UNIT 1

TOPIC 5 : ALKENES

SECTION A

Answer ALL questions. Write your answers in the spaces provided.

For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

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1.

Which of these is **not** a way of limiting global problems caused by polymer disposal?

☒ **A** developing biodegradable polymers

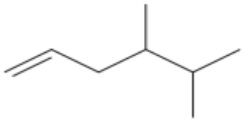
☒ **B** exporting polymer waste

☒ **C** removing toxic waste gases produced by the incineration of polymers

☒ **D** reusing products made from polymers

2.

What is the systematic name of this compound?



☒ **A** 1,1,2-trimethylpent-4-ene

☒ **B** 2,3-dimethylhex-5-ene

☒ **C** 4,5-dimethylhex-1-ene

☒ **D** 4,5,5-trimethylpent-1-ene

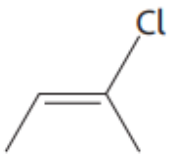
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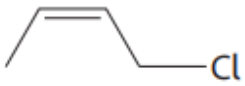
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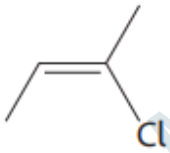
Geometric isomerism is shown by 2-chlorobut-2-ene.

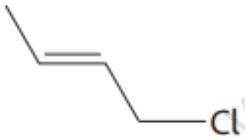
(a) What is the skeletal formula of *E*-2-chlorobut-2-ene?

(1)

☒ **A** 

☒ **B** 

☒ **C** 

☒ **D** 

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What is the **total** number of sigma bonds in *Z*-2-chlorobut-2-ene?

(1)

☒ **A** 3

☒ **B** 4

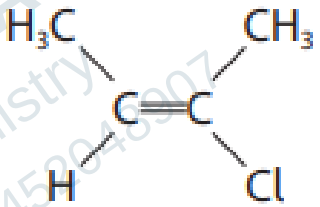
☒ **C** 10

☒ **D** 11

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4.

What is the IUPAC name for the compound with the structure shown?



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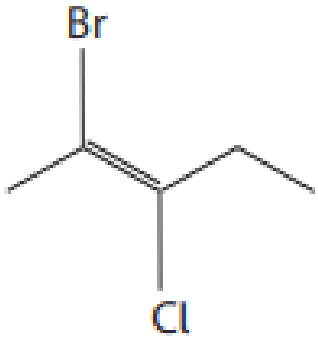
- ☒ **A** *cis*-2-chlorobut-2-ene
- ☒ **B** *trans*-2-chlorobut-2-ene
- ☒ **C** *E*-2-chlorobut-2-ene
- ☒ **D** *Z*-2-chlorobut-2-ene

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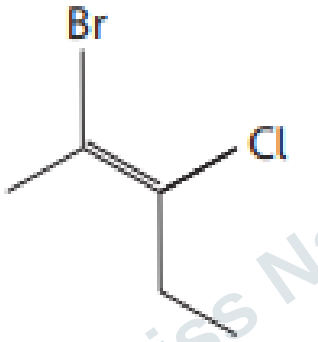
5.

Which structure has the name *E*-2-bromo-3-chloropent-2-ene?

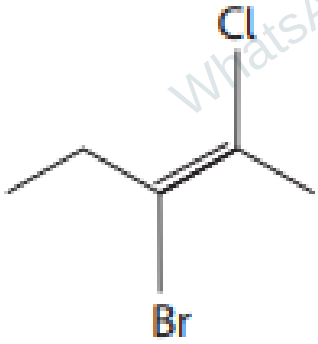
☒ **A**



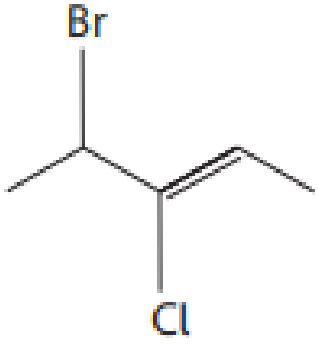
☒ **B**



☒ **C**



☒ **D**



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6.

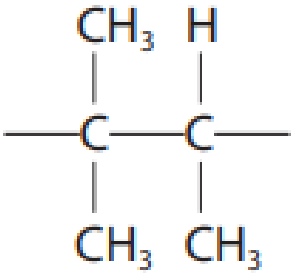
Which molecule can exist as *E-Z* isomers?

- ☒ **A** 2-chloro-4-ethylhex-3-ene
- ☒ **B** 3-chloro-2-methylhex-2-ene
- ☒ **C** 2,3-dimethylhex-2-ene
- ☒ **D** 2,5-dichlorohex-3-ene

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7.

The repeat unit of a polymer is shown.



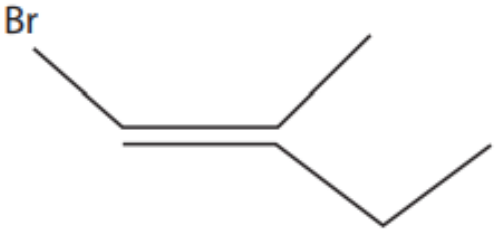
Which is the name of the monomer that forms this polymer?

- ☒ **A** 1,1,2-trimethylethene
- ☒ **B** 1,1-dimethylpropene
- ☒ **C** 2-methylbut-2-ene
- ☒ **D** 3-methylbut-2-ene

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8.

What is the IUPAC name for the compound shown?



- ☒ **A** *E*-1-bromo-2-methylbut-1-ene
- ☒ **B** *Z*-1-bromo-2-methylbut-1-ene
- ☒ **C** *E*-1-bromo-2-ethyl-2-methylethene
- ☒ **D** *Z*-1-bromo-2-ethylpropene

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9.

The skeletal formula of cyclohexa-1,4-diene is shown.



(a) The total number of σ (sigma) bonds in this molecule is

(1)

- ☒ **A** 4
- ☒ **B** 6
- ☒ **C** 12
- ☒ **D** 14

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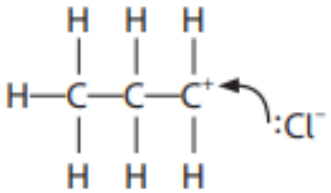
10.

Propene, $CH_3CH{=}CH_2$, reacts with hydrogen chloride, HCl, to form halogenoalkanes.

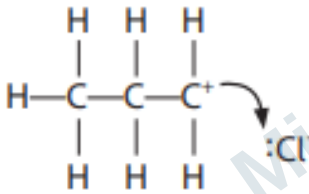
(a) Which of these steps is most likely to occur in the reaction?

(1)

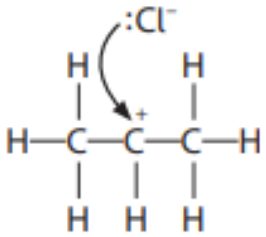
☒ **A**



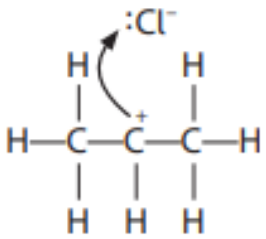
☒ **B**



☒ **C**



☒ **D**



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(b) The reaction of propene with hydrogen chloride is an example of

(1)

- ☒ **A** free radical substitution
- ☒ **B** free radical addition
- ☒ **C** electrophilic substitution
- ☒ **D** electrophilic addition

11.

Ethene reacts with acidified potassium manganate(VII). A student makes four statements about the reaction.

- the organic product can show geometric isomerism
- the type of reaction that takes place is oxidation
- the bond angles around each carbon atom are greater in the product than in ethene
- the acidified potassium manganate(VII) decolourises in the reaction

How many of these statements are correct?

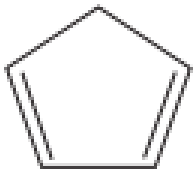
- ☒ **A** one
- ☒ **B** two
- ☒ **C** three
- ☒ **D** four

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12.

A cyclic hydrocarbon has the structure shown.



How many pi (π) and sigma (σ) bonds are present in the molecule?

	pi (π) bonds	sigma (σ) bonds
☒ **A**	2	11
☒ **B**	2	5
☒ **C**	4	3
☒ **D**	4	10

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13.

Which statement about poly(ethene) is **not** correct?

☒ **A** it is an addition polymer

☒ **B** it decolourises bromine water

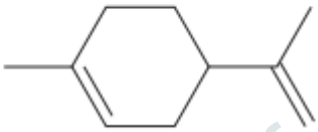
☒ **C** it is non-biodegradable

☒ **D** it has the empirical formula CH_2

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14.

This question is about limonene.



(a) What is the molecular formula of limonene?

(1)

- ☒ **A** $C_{10}H_{10}$
- ☒ **B** $C_{10}H_{16}$
- ☒ **C** $C_{10}H_{18}$
- ☒ **D** $C_{10}H_{22}$

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(b) Limonene is completely hydrogenated by hydrogen in the presence of a nickel catalyst. What is the **empirical formula** of the product formed?

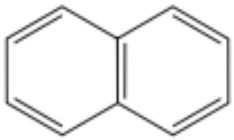
(1)

- ☒ **A** C_5H_{11}
- ☒ **B** C_5H_9
- ☒ **C** C_5H_8
- ☒ **D** CH_2

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15.

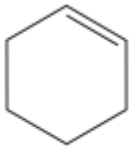
What is the molecular formula of naphthalene?



- ☒ **A** $C_{10}H_8$
- ☒ **B** $C_{10}H_{10}$
- ☒ **C** $C_{12}H_{10}$
- ☒ **D** $C_{12}H_{12}$

16.

This question is about cyclohexene, a cyclic alkene.



(a) What is the general formula of cyclic alkenes such as cyclohexene?

(1)

- ☒ **A** C_nH_{2n-4}
- ☒ **B** C_nH_{2n-2}
- ☒ **C** C_nH_{2n}
- ☒ **D** C_nH_{2n+2}

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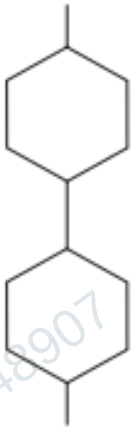
(b) Cyclohexene can form an addition polymer.

Which diagram shows two repeat units of this addition polymer?

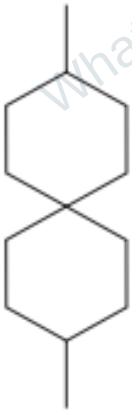
(1)



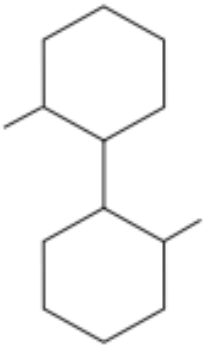
☒ A



☒ B



☒ C

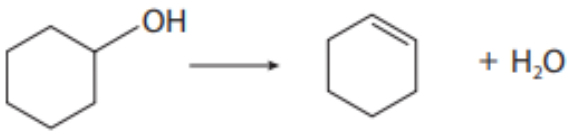


☒ D

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(c) Cyclohexanol can be converted into cyclohexene.



What mass of cyclohexanol is needed to make 7.20 g of cyclohexene, if the yield of this reaction is 72.0 %?

[M_r values: cyclohexanol = 100 cyclohexene = 82.0]

(1)

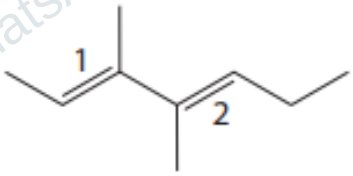
- ☐ **A** 4.25 g
- ☐ **B** 5.90 g
- ☐ **C** 8.78 g
- ☐ **D** 12.2 g

(Total for Question 15 = 3 marks)

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17.

The molecule shown has two double bonds.



Which is the correct identification for each double bond?

	Double bond 1	Double bond 2
☒ **A**	*E*	*E*
☒ **B**	*E*	*Z*
☒ **C**	*Z*	*E*
☒ **D**	*Z*	*Z*

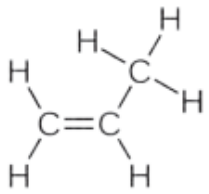
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SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

QUESTION NO 1:

This question is about the reactions of propene.



propene

(a) Write an equation for the incomplete combustion of **one mole** of propene to form carbon dioxide, carbon monoxide, carbon and water as the only products. Include state symbols.

(2)

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(b) State **one** similarity and **one** difference that would be **seen** when propene is mixed with separate samples of acidified potassium manganate(VII) solution and of bromine water.

(2)

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(c) Propene reacts by addition polymerisation to form poly(propene).

Draw the structure of poly(propene), showing **two** repeat units.

(1)

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(d) Propene reacts with bromine monochloride, BrCl, to form 1-bromo-2-chloropropane as the major product.

(i) Complete the diagram of bromine monochloride to show the dipole.

(1)

Br ——— Cl

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(ii) Draw the mechanism for the formation of 1-bromo-2-chloropropane in this reaction.
Include curly arrows, and relevant lone pairs.

(3)

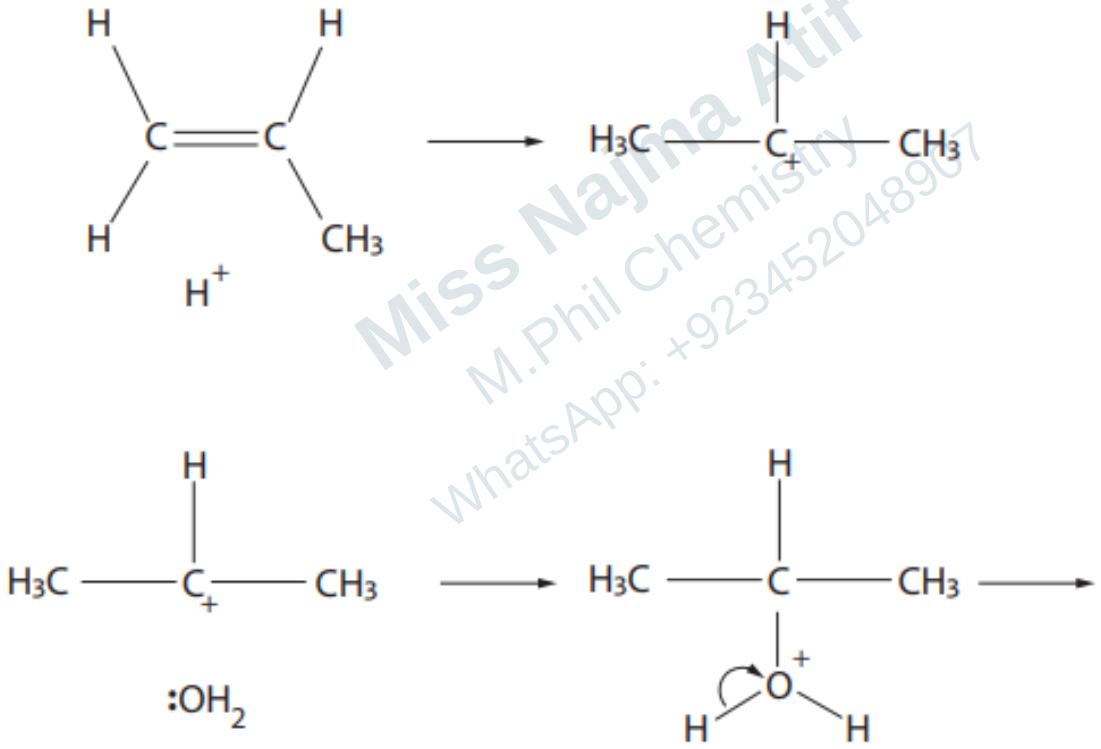
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(e) Propene reacts with steam in the presence of an acid catalyst to form a mixture of the alcohols propan-1-ol and propan-2-ol.

Complete the mechanism for the formation of propan-2-ol, by adding curly arrows.
Include the species formed in the final step.

(3)



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TOTAL FOR QUESTION 1: 12 MARKS

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QUESTION NO 2:

This question is about alkenes.

(a) An alkene has a molar mass of 112 g mol^{-1}.

Deduce the molecular formula of this alkene.

(1)

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(b) There are a number of different alkenes with the molecular formula C_4H_8.

(i) Draw the structure of the **branched-chain** alkene with the molecular formula C_4H_8.

(1)

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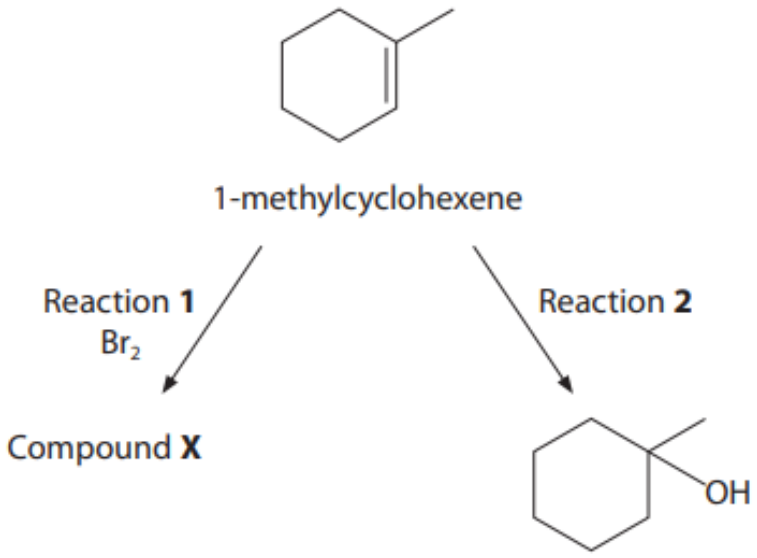
(ii) Give the structures and names of the two geometric isomers with the molecular formula C_4H_8.

(2)

Structure of geometric isomer 1	Structure of geometric isomer 2
Name of isomer 1	Name of isomer 2

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(c) Two reactions of 1-methylcyclohexene are shown.



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(i) Draw the **skeletal** formula of compound **X** formed in Reaction **1**.

(1)

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(ii) Give the reagent and condition needed for Reaction **2**.

(2)

Reagent .....

Condition .....

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(d) Iodine monochloride, ICl, reacts with alkenes in a similar way to hydrogen bromide.

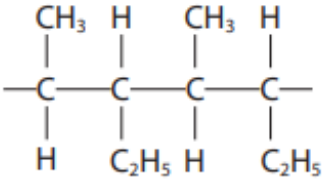
Complete the mechanism for the reaction of iodine monochloride with propene to form the **major** product.
Include curly arrows, the relevant lone pair and the structures of the intermediate and product.

(4)



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(e) A section of a polymer showing two repeat units is given.



Give the **name** of the monomer that forms this polymer.

(1)

TOTAL MARKS FOR QUESTION 2: 12

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QUESTION NO 3:

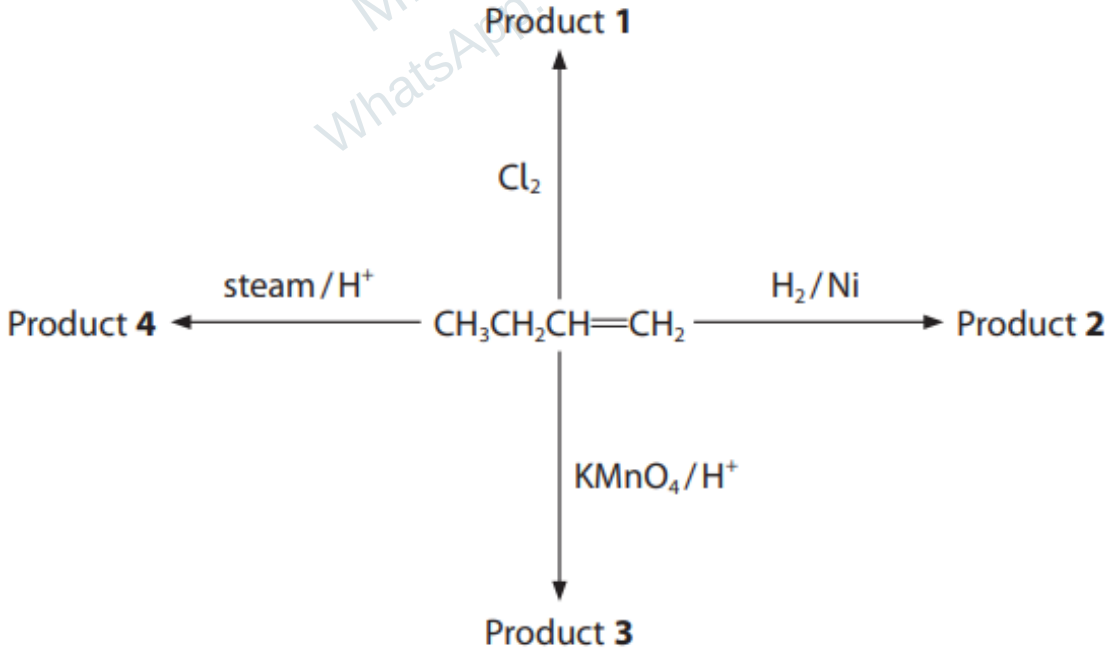
Alkanes and alkenes are obtained from crude oil.

Give the **skeletal** formulae for the other three **alkene** isomers of C_4H_8

(2)

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(iii) Some reactions of but-1-ene are shown.



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Give the name and **structural** formula of each of the products.

(4)

Product	Name	Structural formula
1		
2		
3		
4		

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(c) Draw the displayed formula of poly(but-1-ene) showing two repeat units.

(2)

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(d) State **one** advantage and **one** disadvantage of using incineration for the disposal of polymers, other than the effect on climate.

(2)

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QUESTION NO 4:

This question is about alkenes.

Alkenes contain a carbon to carbon double bond that consists of a σ bond and a π bond.

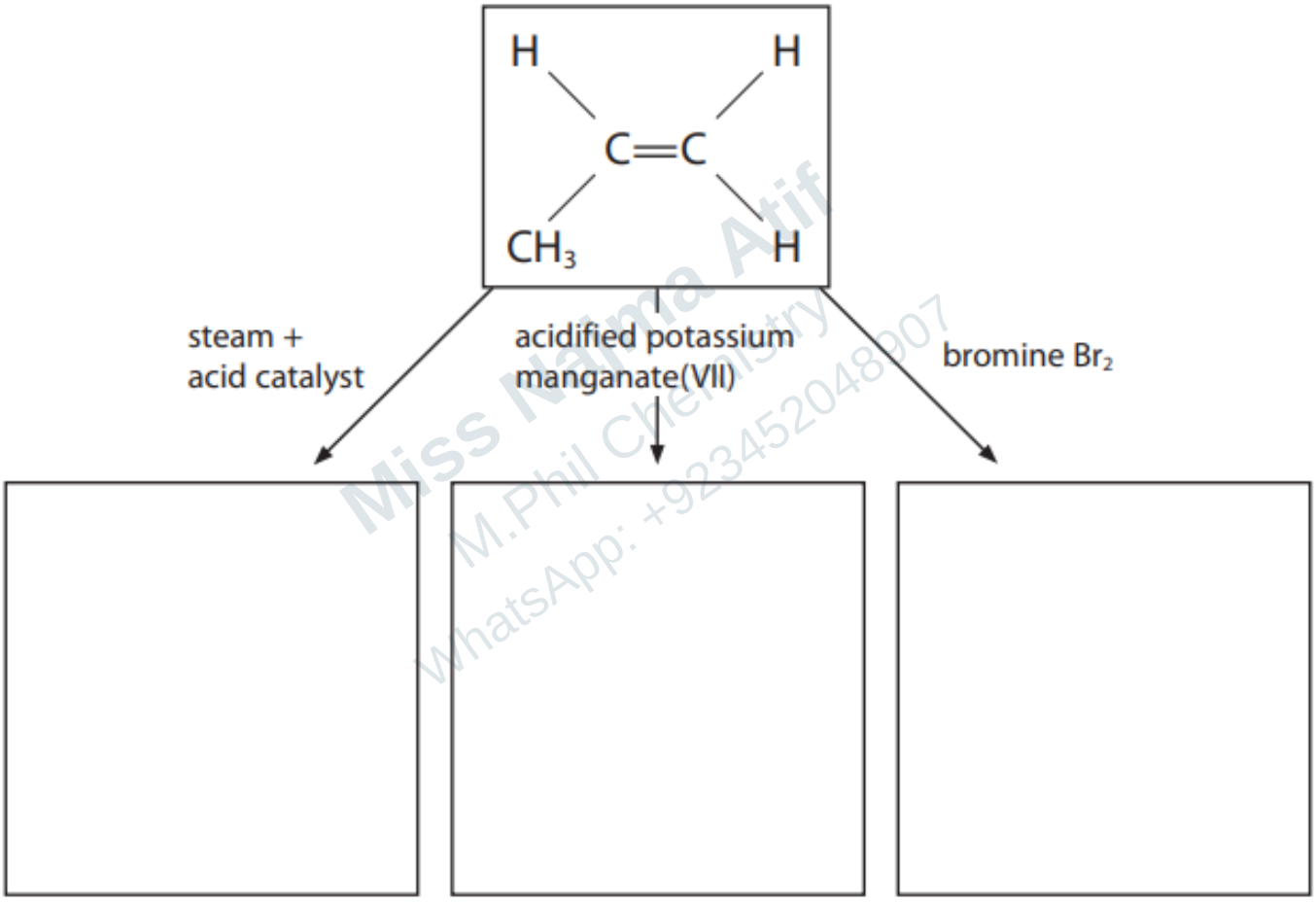
(a) Complete the diagram to show the areas of electron density for each bond. Label the σ bond and the π bond.

(2)

C C

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(b) Propene, C_3H_6, is an alkene. The reagents needed for three reactions of propene are shown.



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(i) In each box, draw the structure of the organic product of the reaction.

(3)

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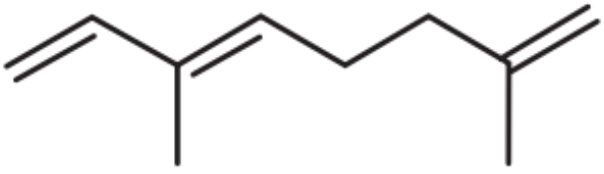
(ii) Propene also reacts with hydrogen bromide, HBr.

Give the mechanism for this reaction to form the **major** product.
Include curly arrows, and relevant lone pairs and dipoles.

(3)

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(c) Alpha-ocimene contains three carbon to carbon double bonds. It is found in plants and has a sweet smell. The skeletal formula of alpha-ocimene is shown.



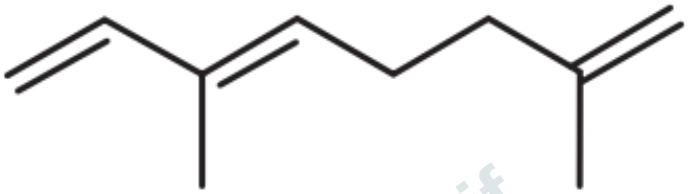
(i) Give the molecular formula of alpha-ocimene.

(1)

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(ii) On the skeletal formula, draw a circle around the part of the molecule that gives rise to the geometric isomerism of alpha-ocimene.

(1)



(iii) Draw the **skeletal** formula of the other geometric isomer of alpha-ocimene.

(1)

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(iv) In an experiment, 0.050 mol of alpha-ocimene reacted with 3.6 dm^3 of hydrogen, H_2, in the presence of a catalyst.

Deduce the structure of the product of this reaction.
You **must** show your working.

[Molar volume of $H_2 = 24\,dm^3\,mol^{-1}$]

(3)

Calculation

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Structure

TOTAL FOR QUESTION 4: 14

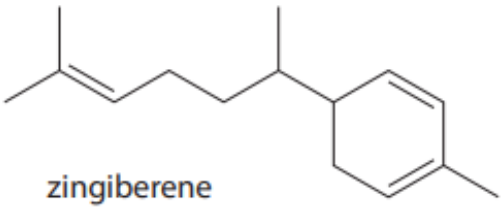
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QUESTION NO 5:

Zingiberene is the compound that gives ginger its characteristic flavour.
Its IUPAC name is 2-methyl-5-(6-methylhept-5-en-2-yl)cyclohexa-1,3-diene.

(a) On the structure of zingiberene, draw a circle around the '2-methyl' group referred to in the IUPAC name.

(1)



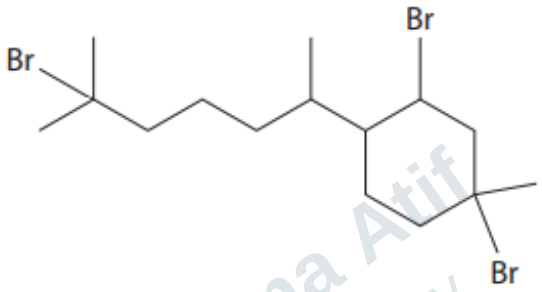
zingiberene

(b) Deduce the molecular formula of zingiberene.

(2)

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(c) When zingiberene reacts with excess hydrogen bromide, there are a number of possible products. The structure of the major product is shown.



(i) Name the type and mechanism of the reaction.

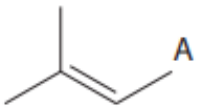
(1)

(ii) The diagram shows a simplified structure of zingiberene, in which part of the molecule is represented by A.

Complete the mechanism for the reaction of zingiberene with **one** molecule of hydrogen bromide.

Include curly arrows, and any relevant dipoles and lone pairs.

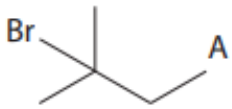
(4)



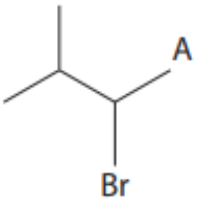
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(iii) For the reaction in (c)(ii) there are two possible products:



I



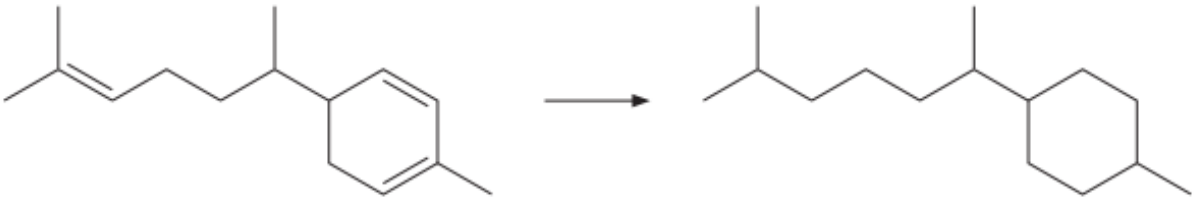
II

Explain why I is the major product, by referring to your mechanism.

(2)

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(d) Zingiberene reacts with hydrogen gas in the presence of a catalyst.



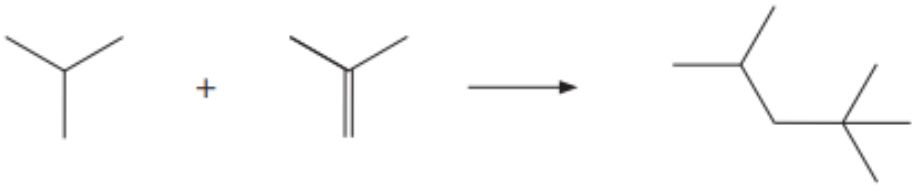
(i) Identify the catalyst, by name or formula.

(1)

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QUESTION NO 6:

(b) Another way to produce iso-octane is by reacting iso-butane with 2-methylpropene.



iso-butane 2-methylpropene iso-octane

Draw the **skeletal** formulae of four isomers of 2-methylpropene.
Include only **one** isomer that does not decolorise bromine water.

(4)

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(c) 2-methylpropene reacts with hydrogen bromide to form two possible products.

(i) Draw the mechanism for the formation of the **major** product of the reaction between 2-methylpropene and hydrogen bromide, HBr.

Include curly arrows, and relevant lone pairs and dipoles.

(4)

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(ii) Give the reason why your product in (c)(i) is the major product.

(1)

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QUESTION NO 7:

Limonene is an oil extracted from the skin of citrus fruits such as oranges or lemons. It is found in some cleaning products such as those used to remove chewing gum.

Limonene has the structure shown.



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(a) Deduce the molecular formula of limonene.

(2)

.....

(b) (i) A few drops of acidified potassium manganate(VII) solution are mixed with a sample of limonene.

State the colour change.

(1)

From ..... to .....

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(ii) Draw the skeletal formula of the structure of the **organic** product formed when the reaction in (b)(i) is carried out with **excess** acidified potassium manganate(VII).

(1)

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(iii) Name the type of reaction that limonene undergoes in (b)(i).

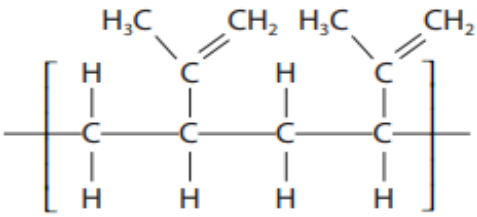
(1)

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(c) On heating, limonene reacts to form two molecules of a smaller hydrocarbon, **Q**.

Q can be polymerised to form **R**, a polymer used to improve the grip of car tyres.

A section of **R** is shown.



Section of polymer **R**

Draw the structure of **Q**.

(1)

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(d) Give **two** ways in which chemists can help minimise problems caused by the disposal of polymers.

(2)

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(e) Limonene is extracted from orange peel using a solvent.
Possible solvents are hexane and liquid carbon dioxide.

Liquid carbon dioxide can be obtained by allowing solid carbon dioxide to melt under high pressure.

(i) Suggest one advantage and one disadvantage of using liquid carbon dioxide rather than hexane to dissolve the limonene. Assume that the carbon dioxide does not escape into the atmosphere.

(2)

Advantage

.....

.....

Disadvantage

.....

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QUESTION NO 8:

(ii) Over 70 million tonnes of poly(propene) are produced each year.

State **two** problems with the disposal of polymers such as poly(propene).

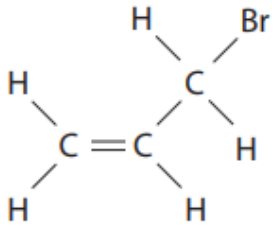
(2)

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(c) Hydrogen bromide reacts with 3-bromopropene to form 1,2-dibromopropane as the major product.

(i) Complete the mechanism to show this reaction.
Include curly arrows, and any relevant lone pairs and dipoles.

(4)





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(ii) Explain why 1,2-dibromopropane is the major product instead of 1,3-dibromopropane.

(2)

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QUESTION NO 9:

This question is about alkenes.

(a) A straight-chain alkene, **X**, has the structure shown.



(i) Draw the skeletal formulae of the four structural isomers of **X** that are alkenes.
Do not include geometric isomers.

(4)

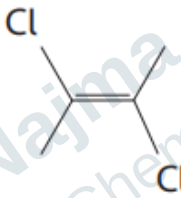
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(ii) Explain why **X** can exist as **geometric** isomers.

(2)

(b) Another compound, **Y**, has the structure shown.



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(i) Give the IUPAC name for **Y**.

(1)

(ii) A student stated that

'Compound **Y** has polar bonds so it is a polar molecule'.

Comment on this statement.

(3)

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(c) Bisabolenes are a group of compounds found in plants and fungi.
Bisabolene molecules contain several carbon–carbon double bonds.

5.51 g of α-bisabolene reacted with 1873 cm^3 of hydrogen gas, H_2.
The reaction occurred at a temperature of 150 °C and a pressure of 152 000 Pa.

[M_r value: α-bisabolene = 204.0]

(i) Calculate the amount, in mol, of α-bisabolene in 5.51 g.

(1)

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(ii) Calculate the amount, in mol, of hydrogen gas that reacted with α-bisabolene.
Use the ideal gas equation, $pV = nRT$.

[$R = 8.31\ J\,mol^{-1}\,K^{-1}$]

(3)

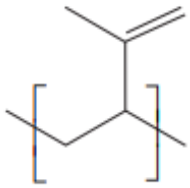
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(iii) Deduce the number of carbon-carbon double bonds in a molecule of α-bisabolene, using your answers to (c)(i) and (c)(ii).

(1)

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(d) The repeat unit of the polymer polyisoprene is shown.



polyisoprene

(i) Draw the **skeletal** formula of the monomer of polyisoprene.

(1)

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(ii) A sample of polyisoprene has a relative molecular mass of 50 250.
Calculate the number of repeat units in the sample.

(2)

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(e) Incinerators used to dispose of polymer waste have a system to remove waste gases.
Suggest why these systems contain solid calcium hydroxide and why it is finely powdered.

(2)

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QUESTION NO 10:

Compounds **A**, **B**, **C** and **D** all have the molecular formula C_4H_8.
A, **B** and **C** each contain one double bond, but **D** does not.
A and **B** are geometric isomers of each other.

(a) Deduce a possible structure and name for each compound.

(4)

Possible structure of **A**	Possible structure of **B**
Name	Name .....
Possible structure of **C**	Possible structure of **D**
Name	Name .....

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(b) The carbon–carbon double bond consists of a σ bond and a π bond.

Describe the difference between the σ bond and the π bond.
Include a labelled diagram in your answer.

(4)

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(c) Give **two** reasons why compounds **A** and **B** exist as geometric isomers.

(2)

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QUESTION NO 11:

(c) 2-Chloropropane can also be produced from the reaction of propene with hydrogen chloride.

(i) Give the mechanism for this reaction.
Include curly arrows and relevant dipoles and lone pairs.

(4)

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(ii) Explain why only a small amount of 1-chloropropane is produced in this reaction.

(2)

QUESTION NO 12:

Both butter and margarine are fats used in cooking.

(a) Margarines are sold as unsaturated fats.

State the meaning of the term unsaturated.

(1)

(b) (i) The degree of unsaturation can be determined by the reaction with bromine water.

Name the type of reaction.

(1)

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Data using 0.5 g of some unsaturated fat in this bromination is given in the table.

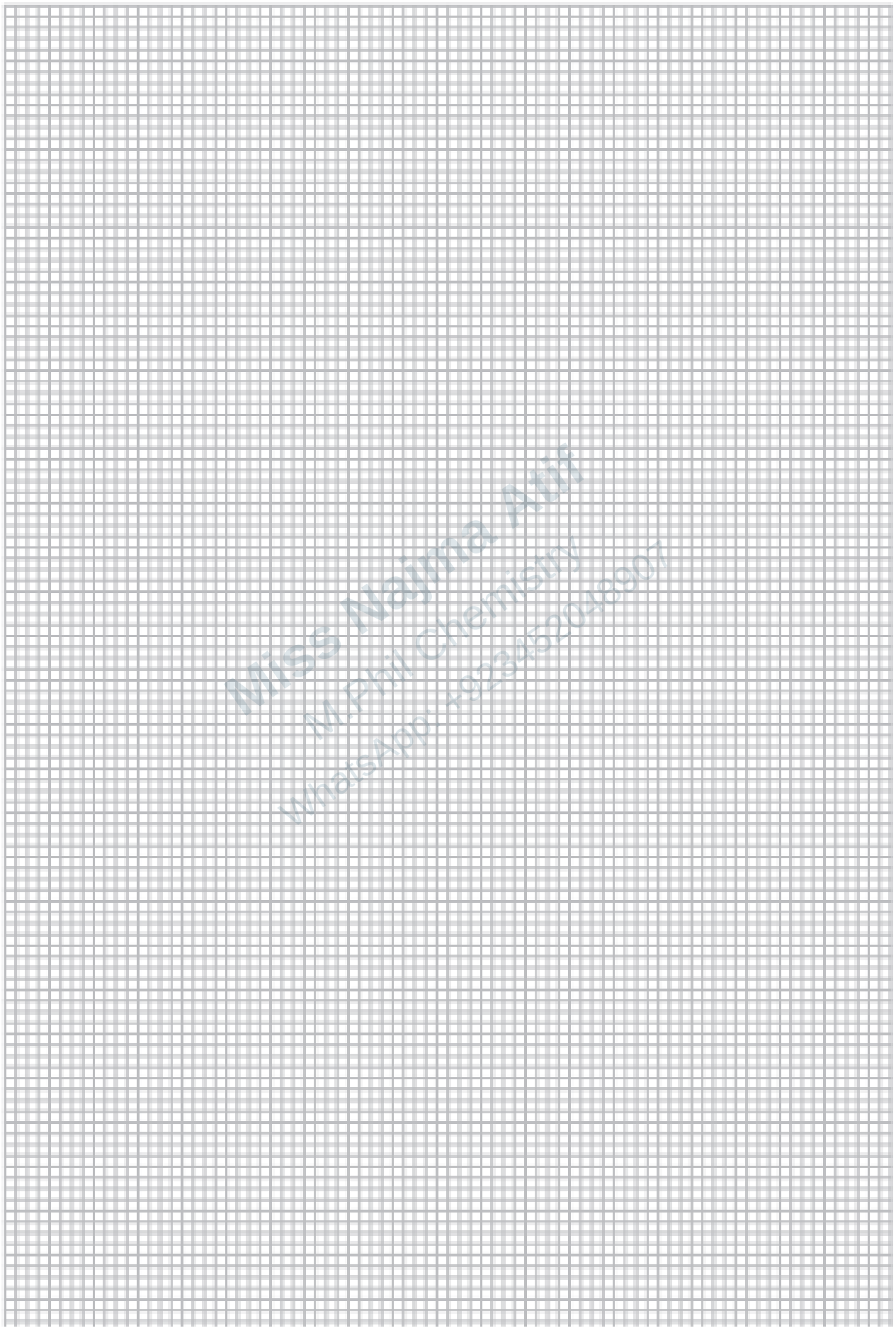
Average number of C═C bonds per molecule	Volume of 0.0625 mol dm^{-3} bromine water / cm^3
1	28.3
2	57.3
3	86.9
4	115

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(ii) Plot a graph of the data. Include a line of best fit.

(3)

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(iii) Data for the bromination of 0.5 g samples of a margarine are shown.

Trial	Volume of 0.0625 mol dm^{-3} bromine water / cm^3
1	36.9
2	34.1
3	39.3
4	32.5

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Calculate the mean volume of bromine water using all results in the table.

(1)

(iv) Determine the average number of C═C bonds per molecule of the unknown sample to 2 significant figures, using your graph.

(1)

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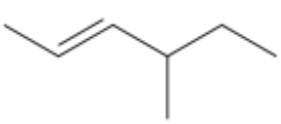
(c) (i) Using the simplest alkene as an example, draw the mechanism to show the reaction with liquid bromine.

(4)

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(ii) Name this compound by applying IUPAC rules.

(1)



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(d) Explain the meaning of "trans" in "trans" fats, using a **skeletal** formula showing four carbon atoms in your answer.

(2)

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QUESTION NO 13:

Many synthetic polymers are used in the home.
Some are used as containers and others as coatings.

PVC and PTFE are two such examples.

(a) Draw the **displayed** formula of each of the monomers for these polymers.

(2)

chloroethene

tetrafluoroethene

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(b) Incineration and recycling are two methods of disposing of polymer waste. Give **one** advantage and **one** disadvantage for each method.

(4)

Incineration

advantage .....

.....

.....

disadvantage .....

.....

.....

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Recycling

advantage .....

.....

.....

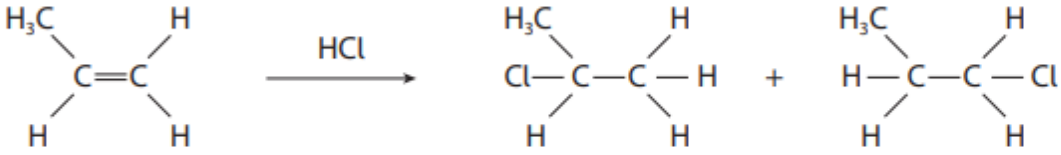
disadvantage .....

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QUESTION NO 14:

19 This question is about two reactions of propene.

Reaction **1**

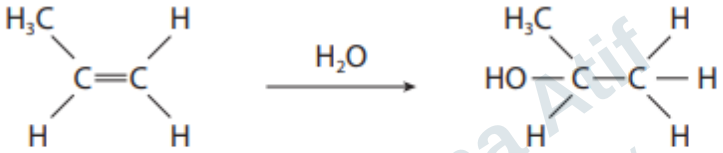


propene

2-chloropropane (major product)

1-chloropropane (minor product)

Reaction **2**



(a) (i) Name the mechanism and type of reaction for Reaction **1**.

(1)

(ii) Explain why the structures of the intermediates in Reaction **1** mean that 2-chloropropane is formed in greater yield than 1-chloropropane.

(3)

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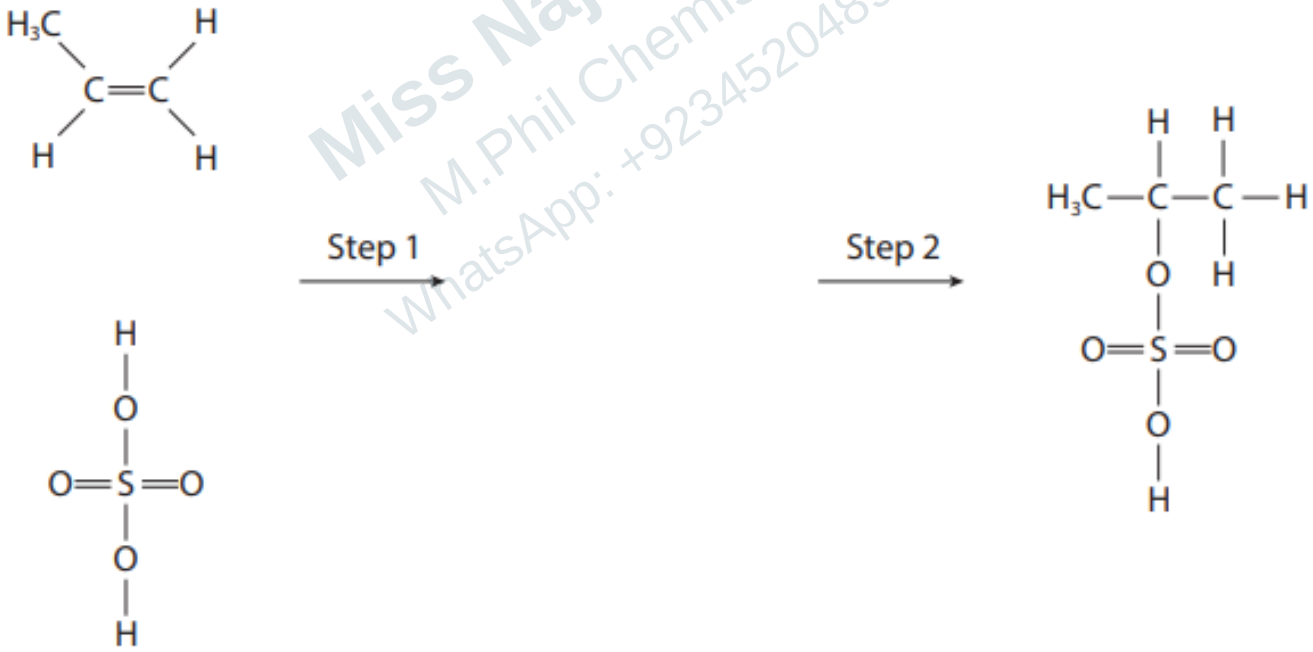
(b) Reaction **2** proceeds in two stages.
The equation for the first stage is shown.

$$CH_3CH{=}CH_2 + H_2SO_4 \rightarrow CH_3CH(OSO_2OH)CH_3$$

The mechanism for this reaction is the same as Reaction **1**.

Complete the mechanism by including the intermediate structure, curly arrows and relevant dipoles, charges and lone pairs.

(4)



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