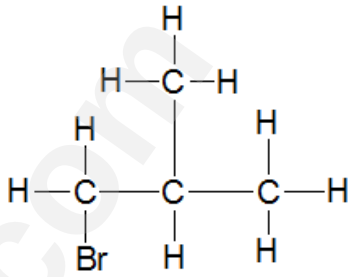
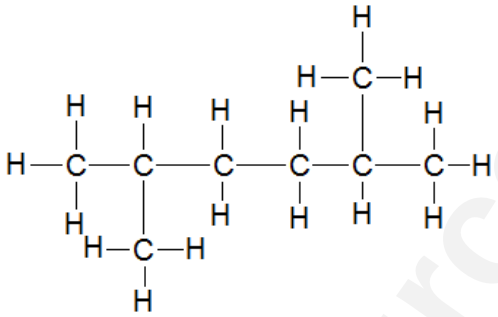
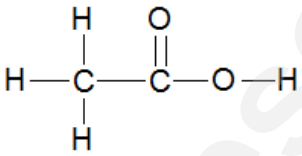
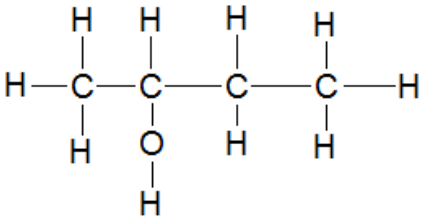
QUESTION 2 (Start on a new page.)

The letters **A** to **F** in the table below represent six organic compounds. Use these compounds to answer the questions that follow:

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

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2.1 Define the term *functional group*. (2)

2.2 Write down the letter(s) representing organic molecules that is an …

2.2.1 alkene (1)

2.2.2 aldehyde (1)

Write down IUPAC names of organic molecules represented by the following letters:

2.2.3 B (2)

2.2.4 C (2)

2.2.5 E (2)

Write down the:

2.2.6 structural formula of compound D. (2)

2.2.7 general formula of compound A. (2)

To which homologous series do organic molecules represented by the following letters belong?

2.2.8 B (1)

2.2.9 F (1)

Many of the plastics we use in everyday life and in industry are made from long chains of monomers.

2.3 Define a monomer. (2)

[18]

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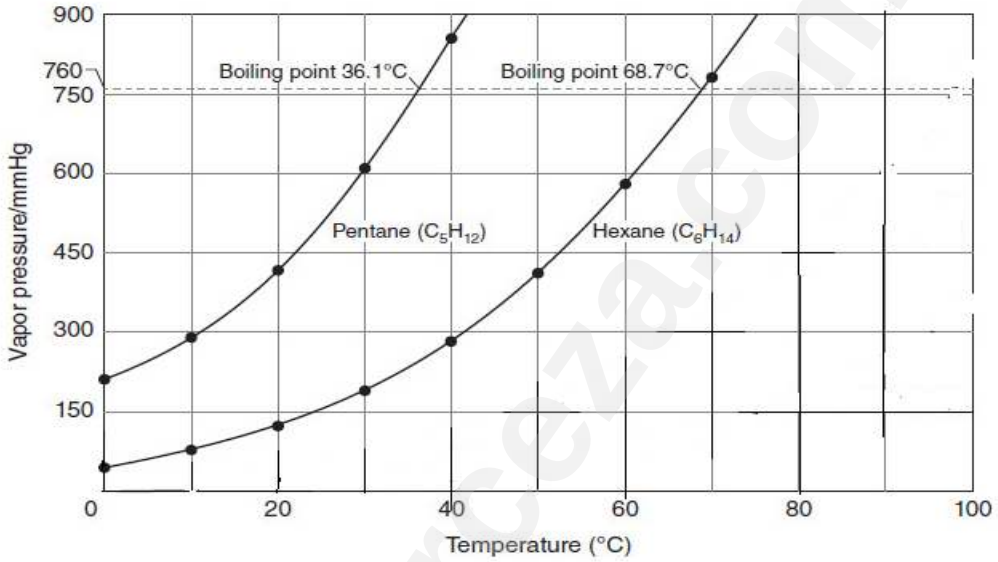
QUESTION 3 (Start on a new page.)

As the liquid evaporates, the vapors on the surface of the liquid exert a *vapor pressure*. Vapor pressure varies with the liquid's temperature. If atmospheric pressure changes, a liquid's boiling point will also change.

The graph below illustrates the relationship between vapor pressure and temperature for TWO organic compounds belonging to the alkane group.



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

3.2 Write down the TYPE of intermolecular forces between organic molecules mentioned in the graph above. (1)

3.3 Explain the trend in the boiling points of the two organic molecules shown in the graph above. (3)

3.4. Explain the relationship between the vapour pressure and the boiling point in the graph above. (2)

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3.5 The picture below illustrates how much easier it is to pour water than to pour syrup into a container.

3.5.1 Which property of the two liquids is responsible for the manner in which they flow into the container? (1)

3.5.2 Explain the difference in the manner in which the water and syrup flow into the containers. (3)

[12]

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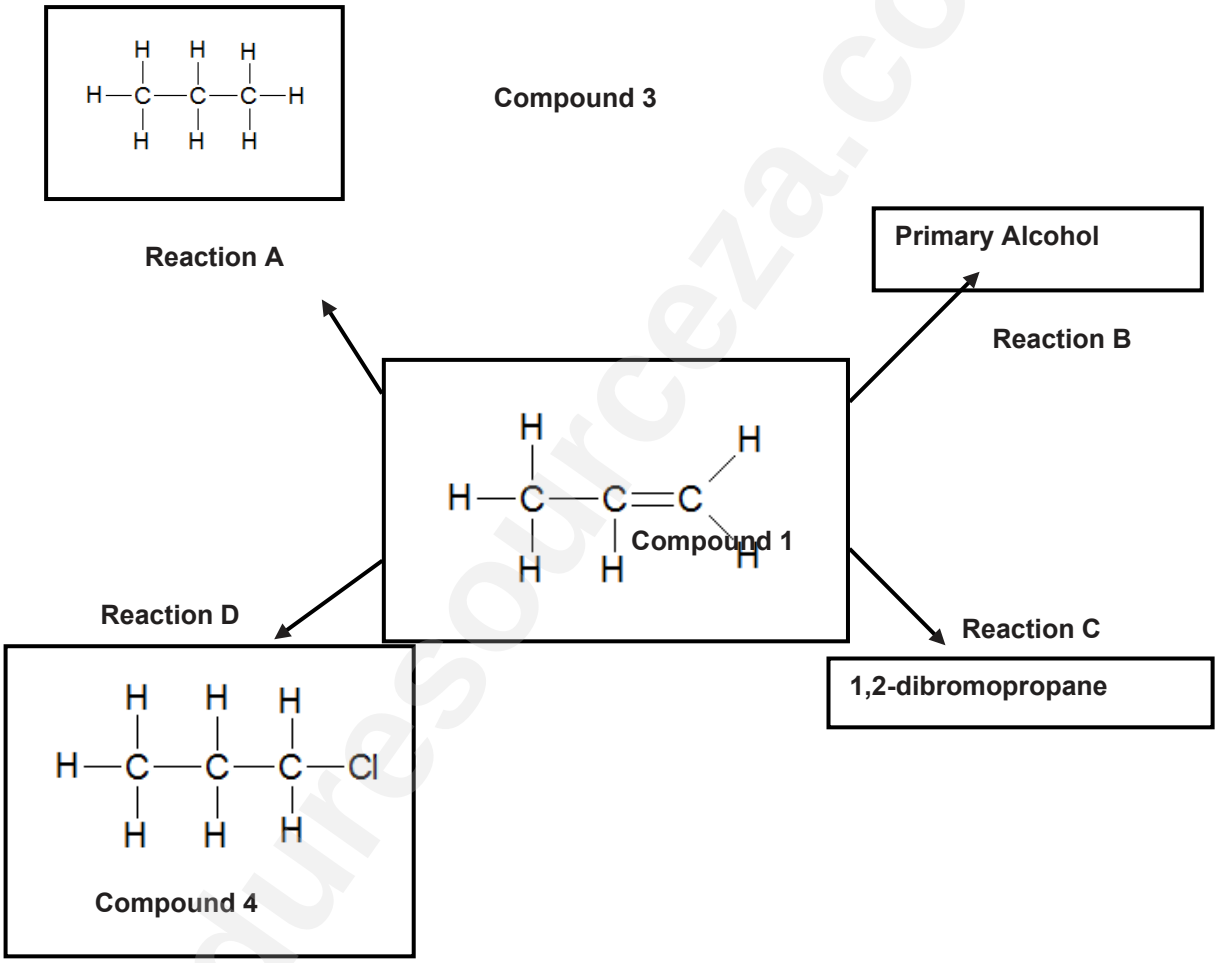
QUESTION 4 (Start on a new page)

4.1 Ethyne is the gas used in oxyacetylene blow torches during the cutting and welding of metals.

4.1.1 Write down the balanced equation for the reaction above in sufficient oxygen. (3)

4.2 Compound 1 is an alkene and can undergo addition reaction which is widely used in the industry. The flow diagram below shows the different addition reactions of COMPOUND 1.

TO GROUP THIS DIAGRAM 7



Write down the IUPAC name of organic molecules represented by:

4.2.1 Compound 3. (2)

4.2.2 Compound 4. (2)

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Write down NAMES of addition reaction represented by…

4.2.3 Reaction **A** (1)

4.2.4 Reaction **B** (1)

4.2.5 Reaction **C** (1)

4.2.6 Reaction **D** (1)

Use structural formulae to represent:

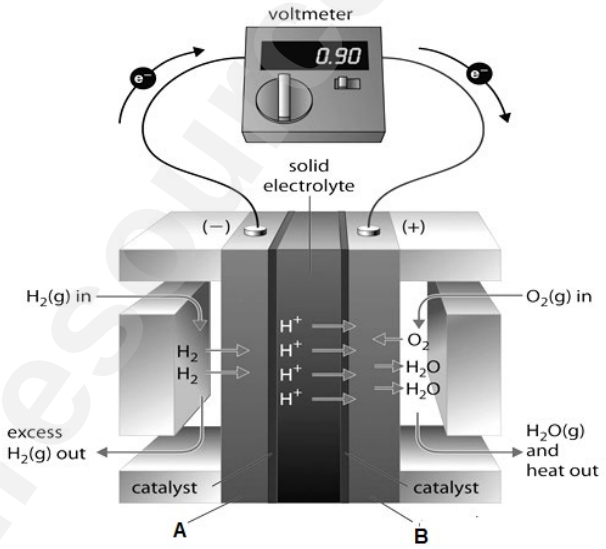
4.2.7 Reaction **B** forming the primary alcohol. (3)

4.2.8 Reaction **C** forming 1,2-dibromopropane. (3)

[17]

QUESTION 5 (Start on a new page.)

The diagram below illustrates how a Hydrogen Fuel Cell produces electrical energy directly from a chemical reaction just like a galvanic cell.Hydrogen is oxidized to protons at the anode, and oxygen is reduced and combines to form water.



5.1 What energy conversion takes place in the Hydrogen represented in the diagram above? (2)

5.2 At which electrode **A** or **B** does oxidation occur? (1)

5.3 Which substance in the cell in the diagram above is a reducing agent? (2)

5.4 Write down the following reactions for the cell in the diagram above.

5.4.1 Reduction half reaction. (2)

5.4.2 Overall net cell reaction. (3)

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5.4.3 Calculate the Emf of the cell in the diagram above. (4)

5.5 Mention THREE standard conditions of a galvanic cells. (3)

[17]

QUESTION 6

Gold plating is done using an electrolytic cell where a thin layer of gold is deposited onto the surface of another metal. A group of technical scientists bought a basic kit comprising of the apparatus below to perform an experiment on electroplating a metal spoon.

Connecting wires
A gold electrolyte
A gold electrode
A metal spoon
A power supply
A switch

6.1 Define the term *electrolytic cell*. (2)

6.2 The success of the experiment depends on the correct connection of the gold electrode and the metal spoon.

6.2.1 Draw a fully labelled diagram to show the correct connection of an electrolytic cell that will result in the gold plating of the metal spoon, Show the positive and the negative terminal of the power supply. (6)

6.2.2 Is gold plating a spontaneous or a non-spontaneous reaction? (1)

6.2.3 Explain the answer in QUESTION 6.2.2 (2)

6.2.4 Which electrode is the anode? Write only (METAL SPOON/GOLD ELECTRODE) (1)

6.2.5 Briefly explain how the gold spoon gets electroplated with gold. (2)

6.2.6 Write down TWO reasons why gold plating is preferred in jewellery. (2)

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6.3 Due to challenges with the economy and high petrol and diesel prices, the alternative way for people to fuel their cars might be the production of cars *that use a fuel cell as a power source* such as the one shown below. In fuel cells, the only two products used are water and electricity.

6.3.1 Mention at least TWO advantages of using the fuel cell car shown above. (2)

[18]

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Eastern Cape 2020

QUESTION 1: MULTIPLE-CHOICE QUESTIONS

Various options are provided as possible answers to the following questions. Choose the answer and write only the letter (A–D) next to the question numbers

(1.1–1.10) in the ANSWER BOOK, for example 1.11 E.

1.1 Which ONE of the following organic compounds does NOT contain a carbonyl group?

A Aldehydes

B Alcohols

C Ketones

D Esters (2)

1.2 Which ONE of the following general formulae represents alkynes?

A C_nH_{2n-2}

B C_nH_{2n-1}

C C_nH_{2n}

D C_nH_{2n+2} (2)

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

A Ethanal and butanol

B Ethanoic acid and butanol

C Ethanol and butanoic acid

D Ethanal and butanoic acid (2)

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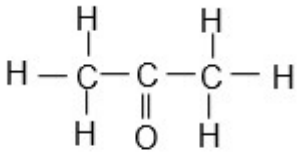
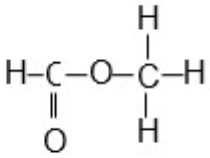
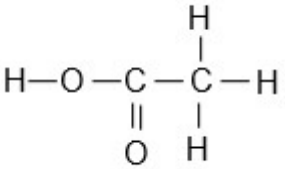
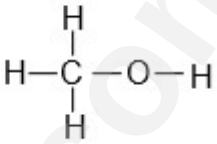
1.4 Which ONE of the following compounds represents a ketone?

A 

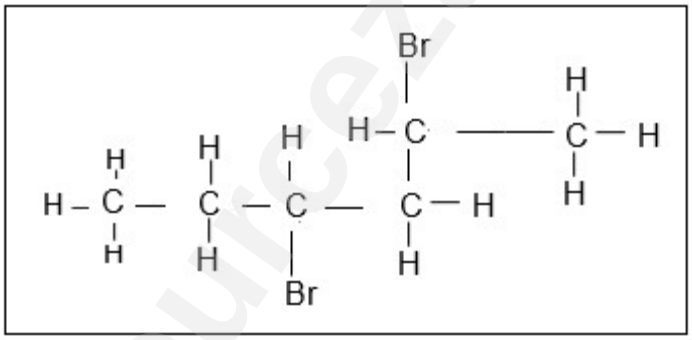
B 

C 

D 

(2)

1.5 The structural formula of a haloalkane is represented below.



Which ONE of the following descriptions is the correct IUPAC NAME for this organic molecule?

A 3,5-dibromohexane

B 4-bromo-5-bromo-5-methylpentane

C 2,4-dibromohexane

D 2-bromo-1-bromo-1-methylpentane (2)

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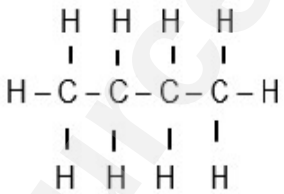
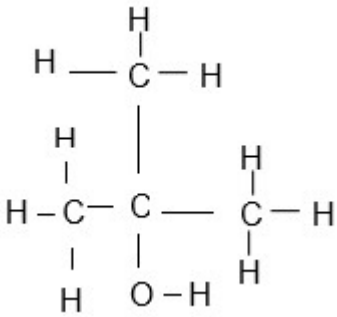
QUESTION 2

Organic chemistry is the chemistry of organic molecules divided into homologous series which are identified by the functional groups. It is this branch of chemistry that is applied in the industry and in medicine. Pharmaceuticals used in cancer treatment and other conditions follow organic synthesis.

2.1 Explain the term *homologous series*. (2)

2.2 Define the term *functional group*. (2)

2.3 Study the organic compounds listed in the table below, labelled **A**–**F** and answer the questions that follow.

A	**B**	**C**
But-2-ene	1-chlorobutan-2-one	Propan-1-ol
D	**E**	**F**
3-bromo-5methylhexene		

Write down the LETTER that represents:

2.3.1 An alkane (1)

2.3.2 A primary alcohol (1)

2.4 Write down the IUPAC name of structures:

2.4.1 **E** (2)

2.4.2 **F** (2)

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2.5 Draw the structural formula of:

2.5.1	**A**	(2)
2.5.2	**C**	(2)
2.5.3	An isomer of **E**	(2)

2.6 Define the term *positional isomer*in words. (2)

2.7 To which homologous series does compound **B** belong? (1)

2.8 Draw the structural formula of the functional group of compound **B.** (2)

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QUESTION 3 (Start on a NEW page.)

Rubber is a naturally occurring compound. The diene, 2-methyl-1,3-butandiene, 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 fight against HIV/Aids and COVID-19.

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

3.1 Define the term *polymer* in words. (2)

3.2 Is but-2-ene an example of a saturated or an unsaturated hydrocarbon?

Give a reason for the answer. (3)

3.3 Write down the structural formula of 2-methylbutane. (2)

3.4 With regard to the environment, name TWO disadvantages of rubber and the production of rubber. (2)

3.5 With regard to human life, name TWO benefits of rubber and the production of rubber. (4)

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QUESTION 4

In the table below FIVE alcohols, represented by the letters **A–E**,are listed.

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

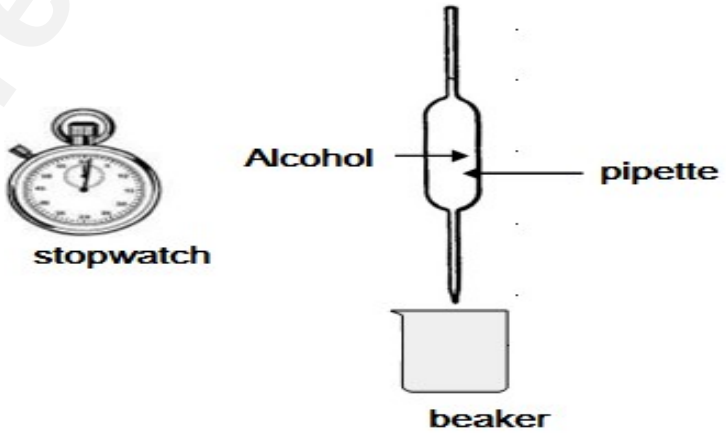
4.1 Write down the letter that represents a secondary alcohol from the above list. (2)

4.2 Letter **E** represents 2-methylpropan-2-ol. Write down the following for this alcohol:

4.2.1 The structural formula (2)

4.2.2 The letter of an alcohol that represents its structural isomer (2)

4.3 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 above table. They use the apparatus shown below.



The learners use a 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.

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	ALCOHOL	FLOW TIME (s)
A	Methanol	4,0
B	Ethanol	7,9
C	Propan-1-ol	14,3

4.3.1 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. (2)

4.3.2 Refer to the intermolecular forces of the three alcohols **A**, **B** and **C** to explain the trend in viscosities as shown in the table. (3)

4.3.3 Lubricants reduce friction. Which ONE of alcohols, **A**, **B** or **C**, will be the best lubricant? Explain your answer. (3)

4.3.4 Define the term *vapour pressure* in words. (2)

4.4 Which ONE of 2-methylpropan-2-ol and butan-2-ol has a higher viscosity? Explain the answer. (3)
[19]

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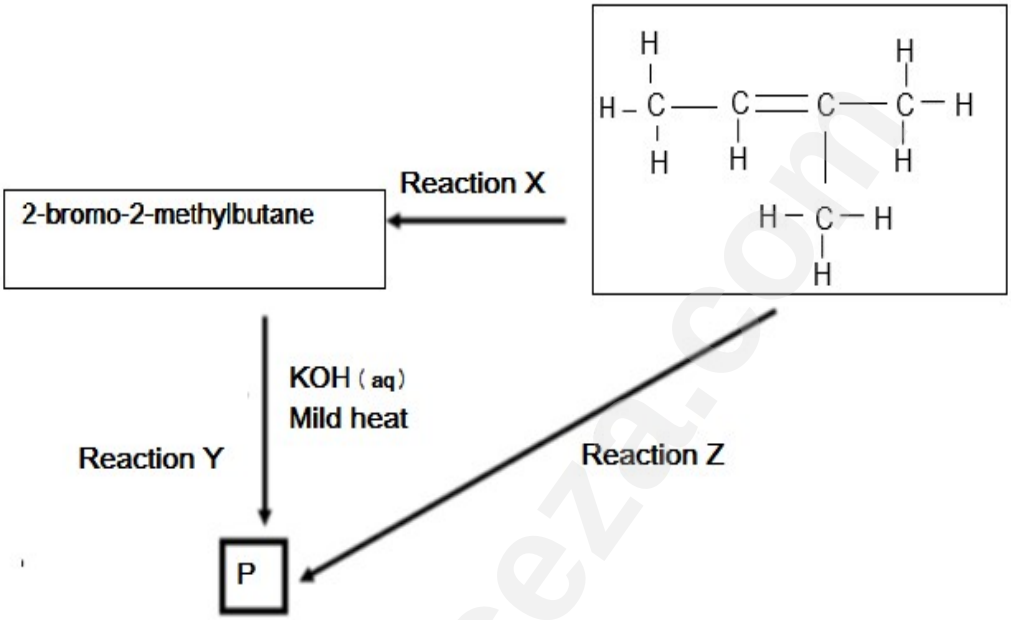
QUESTION 5

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



5.1 Name the type of reaction represented by **reactionX.** (2)

5.2 State TWO reaction conditions required for **reactionX** to take place. (2)

5.3 **ReactionY** represents a substitution reaction. Write down the structural formula of compound **P** formed in the reaction. (2)

5.4 Apart from the organic reactant, write down the NAME or FORMULA of the other reactant needed in **reactionZ** (2)

5.5 Write down a balanced chemical reaction for the formation of compound **P** using structural formulae. (4)

5.6 Name the type of reaction represented by **reactionZ.** (2)

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5.7 A car engine at a Shell Garage in Willowvale was running when a debate started between learners of a Technical Sciences class in a particular secondary school in that area. They noticed smoke coming out of the exhaust system and liquid droplets at the back of the exhaust system. One learner claimed that hexane was burning inside. They eventually reached an agreement about their observations.

5.7.1 Give the names of the products of combustion of hexane. (2)

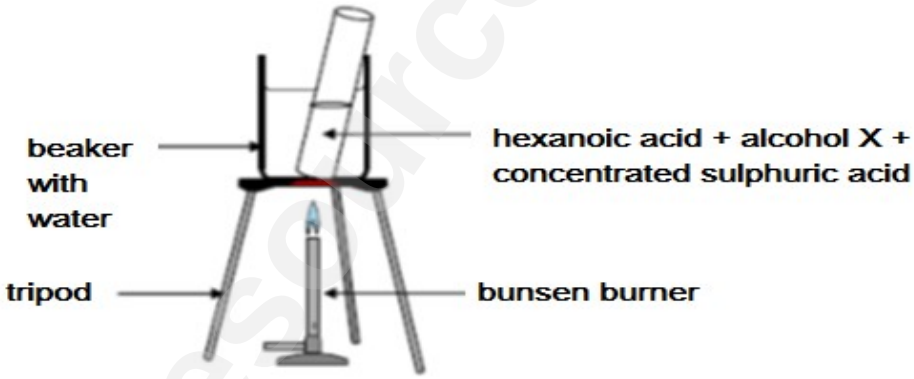
5.7.2 Write down a balanced equation for the complete combustion of hexane. (4)

[20]

QUESTION 6

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.



6.1 Write down the IUPAC name of alcohol **X**. (2)

6.2 What is the role of the sulphuric acid in the above reaction? (2)

6.3 Use structural formulae to write down a balanced equation for the preparation of ethyl hexanoate. (4)

6.4 Give ONE reason why the test tube and its contents are heated in a water bath and not directly over the flame. (2)

6.5 Write down ONE use of esters in the food manufacturing industry. (2)

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ATTACHMENTS

Differences between Galvanic Cell and Electrolytic Cell

Galvanic Cell	Electrolytic Cell
A Galvanic cell converts chemical energy into electrical energy.	An electrolytic cell converts electrical energy into chemical energy.
Here, the redox reaction is spontaneous and is responsible for the production of electrical energy.	The redox reaction is not spontaneous and electrical energy has to be supplied to initiate the reaction.
The two half-cells are set up in different containers, being connected through the salt bridge or porous partition.	Both the electrodes are placed in a same container in the solution of molten electrolyte.
Here the anode is negative and cathode is the positive electrode. The half-reaction at the anode is oxidation and that at the cathode is reduction.	Here the anode is positive and **cathode is the negative electrode**. The half-reaction at the anode is oxidation and that at the cathode is reduction.
The electrons are supplied by the species getting oxidized. They move from anode to the cathode in the external circuit.	The external battery supplies the electrons. They enter through the cathode and come out through the anode.

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DATA FOR TECHNICAL SCIENCES GRADE 12

PAPER 2

GEGEWENS VIR TEGNIESE WETENSKAPPE GRAAD 12

VRAESTEL 2

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

PHYSICAL CONSTANTS / *FISIESE KONSTANTES*

CONSTANT / *KONSTANTE*	**SYMBOL / *SIMBOOL***	**VALUE / *WAARDE***
Standard pressure *Standaarddruk*	$p^{\ominus}$	$1{,}01 \times 10^{5}$ Pa
Standard temperature *Standaard temperatuur*	$T^{\ominus}$	298 K/25 ^{0}C

TABLE 3 / *TABEL 3*: ELECTROCHEMISTRY / *ELEKTROCHEMIE*

Emf / *Emk*

$$E^{\theta}_{cell} = E^{\theta}_{cathode} - E^{\theta}_{anode} \quad / \quad E^{\theta}_{sel} = E^{\theta}_{katode} - E^{\theta}_{anode}$$

or / *of*

$$E^{\theta}_{cell} = E^{\theta}_{reduction} - E^{\theta}_{oxidation} \quad / \quad E^{\theta}_{sel} = E^{\theta}_{reduksie} - E^{\theta}_{oksidasie}$$

or / *of*

$$E^{\theta}_{cell} = E^{\theta}_{oxidising\ agent} - E^{\theta}_{reducing\ agent} \quad / \quad E^{\theta}_{sel} = E^{\theta}_{oksideermiddel} - E^{\theta}_{reduseermiddel}$$

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TABLE 4A: STANDARD REDUCTION POTENTIALS
TABEL 4A: STANDAARD-REDUKSIEPOTENSIALE

Increasing oxidising ability / *Toenemende oksiderende vermoë*

Half-reactions/*Halfreaksies*			E^{θ} (V)
$F_2(g) + 2e^-$	⇌	$2F^-$	+ 2,87
$Co^{3+} + e^-$	⇌	Co^{2+}	+ 1,81
$H_2O_2 + 2H^+ + 2e^-$	⇌	$2H_2O$	+1,77
$MnO_4^- + 8H^+ + 5e^-$	⇌	$Mn^{2+} + 4H_2O$	+ 1,51
$C\ell_2(g) + 2e^-$	⇌	$2C\ell^-$	+ 1,36
$Cr_2O_7^{2-} + 14H^+ + 6e^-$	⇌	$2Cr^{3+} + 7H_2O$	+ 1,33
$O_2(g) + 4H^+ + 4e^-$	⇌	$2H_2O$	+ 1,23
$MnO_2 + 4H^+ + 2e^-$	⇌	$Mn^{2+} + 2H_2O$	+ 1,23
$Pt^{2+} + 2e^-$	⇌	Pt	+ 1,20
$Br_2(\ell) + 2e^-$	⇌	$2Br^-$	+ 1,07
$NO_3^- + 4H^+ + 3e^-$	⇌	$NO(g) + 2H_2O$	+ 0,96
$Hg^{2+} + 2e^-$	⇌	$Hg(\ell)$	+ 0,85
$Ag^+ + e^-$	⇌	Ag	+ 0,80
$NO_3^- + 2H^+ + e^-$	⇌	$NO_2(g) + H_2O$	+ 0,80
$Fe^{3+} + e^-$	⇌	Fe^{2+}	+ 0,77
$O_2(g) + 2H^+ + 2e^-$	⇌	H_2O_2	+ 0,68
$I_2 + 2e^-$	⇌	$2I^-$	+ 0,54
$Cu^+ + e^-$	⇌	Cu	+ 0,52
$SO_2 + 4H^+ + 4e^-$	⇌	$S + 2H_2O$	+ 0,45
$2H_2O + O_2 + 4e^-$	⇌	$4OH^-$	+ 0,40
$Cu^{2+} + 2e^-$	⇌	Cu	+ 0,34
$SO_4^{2-} + 4H^+ + 2e^-$	⇌	$SO_2(g) + 2H_2O$	+ 0,17
$Cu^{2+} + e^-$	⇌	Cu^+	+ 0,16
$Sn^{4+} + 2e^-$	⇌	Sn^{2+}	+ 0,15
$S + 2H^+ + 2e^-$	⇌	$H_2S(g)$	+ 0,14
$2H^+ + 2e^-$	**⇌**	**$H_2(g)$**	**0,00**
$Fe^{3+} + 3e^-$	⇌	Fe	– 0,06
$Pb^{2+} + 2e^-$	⇌	Pb	– 0,13
$Sn^{2+} + 2e^-$	⇌	Sn	– 0,14
$Ni^{2+} + 2e^-$	⇌	Ni	– 0,27
$Co^{2+} + 2e^-$	⇌	Co	– 0,28
$Cd^{2+} + 2e^-$	⇌	Cd	– 0,40
$Cr^{3+} + e^-$	⇌	Cr^{2+}	– 0,41
$Fe^{2+} + 2e^-$	⇌	Fe	– 0,44
$Cr^{3+} + 3e^-$	⇌	Cr	– 0,74
$Zn^{2+} + 2e^-$	⇌	Zn	– 0,76
$2H_2O + 2e^-$	⇌	$H_2(g) + 2OH^-$	– 0,83
$Cr^{2+} + 2e^-$	⇌	Cr	– 0,91
$Mn^{2+} + 2e^-$	⇌	Mn	– 1,18
$A\ell^{3+} + 3e^-$	⇌	$A\ell$	– 1,66
$Mg^{2+} + 2e^-$	⇌	Mg	– 2,36
$Na^+ + e^-$	⇌	Na	– 2,71
$Ca^{2+} + 2e^-$	⇌	Ca	– 2,87
$Sr^{2+} + 2e^-$	⇌	Sr	– 2,89
$Ba^{2+} + 2e^-$	⇌	Ba	– 2,90
$Cs^+ + e^-$	⇌	Cs	- 2,92
$K^+ + e^-$	⇌	K	– 2,93
$Li^+ + e^-$	⇌	Li	– 3,05

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TABLE 4B: STANDARD REDUCTION POTENTIALS
TABEL 4B: STANDAARD-REDUKSIEPOTENSIALE

Increasing oxidising ability ↓

Half-reactions/*Halfreaksies*			E^{θ} (V)
$Li^+ + e^-$	⇌	Li	– 3,05
$K^+ + e^-$	⇌	K	– 2,93
$Cs^+ + e^-$	⇌	Cs	– 2,92
$Ba^{2+} + 2e^-$	⇌	Ba	– 2,90
$Sr^{2+} + 2e^-$	⇌	Sr	– 2,89
$Ca^{2+} + 2e^-$	⇌	Ca	– 2,87
$Na^+ + e^-$	⇌	Na	– 2,71
$Mg^{2+} + 2e^-$	⇌	Mg	– 2,36
$A\ell^{3+} + 3e^-$	⇌	$A\ell$	– 1,66
$Mn^{2+} + 2e^-$	⇌	Mn	– 1,18
$Cr^{2+} + 2e^-$	⇌	Cr	– 0,91
$2H_2O + 2e^-$	⇌	$H_2(g) + 2OH^-$	– 0,83
$Zn^{2+} + 2e^-$	⇌	Zn	– 0,76
$Cr^{3+} + 3e^-$	⇌	Cr	– 0,74
$Fe^{2+} + 2e^-$	⇌	Fe	– 0,44
$Cr^{3+} + e^-$	⇌	Cr^{2+}	– 0,41
$Cd^{2+} + 2e^-$	⇌	Cd	– 0,40
$Co^{2+} + 2e^-$	⇌	Co	– 0,28
$Ni^{2+} + 2e^-$	⇌	Ni	– 0,27
$Sn^{2+} + 2e^-$	⇌	Sn	– 0,14
$Pb^{2+} + 2e^-$	⇌	Pb	– 0,13
$Fe^{3+} + 3e^-$	⇌	Fe	– 0,06
$2H^+ + 2e^-$	**⇌**	**$H_2(g)$**	**0,00**
$S + 2H^+ + 2e^-$	⇌	$H_2S(g)$	+ 0,14
$Sn^{4+} + 2e^-$	⇌	Sn^{2+}	+ 0,15
$Cu^{2+} + e^-$	⇌	Cu^+	+ 0,16
$SO_4^{2-} + 4H^+ + 2e^-$	⇌	$SO_2(g) + 2H_2O$	+ 0,17
$Cu^{2+} + 2e^-$	⇌	Cu	+ 0,34
$2H_2O + O_2 + 4e^-$	⇌	$4OH^-$	+ 0,40
$SO_2 + 4H^+ + 4e^-$	⇌	$S + 2H_2O$	+ 0,45
$Cu^+ + e^-$	⇌	Cu	+ 0,52
$I_2 + 2e^-$	⇌	$2I^-$	+ 0,54
$O_2(g) + 2H^+ + 2e^-$	⇌	H_2O_2	+ 0,68
$Fe^{3+} + e^-$	⇌	Fe^{2+}	+ 0,77
$NO_3^- + 2H^+ + e^-$	⇌	$NO_2(g) + H_2O$	+ 0,80
$Ag^+ + e^-$	⇌	Ag	+ 0,80
$Hg^{2+} + 2e^-$	⇌	$Hg(\ell)$	+ 0,85
$NO_3^- + 4H^+ + 3e^-$	⇌	$NO(g) + 2H_2O$	+ 0,96
$Br_2(\ell) + 2e^-$	⇌	$2Br^-$	+ 1,07
$Pt^{2+} + 2e^-$	⇌	Pt	+ 1,20
$MnO_2 + 4H^+ + 2e^-$	⇌	$Mn^{2+} + 2H_2O$	+ 1,23
$O_2(g) + 4H^+ + 4e^-$	⇌	$2H_2O$	+ 1,23
$Cr_2O_7^{2-} + 14H^+ + 6e^-$	⇌	$2Cr^{3+} + 7H_2O$	+ 1,33
$C\ell_2(g) + 2e^-$	⇌	$2C\ell^-$	+ 1,36
$MnO_4^- + 8H^+ + 5e^-$	⇌	$Mn^{2+} + 4H_2O$	+ 1,51
$H_2O_2 + 2H^+ + 2e^-$	⇌	$2H_2O$	+1,77
$Co^{3+} + e^-$	⇌	Co^{2+}	+ 1,81
$F_2(g) + 2e^-$	⇌	$2F^-$	+ 2,87

Increasing reducing ability ↑

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MARKING GUIDELINES

QUESTION 1 (EASTERN CAPE 2019)

1.1	A ✓✓	1.2	A ✓✓	1.3	B✓✓
1.4	C✓✓	1.5	A✓ ✓	1.6	B ✓✓

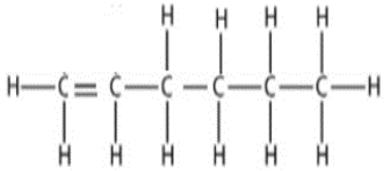
[12]

QUESTION 2

2.1 A series of organic molecules that can be described by the same general formula and where each member differs from the next by a CH_2 group ✓✓ (2)

2.2.1 Organic molecules with the same molecular formula, but different structural formula.✓✓ (2)

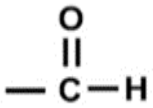
2.2.2



✓✓

(2)

2.2.3

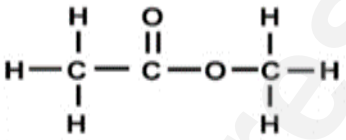


✓

Aldehydes ✓ (2)

2.2.4 3-Chlorobut-1-ene ✓✓ (2)

2.2.5



Methyl ethanoate

Mark allocation	
Methyl (part)	✓
Ethanoate (part)	✓

(2)

2.3.1 Small organic molecules that can be covalently bonded to each other in a repeating pattern. ✓✓ (2)

2.3.2 2-Ethene ✓✓ (2)

2.3.3 Manufacturing of plastic bags ✓
Synthesis of bullet proof vests ✓
Manufacturing of plastic bottles ✓
Manufacturing of cling wrap ✓ (any 2) (2)

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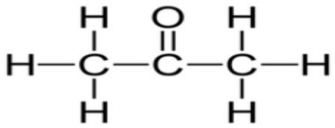
QUESTION 3

3.1 C_nH_{2n+2} ✓ (1)

3.2 ✓ ✓



(2)

3.3 Propanal ✓ ✓ (2)

3.4.1 Hydrogen bonds and London forces ✓ (1)

3.4.2 Van der Waals forces (London forces) or Induced dipole force ✓ (any 1) (1)

3.5 As the strength of the intermolecular forces become stronger (increases) ✓ then the vapour pressure will become lower ✓ (decrease)
OR
As the strength of intermolecular forces become weaker, ✓ then the vapour pressure will become higher ✓ (increase). (2)

3.6 Ethanoic acid ✓. Ethanoic acid has stronger intemolecular forces than Propan-1-ol hence a lower vapour pressure ✓ thus more energy will be required to overcome the intermolecular forces in ethanoic acid than in Propan-1-ol. ✓ The lower the vapour pressure, the higher the boiling point. ✓
(4)

[13]

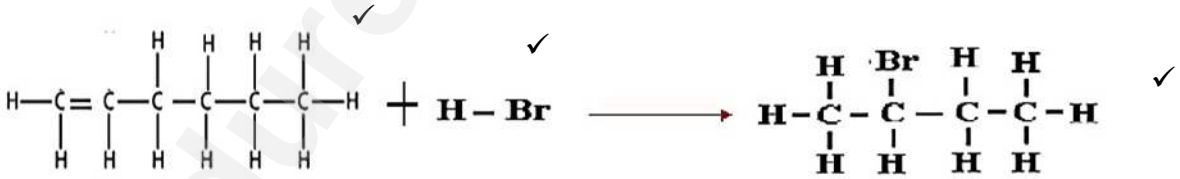
QUESTION 4

4.1 Addition (reaction) Hydration ✓ (1)

4.2 Add sodium hydroxide or potassium hydroxide ✓
Heat the reaction mixture ✓ (2)

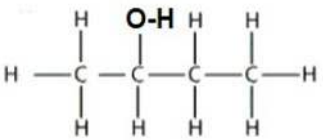
4.3 2-bromo✓ butane ✓ (2)

4.4



(3)

4.5



✓ ✓

(3)

Butan-2-ol ✓

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4.6 $C_4H_8 + 6O_2$ ✓→ $4\ CO_2 + 4\ H_2O$ ✓ balance ✓ (3)

4.7 Hydrolysis ✓ ✓ (2)

[16]

QUESTION 5

5.1 An electrolyte is a substance of which the aqueous solution contains ions. ✓ ✓

OR

A substance that dissolves in water to give a solution that conducts electricity ✓ ✓

OR

A substance that forms free ions when melted. ✓ ✓ (2)

5.2 Temperature: 298 K or 25 °C ✓
Concentration: 1 $mol.dm^{-3}$ ✓ (2)

5.3.1 $2\ Cl^- \rightarrow Cl_2 + 2e^-$ ✓ ✓ (2)

5.3.2 $Cu^{2+} + 2e^- \rightarrow Cu$ ✓ ✓ (2)

5.4 Electrolytic cell – Converts electrical energy to chemical energy. (2)

5.5 **Q** ✓ Reduction takes place ✓ (2)

5.6.1 Cu is a stronger reducing agent ✓ than Cl^- ions.

Cu will be oxidised to Cu^{2+} ions ✓ resulting in the plate becoming eroded. ✓ (3)

5.6.2 Non-spontaneous ✓ (1)

QUESTION 6

6.1 **Galvanic Cell:** Chemical energy is converted to electrical energy. ✓ ✓ (2)

6.2 External circuit ✓ ✓ **or** through the voltmeter. ✓ ✓ (2)

6.3 It maintains electrical neutrality✓ ✓

OR

It separates the two compartments so that they do not mix. ✓ ✓ (2)

6.4 $Zn \rightarrow Zn^{2+} + 2e^-$ ✓ ✓ (2)

6.5 from Zn to Cu ✓ (1)

6.6 $Zn + Cu^{2+}$ ✓ $\rightarrow Zn^{2+} + Cu$ ✓ ✓ (3)

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6.7 $E^{\theta}cell = E^{\theta}cathode - E^{\theta}anode$ ✓
$= 0,34$ ✓ $- (-0,76)$ ✓
$= 1,1V$ ✓ (4)

6.8 It means they did not take the measurements at standard conditions✓where temperature is 298 K or 25 °C ✓and concentration of 1 $mol.dm^{-3}$. ✓ (3)

6.9.1 During solar construction, the following are identified as environmental threats:
- a release of greenhouse gases ✓
- pollution of drinking pure water ✓ (2)

6.9.2 Lowers the electricity bill ✓
Increases home resale value ✓
Takes advantage of tax credits from the government ✓
Net metering allows reselling of excess electricity to the utility company ✓ **(Any 2)** (2)

QUESTION 1 **National 2019**

1.1	B ✓ ✓	1.2	C ✓ ✓	1.3	A ✓ ✓
1.4	B ✓ ✓	1.5	C ✓ ✓	1.6	D ✓ ✓ **[12]**

QUESTION 2

2.1 A series of organic compounds that can be described by the same general. formula and where each member differs from the next by a CH_2 group. ✓ ✓✓ (3)

2.2 Alkanes/ Alkenes/ Alkynes ✓ (any 1) (1)

2.3
- Saturated hydrocarbons have carbon-carbon single (covalent) bonds only. Each carbon atom contains a maximum possible number of hydrogen atoms. ✓
- Unsaturated hydrocarbons have double/triple/multiple (covalent) bonds between carbon-carbon atoms. ✓

(2)

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

OR

An atom/a group of atoms/bond that determines the chemistry of a molecule. ✓ ✓ (2)

2.5.1 F ✓
A ✓ (2)

2.5.3 B and G ✓
C and H ✓ (2)

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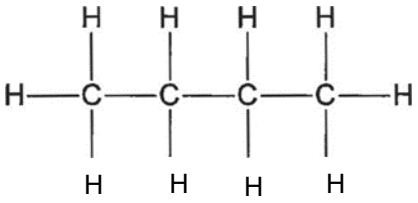
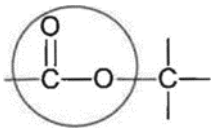
2.6 B and G: positional isomers ✓
C and H: functional isomers ✓ (2)

2.7.1



✓✓ (2)

2.7.2



Marking Criteria	
• If the bonds are missing	$\frac{0}{2}$
• If hydrogen atoms are added	$\frac{0}{2}$
NB: Do not penalise if the functional group is encircled	

(2)

2.8.1 2-bromo butane ✓✓

2.8.2 Butan-2-one/ 2-butanone ✓✓

NB:
If the hyphen is omitted or added incorrectly,
If position of Br is omitted, 1/2
If butane only, 1/2

(2)

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

[26]

QUESTION 3

3.1 London forces/dispersion forces/induced dipole forces (momentarily dipole forces) Y ✓ (1)

3.2 B has a shorter chain length/is more compact (branched/spherical) /smaller surface area than A ✓

- The intermolecular forces/London forces/dispersion forces between molecules of **B** are weaker than those of **A**.
- Less energy is needed to overcome intermolecular forces/London forces/dispersion forces in **B** than in **A**

OR

- A has a longer chain length/is less compact /larger surface area/no branch than **B**.
- More energy is needed to overcome intermolecular forces/London forces/dispersion forces in **A** than in **B**

3.3 The temperature at which the solid and liquid phases of a substance are at equilibrium ✓✓ (2)

3.4 Accept: butane (structural formula of butane/ -0,5^0 C) ✓ (1)

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3.5 **(NEGATIVE MARKING FROM QUESTION 3.4)**
The higher the boiling point, the higher the melting point✓✓
OR
The lower the boiling point, the lower the melting
OR
The stronger the intermolecular forces, the higher the melting point.
OR
The weaker the intermolecular forces, the lower the melting point.

OR
The longer the chain length, the higher the melting point
OR
The shorter the chain length, the lower the melting point
OR
The more the branches, the lower the melting point.
OR
The less the branches, the higher the melting point (2)

3.6 Lower than ✓ (1)

4.1 Combustion/oxidation ✓ (1)

4.2.1 Hydrolysis/substitution ✓ (1)

4.2.2 Hydrohalogenation/hydrobromination/addition ✓ (1)

4.3.1 Butane ✓✓ (2)

4.3.2 Butan-2-ol ✓✓ (Accept: 2-butanol) (2)
(**NB**: If the hyphen or 2 is omitted or incorrect position of functional group, ½)

4.3.3 2-bromo ✓butane✓

Marking Criteria	Marks
• If the hyphen or 2 is omitted or incorrect position of functional group.	1/2
• If the hyphen is omitted or added incorrectly	1/2
• If butane only,	1/2
• If position of Br is omitted,	1/2

(2)

4.3.4 Mild heat. ✓ (**Accept:** low temperature)
(**NOTE**: Penalise if only 'Heat' has been written.
OR
A dilute (aqueous solution of a) strong base / NaOH / KOH ✓ (1)

QUESTION 5

5.1 Electrolytic (cell) ✓ (1)

5.2 Electrical (energy) to chemical (energy).✓✓ (2)

5.3 A substance that dissolves in water to give a solution that conducts electricity✓✓ (2)
OR
A solution that conducts electricity (through the movement of ions).
OR
A substance of which the aqueous solution contains ions.

5.4 Cations ✓ (1)

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5.5.1 $Cu^{2+} + 2e \longrightarrow Cu$ ✓✓ (2)

5.5.2 $2Cl^- \rightarrow Cl_2 + 2e^-$ ✓✓ (2)

5.6 A substance that is reduced/gains electrons ✓✓

OR

A substance that undergoes reduction

OR

A substance that undergoes a decrease in oxidation number. (2)

5.7 Cl^- ✓✓/ Chloride ions ✓✓ (2)

5.8 Anode to cathode ✓ (1)

5.9 $Cu^{2+} + 2Cl^-$ ✓ $\longrightarrow Cu + Cl_2$ ✓ (2)

QUESTION 6

6.1 (Electrochemical) cell that converts chemical energy to electrical energy. ✓✓ (2)
Accept: Spontaneous cell, (Max marks ½)

6.2 Mg/Magnesium ✓ (**Accept**: negative electrode.) (1)

6.3 (Ions in) moist soil ✓ (1)

6.4
- It maintains electrical neutrality of the electrolyte (cell) through the movement of ions. ✓
- It completes the circuit. ✓

(2)

6.5 Decreases ✓ (1)

6.6 (NEGATIVE MARKING FROM **QUESTION 6.5**)

Magnesium is oxidised (to magnesium ions).✓✓

OR

Magnesium loses electrons. ✓ ✓ (2)

6.7 $2Mg + 0_2 + 4H^+$ ✓ $\rightarrow 2Mg^{2+} + 2H_2O$ ✓✓ (3)

6.8

OPTION 1	OPTION 2
$E^\theta_{cell} = E^\theta_{cathode} - E^\theta_{anode}$ ✓ $E^\theta_{sel} = E^\theta_{katode} - E^\theta_{anode}$ $= 1,23$ ✓ $- (-2,36)$ ✓ $= 3,59$ V ✓	$Mg \rightarrow Mg^{2+} + 2e^-$ $-(-2,36)$ ✓ $O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$ $1,23$ ✓ $2Mg + O_2 + 4H^+ \rightarrow 2Mg^{2+} + 2H_2O$ ✓ $3,59$ V✓

(4)

Accept: any correct formula from data sheet,

NOTE:
Penalise once if unconventional abbreviations are used in the formula.

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6.9.1
- Solar (energy)/photovoltaic cells/Radiant (energy) ✓
- Biodiesel ✓
- Fuel cells ✓
- Wind (energy) ✓
- Nuclear (energy) ✓ (Any THREE) (3)

6.9.2
- It is easy to use. ✓
- Cost is lower than petroleum diesel ✓
- Lower $C0_2$ emission/less greenhouse gases/environmentally friendly ✓
- It is not toxic. ✓
- Safer to handle and store. ✓
- Ensure proper recycling of waste products ✓
- Uses natural resources/renewable (resources). (Any THREE) ✓ (3)

GAUTENG 2020
QUESTION 1

1.1	A ✓✓	1.2	C ✓✓	1.3	A ✓✓
1.4	A ✓✓	1.5	B ✓✓	1.6	A ✓✓

[12]

QUESTION 3

3.1 The pressure exerted by a vapour at equilibrium with its liquid ✓in a closed system. ✓ (2)

3.2 London / dispersion forces ✓ (1)

3.3 All organic molecules in the table consist of weak London forces.
- Boiling point decreases with a decrease in the chain length (surface area). ✓
- The lower the boiling point the weaker the intermolecular forces. ✓
- Less energy is required to overcome intermolecular forces. ✓

OR

- Boiling point increases with an increase in the chain length (surface area). ✓
- The higher the boiling point the stronger the intermolecular forces. ✓
- More energy is required to overcome intermolecular forces. ✓ (3)

3.4 Boiling point increases with a decrease in vapor pressure ✓✓ (2)

3.5.1 Viscosity ✓ (1)

3.5.2 Syrup is denser than water✓ therefore it <u>has stronger intermolecular forces</u> than water.✓
The stronger the intermolecular forces, the <u>higher the viscosity</u>✓ (3)

QUESTION 4

4.1.1 $2C_2H_2 + 3O_2 \rightarrow 2CO_2 + 2H_2O$ (reactants) ✓ (products) ✓ (balancing) ✓ (3)

4.2.1 Propane ✓✓ (2)

4.2.2 1-chloropropane ✓✓ (2)

4.2.3 Hydrogenation ✓ (1)

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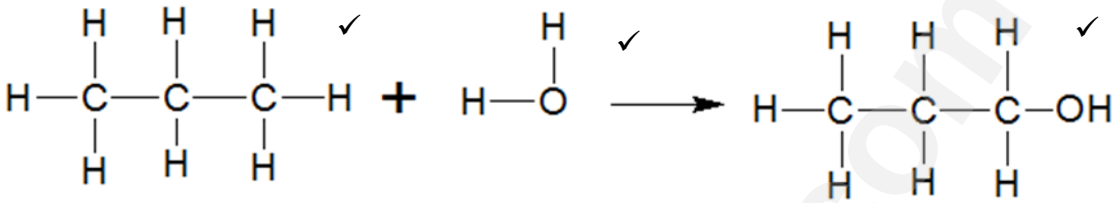
4.2.4 Hydration ✓ (1)

4.2.5 Halogenation ✓ (1)

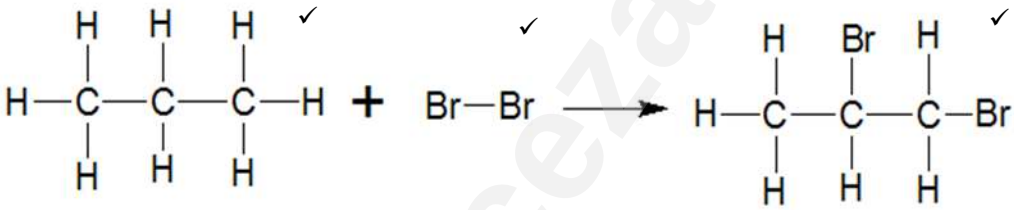
4.2.6 Hydrogenation ✓ (1)

4.2.7



(3)

4.2.8



(3)

[17]

QUESTION 5

5.1 From chemical to electrical energy. ✓✓ (2)

5.2 A ✓ (1)

5.3 Hydrogen gas / H_2 ✓✓ (2)

5.4.1 $O_2(g) + 4H^+ + 4e^-$ ✓ $\rightarrow 2H_2O(g)$ ✓ (2)

5.4.2 $2H_2(g)$ ✓ $+ O_2(g)$ ✓ $\rightarrow 2H_2O$ ✓

Award 2/3 if: $2H_2(g) + 4H^+ + O_2(g) \rightarrow 2H_2O + 4H^+$ (3)

5.4.3 **OPTION 1:**

$E^{\ominus}_{cell} = E^{\ominus}_{reduction} - E^{\ominus}_{oxidation}$ ✓
$= 1{,}26$ ✓ $- (0)$ ✓
$= 1{,}26$ V ✓

OPTION 2:

$H_2 \rightarrow 2H^+ + 2e^-$ 0,00 V ✓
$O2 + 4H^+ + 4e^- \rightarrow 2H_2O$ ✓
+ 1,26 ✓
$H_2 + O_2 \rightarrow H_2O$ 1,26 V ✓ (4)

5.5 Temperature = 298 K / 25 °C ✓
Pressure = 100 Kpa / 1,01 x 105 Pa ✓
Concentration = 1 mol.dm^{-3} ✓ (3)

[17]

QUESTION 6

6.1 An electrochemical cell that converts electrical energy to chemical energy. ✓✓ (2)

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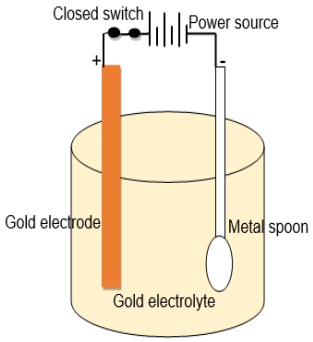
6.2.1



Marking Criteria	Marks
Gold electrolyte connected to the positive terminal of the power source	✓
Metal spoon connected to the negative terminal of the power source	✓
Closed switch	✓
Gold electrolyte indicated in the solution	✓
Power source correctly connected	✓
Only one container with electrolyte used	✓

6.2.2 Non-Spontaneous ✓ (1)

6.2.3 The reaction will not occur on its own unless the cell is connected to a power source. ✓✓ (2)

6.2.4 Gold electrode ✓ (1)

6.2.5 The gold electrode is the reducing agent / undergoes oxidation therefore it donates electrons to the solution. ✓
The gold ions in the gold solution accepts the electrons and form a deposit around the spoon. ✓ (2)

6.2.6 It enhances the look of a gold-plated material. ✓
It is less expensive than the original gold. ✓ (2)

6.3.1
- The fuel cell not only does not create pollution. ✓
- It also makes a by-product that in some environments is a valuable commodity (water). ✓
- Conventional batteries used in fuel cars are heavy and expensive to replace✓ **(Any 2)** (2)

[18]

QUESTION 1

1.1 B □□ 1.2 A □□ 1.3 C □□

1.4 A □□ 1.5 C □□ 1.6 C □□ **[12]**

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QUESTION 2

2.1 A series of organic molecules that can be described by the same general formula and where each member differs from the next by a CH_2 group. □□ (2)

2.2 A group of atoms whose bonding is the same from molecule to molecule with similar physical and chemical properties.□□□ (2)

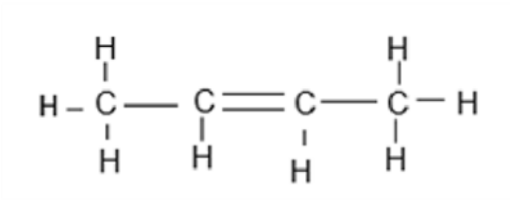
2.3.1 **E** □ (1)

2.3.2 **C** □ (1)

2.4.1 Butane □□ (2)

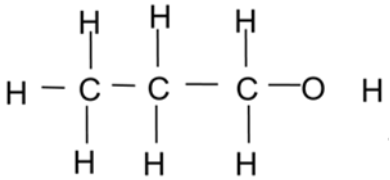
2.4.2 2-methylpropan-1-ol □□ OR 2-methylpropanol □□ (2)

2.5.1



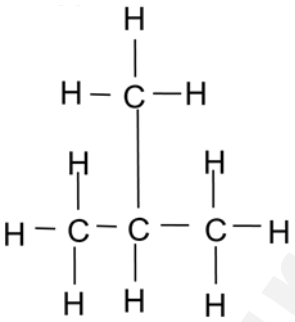
✓✓ (2)

2.5.2



✓✓ (2)

2.5.3

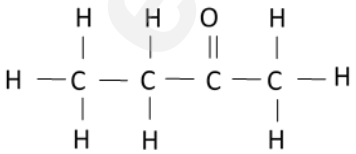


✓✓ (2)

2.6 Positional isomers are organic molecules with the same molecular formula/ and <u>same structural formula/ and same functional group</u>,□□ but <u>differ from</u> <u>each other in the location (position)</u>□□ of the functional group in the carbon chain. (2)

2.7 Ketones (1)

2.8 (2)



✓✓

[21]

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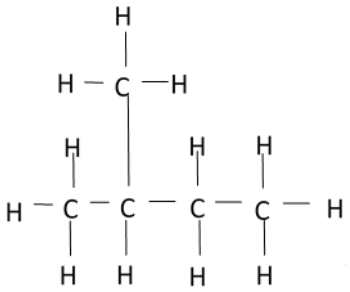
QUESTION 3

3.1 It is a long chain of monomers, covalently bonded together (in a repeating patterns).□□□ (2)

3.2 Unsaturated□ Not all C-C bonds are single bonds □□□□**OR** (3)

It contains C-C double bonds □□

3.3



✓✓ (2)

3.4
- Destruction of indigenous forests (leading to global warming) □
- Rubber is not biodegradable – disposal impacts negatively on environment □
- Burning of rubber releases toxic gases □ (any 2) (2)

3.5
- Job creation □□
- Tyres for cars / gloves for medical industry / raincoats etc □□
- Protective devices – insulation □□□□□□□□□□□□□□□(any 2) (4)

[13]

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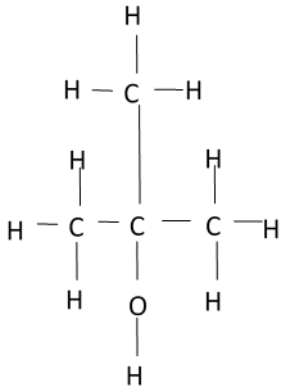
QUESTION 4

4.1 D □□ (2)

4.2.1



✓✓

(2)

4.2.2 D □□ (2)

4.3.1 C □ (propan-1-ol/1-propanol)
Longest flow time / flows the slowest / most resistance to flow. □ (2)

4.3.2 Increase in chain length □/ molecular mass / molecular size / surface area from A to C. □
Increase in strength of intermolecular/ Van der Waals / Dispersion / London forces. □ (3)

4.3.3 **C**. □ Since it is having strong intermolecular forces and the longest chain length □ which contributes to its resistance to flow makes propan-1-ol a best lubricant. □ (3)

4.3.4 Vapour pressure is a measure of the tendency of a material to change into a gaseous state. □□
(2)

4.4 **E** (butan-2-ol or 2-butanol) □
The more branched/more compact alcohol/**E** has a smaller surface area (over which the intermolecular forces act). □ Decrease in strength of intermolecular forces/ reduced resistance to flow (and thus lower viscosity).□□
(3)

OR

The straight-chain alcohol/**D** has a larger surface area/less compact (over which intermolecular forces act). □
Increase in strength in intermolecular forces. Increased resistance to flow (and thus higher viscosity□

QUESTION 5

5.1 Addition (reaction) □□ (2)

5.2 Add acidic reagent HBr□
At room temperatures **or** 25 ºC□ (2)

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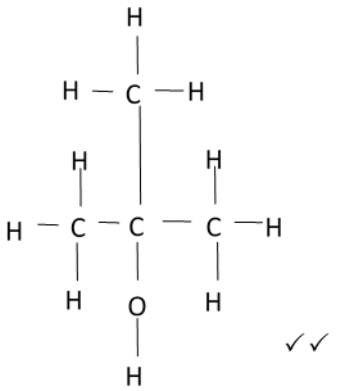
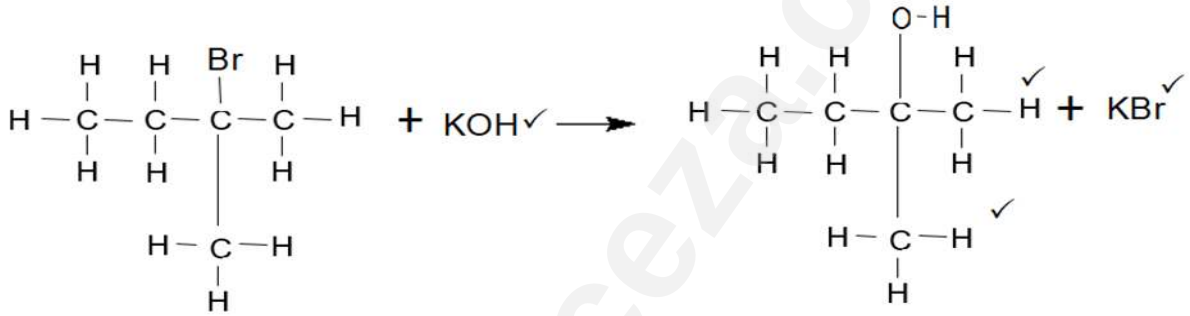
5.3



✓✓ (2)

5.4 H_2O □□ / Water □□ (2)

5.5



(4)

5.6 Addition (reaction) □□ (2)

5.7.1 Water □ and Carbon Dioxide □ (2)

5.7.2 $2\ C_6H_{14}$ □ + $19\ O_2$ □ → $12\ \underline{CO_2 + 14\ H_2O}$ □ (□ balancing is 1 mark)

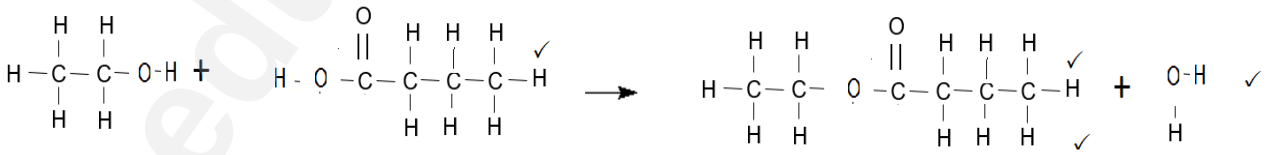
(4)
[20]

QUESTION 6

6.1 Ethanol □□ (2)

6.2 It acts as a catalyst □□

6.3



(4)

6.4 The contents of the mixture are <u>flammable</u> □□ (2)

6.5 They are used to flavour foods and sweets □□ (2)
[12]

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7. Previous question papers

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