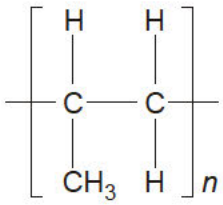
F322: Chains, Energy and Resources

2.1.3 Alkenes

1. Alkenes are used to make addition polymers.
The repeat unit for an addition polymer is shown below.

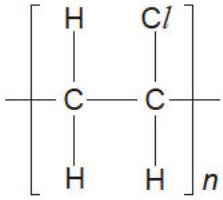


What is the name of the monomer used to make this polymer?

.....

[Total 1 mark]

2. Poly(chloroethene) has the repeat unit below.



This repeat unit can be written as —CH_2CHCl— .

One way to dispose of poly(chloroethene) is to react it with oxygen at high temperature.
This is called incineration.

(i) Complete the following equation that shows the reaction taking place during incineration.

—CH_2CHCl— + ... O_2 → ..... CO_2 + ... H_2O + ... HCl

[1]

(ii) Research chemists have reduced the environmental impact of incineration by removing the HCl formed from the waste gases.

Suggest a type of reactant that could be used to remove the HCl .

.....

[1]

[Total 2 marks]

3. The disposal of polymers causes environmental damage.
Research chemists are developing polymers that will reduce this environmental damage and increase sustainability.

Describe **two** ways in which chemists can reduce this environmental damage.

.....

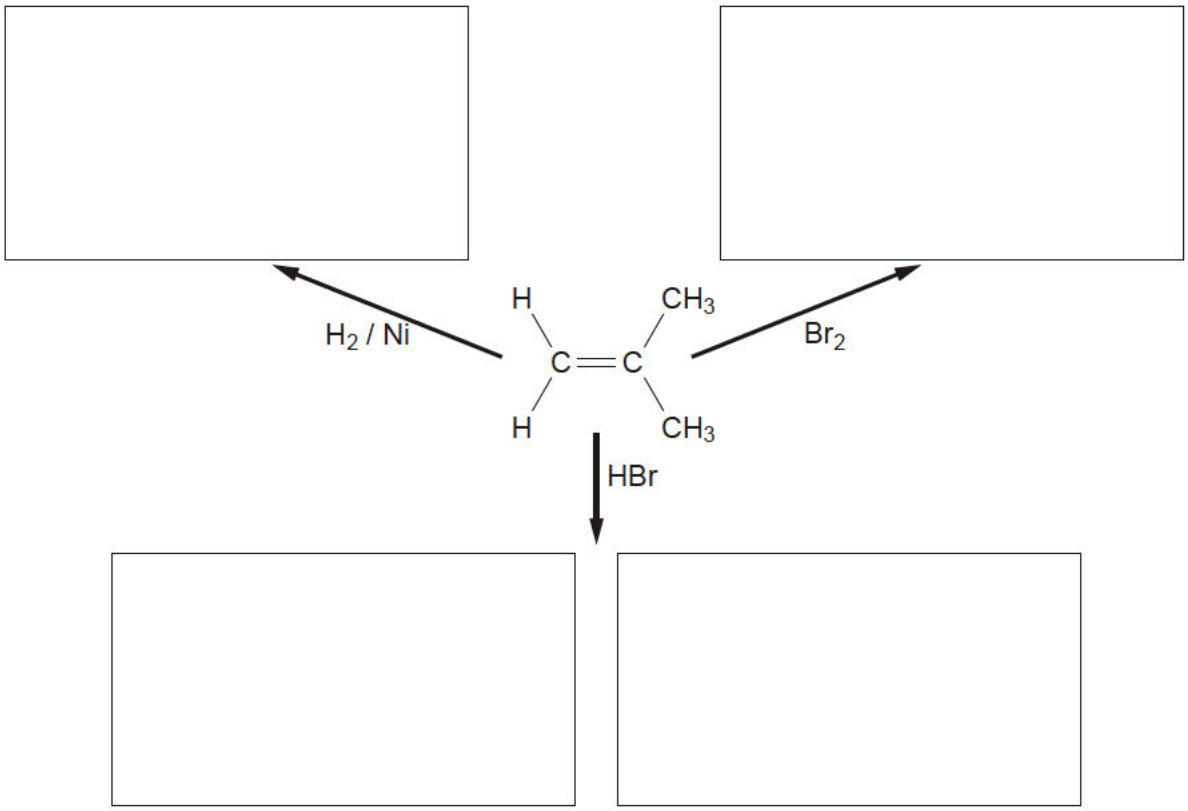
.....

.....

[Total 2 marks]

4. Alkenes are unsaturated hydrocarbons used in the industrial production of many organic compounds.

Complete the flowchart below to show the organic product formed in each addition reaction of methylpropene.



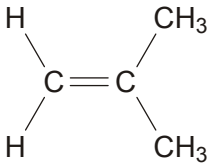
mixture of isomers

[Total 4 marks]

5. Curly arrows are used in reaction mechanisms to show the movement of electron pairs during chemical reactions.

Use curly arrows to outline the mechanism for the addition reaction of methylpropene with bromine. The structure of methylpropene has been drawn for you.

Include relevant dipoles in your answer.



[Total 4 marks]

6. Fluoroalkenes are used to make polymers. For example, PVF, $(CH_2CHF)_n$, is used to make non-flammable interiors of aircraft.

(i) Draw **two** repeat units of the polymer PVF showing all bonds.

[1]

(ii) Draw the structure of the monomer of PVF.

[1]

[Total 2 marks]

7. Once polymers have been used, they become waste.

Outline **two** ways that waste polymers are processed usefully, rather than just dumped in landfill sites.

.....

.....

.....

.....

.....

[Total 2 marks]

8. But-1-ene is just one isomer with the molecular formula C_4H_8.

The chemical properties of but-1-ene are similar to those of ethene.

- Using this information, predict the organic products in, and the equations for, the reactions of but-1-ene with bromine, hydrogen bromide and steam.
- Draw a section of the polymer formed from but-2-ene by showing two repeat units.
- Discuss **two** ways in which chemists are trying to minimise the damage to the environment caused by the disposal of polymers.

[Total 10 marks]

9. (a) Propan-2-ol can be formed by the hydration of an alkene in the presence of a catalyst.

(i) Suggest a suitable catalyst for this reaction.

.....

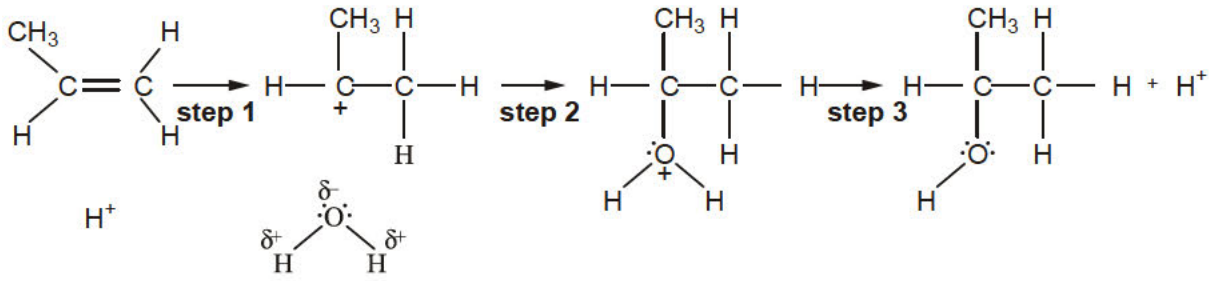
[1]

(ii) This is an electrophilic addition reaction. What is meant by the term *electrophile*?

.....

[1]

(b) A mechanism for the reaction in (a) is shown below.



(i) Add 'curly arrows' to the mechanism to show the movement of electron pairs in steps **1**, **2** and **3**.

[3]

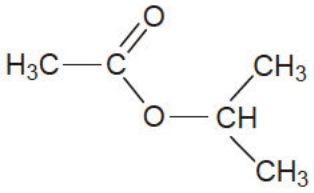
(ii) Suggest, with a reason, the role of the H^+.

.....

[1]

[Total 6 marks]

10. Methyl allyl chloride, MAC, is an important industrial chemical. It is used as an intermediate in the production of synthetic fibres, pharmaceuticals and epoxy resins. The structural formula of MAC is shown below.



compound **D**

(a) Give the **systematic** chemical name of MAC.

.....

[1]

(b) MAC contains the alkene group and can undergo polymerisation. Draw a section of the polymer, poly(MAC), showing **two** repeat units.

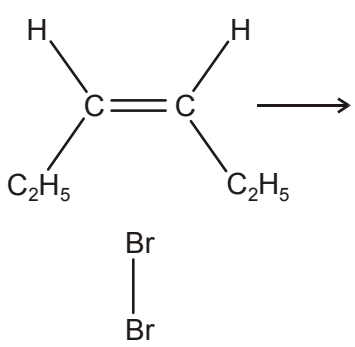
[2]

[Total 3 marks]

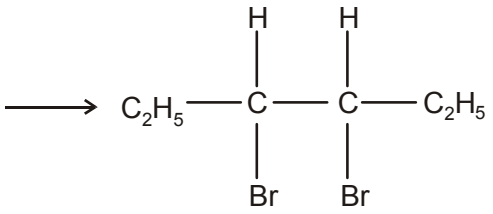
11. (a) Hex-3-ene reacts with Br_2 to produce 3,4-dibromohexane.

Describe, with the aid of curly arrows, the movement of the electrons in the mechanism.

Show the intermediate, any relevant dipoles and lone pairs of electrons.



intermediate



3,4-dibromohexane

[4]

(b) The mechanism in (a) shows *cis*-hex-3-ene reacting with Br_2. *Trans*-hex-3-ene also reacts with Br_2 to produce 3,4-dibromohexane.

(i) How does the structure of *trans*-hex-3-ene differ from that of *cis*-hex-3-ene?

.....

.....

[1]

(ii) Explain why both *cis* and *trans* hex-3-ene react with Br_2 to produce the same structural isomer.

.....

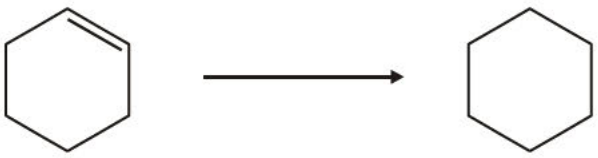
.....

.....

[1]

[Total 6 marks]

12. Cyclohexene can be converted into cyclohexane.



cyclohexene **cyclohexane**

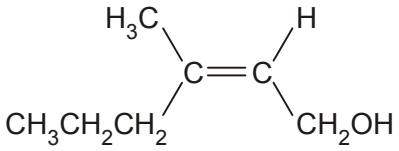
Suggest suitable reagents and conditions for this reaction.

reagents .....

conditions .....

[Total 2 marks]

13. Body odour often begins with secretions from glands called apocrine glands, which are most numerous in the armpits. Bacteria, which live in the armpits, use these secretions to produce energy and many different waste products. Scientists have isolated one of these waste products, compound **E**, which is shown below.



compound **E**

Compound **E** contains two functional groups, one of which is a primary alcohol.

(i) **Name** the other functional group and state how you could test for it.

name of the other functional group .....

test .....

observation .....

[3]

(ii) Name compound **E** .....

[1]

[Total 4 marks]

14. In this question, one mark is available for the quality of use and organisation of scientific terms.

Alkenes are used in the industrial production of many organic compounds.

Outline how alkenes are used in the manufacture of

- margarine,
- polymers such as poly(propene).

State any essential conditions.

Write a balanced equation for the manufacture of poly(propene) and draw a section of the polymer to show two repeat units.

State **two** difficulties in the disposal of polymers like poly(propene).

Suggest **two** ways in which waste polymers may be treated in the future.

[9]

Quality of Written Communication [1]

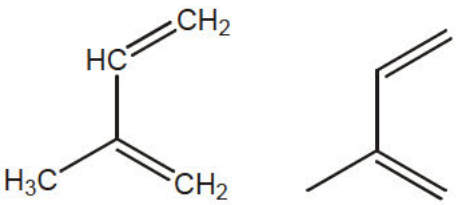
[Total 10 marks]

15. Isoprene is an alkene that can be tapped from some trees. It is the monomer in natural rubber.

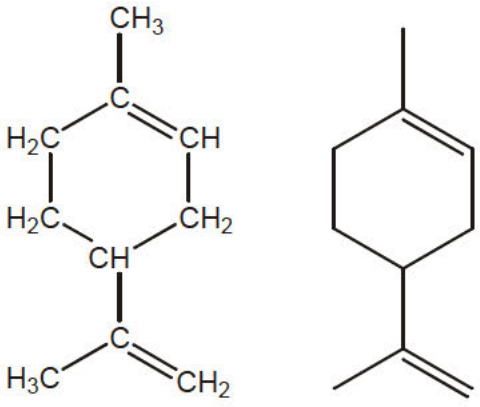
Limonene is a natural oil found in the rind of oranges and lemons.

Both isoprene and limonene contain two double bonds.

Their structural and skeletal formulae are shown below.



isoprene



limonene

(a) (i) What is the molecular formula of **isoprene**? .....

[1]

(ii) What is the empirical formula of **limonene**? .....

[1]

(b) In the presence of a suitable catalyst, isoprene and limonene both react with hydrogen.

(i) State a suitable catalyst for this reaction. .....

[1]

(ii) Write an equation for the reaction when **isoprene** reacts **completely** with hydrogen.

[2]

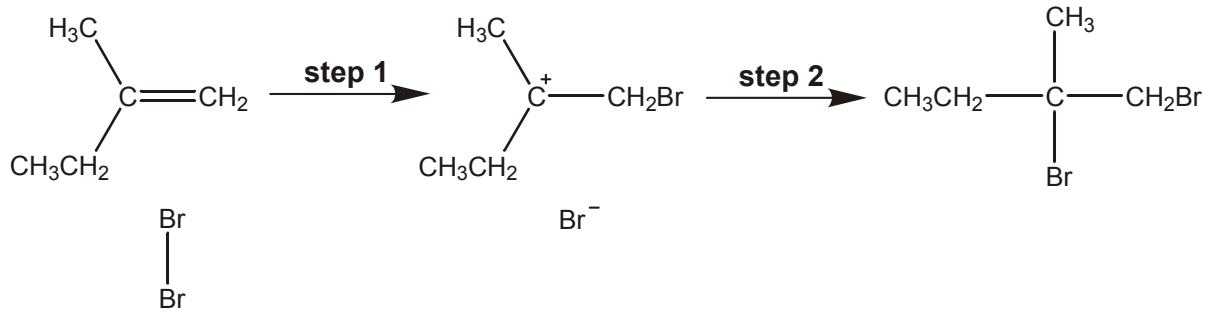
(iii) Draw the skeletal formula of a product formed when **limonene** reacts **partially** with hydrogen.

[1]

[Total 6 marks]

16. 2-Methylbut-1-ene can be formed by the partial hydrogenation of isoprene.

2-Methylbut-1-ene reacts with Br_2 to produce 1,2-dibromo-2-methylbutane by an electrophilic addition mechanism. The mechanism for the reaction is shown below.



(i) In **step 1**, Br_2 behaves as an electrophile. Explain what is meant by the term *electrophile*.

.....

[1]

(ii) Label any relevant dipoles and add 'curly arrows' to the mechanism to show the movement of electron pairs in **step 1** and in **step 2**.

[3]

[Total 4 marks]

17. Chloroethene, CH_2CHCl, is polymerised to form poly(chloroethene) commonly known as *pvc*.

(i) Draw a section of *pvc* showing **three** repeat units. Put a bracket round one repeat unit.

[2]

(ii) Polymers such as *pvc* are difficult to dispose of because they are non-biodegradable. Increasingly, they are disposed of by combustion.

State the problem associated with the combustion of polymers such as *pvc.*

.....

.....

[1]

(iii) State **two** ways in which chemists are trying to minimise the damage to the environment caused by the disposal of halogenated plastics such as *pvc*.

.....

.....

.....

[2]

[Total 5 marks]

18. (a) Compound **A** is a chloroalkene with the percentage composition by mass: C, 24.7%; H, 2.1%; C*l*, 73.2%.

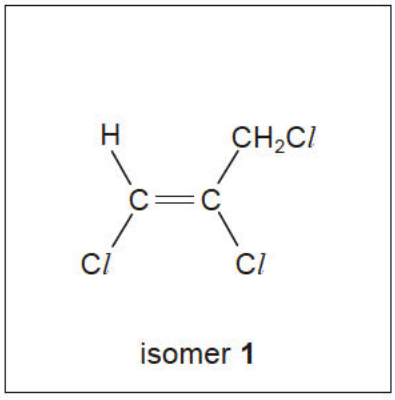
(i) Calculate the empirical formula of compound **A**. Show your working.

[2]

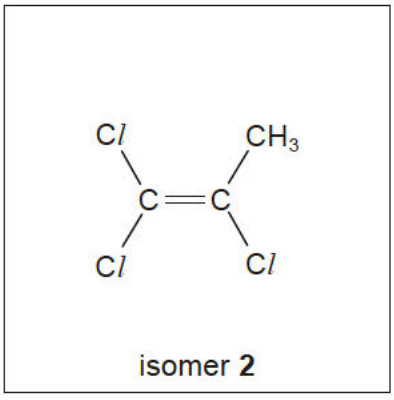
(ii) The relative molecular mass of compound **A** is 145.5. Show that the molecular formula is $C_3H_3Cl_3$.

[2]

(b) Compound **A** is one of six possible structural isomers of $C_3H_3Cl_3$ that are chloroalkenes. Two of these isomers are shown below as isomer **1** and isomer **2**.

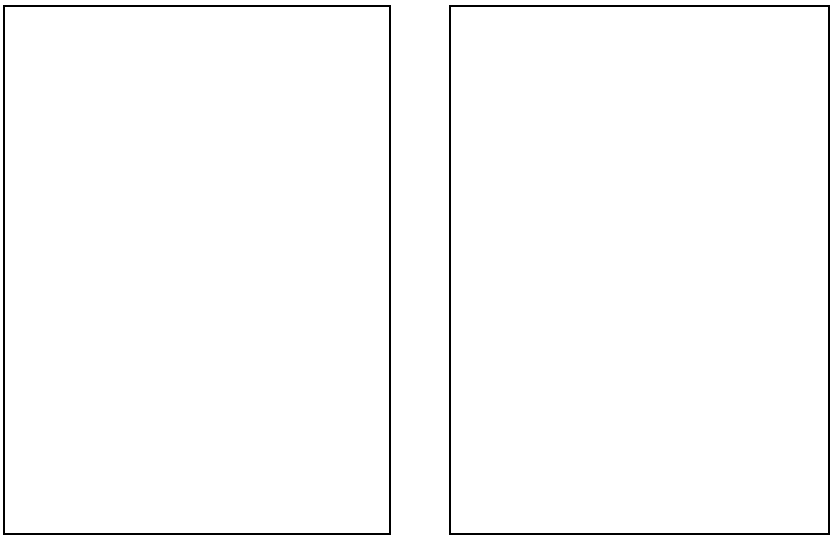


isomer **1**



isomer **2**

(i) Draw two other structural isomers of $C_3H_3Cl_3$ that are chloroalkenes.



[2]

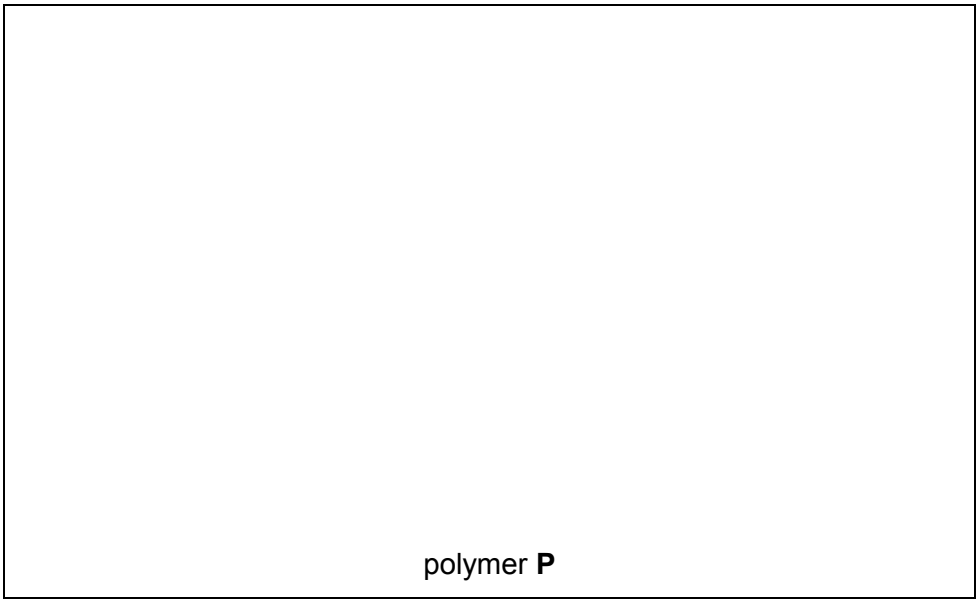
(ii) Name isomer **1**. .....

[2]

(c) All of the isomers in (b) readily polymerise.

(i) Draw a section of the polymer **P** that could be formed when isomer **2** polymerises.

Show two repeat units.



[2]

(ii) Addition polymers can be difficult to dispose of.

State **two** general problems in the disposal of polymers and identify an extra problem when disposing of polymer **P**.

.....

.....

.....

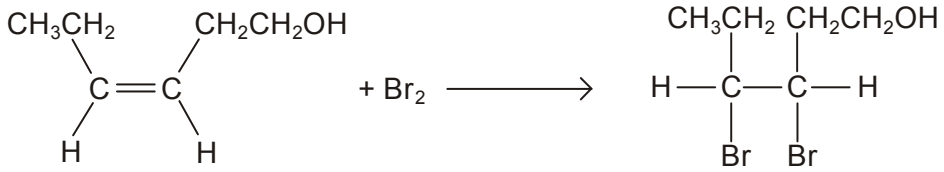
.....

.....

[3]

[Total 13 marks]

19. Leaf alcohol reacts with bromine as shown in the equation below.



(i) State what you would **see** when bromine reacts with leaf alcohol.

.....

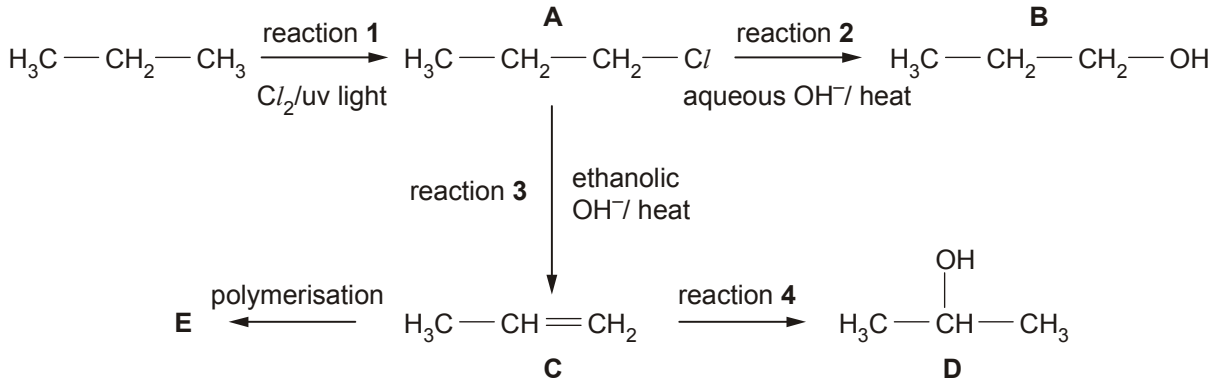
[1]

(ii) Complete, with the aid of curly arrows, the mechanism involved in the reaction between leaf alcohol and bromine. Show any relevant dipoles, charges and lone pairs of electrons.

[4]

[Total 5 marks]

20. Propane, C_3H_8, is used in the reaction sequence shown below.



(a) The reaction sequence shows several important reaction mechanisms. Select from reactions **1** to **4**, the reaction that shows

(i) free radical substitution, reaction .....

[1]

(ii) electrophilic addition, reaction .....

[1]

(iii) elimination, reaction .....

[1]

(b) In reaction **2**, the aqueous OH^- acts as a nucleophile.

(i) State what is meant by the term *nucleophile*.

.....

[1]

(ii) Complete, with the aid of curly arrows, the mechanism involved in reaction **2**. Show any relevant dipoles.

$H_3C-CH_2-CH_2-Cl \longrightarrow H_3C-CH_2-CH_2-OH$ + ...

OH^-

[4]

(c) Compounds **B** and **D** are structural isomers of each other.

(i) State what is meant by the term *structural isomers*.

.....

.....

[2]

(ii) Draw the skeletal formulae of compounds **B** and **D**.

Compound **B**	Compound **D**

[2]

(d) Compound **C** can be polymerised to form compound **E**.

(i) State the type of polymerisation. .....

[1]

(ii) Name compound **E**. .....

[1]

(iii) Draw a section of compound **E**. Show **two** repeat units.

[1]

[Total 15 marks]

21. Propene, $CH_3CH=CH_2$, is an alkene and undergoes an addition reaction with bromine.

(i) State what you would **see** when propene reacts with bromine.

.....

[1]

(ii) Complete, with the aid of curly arrows, the mechanism involved in the reaction between propene and bromine. Show any relevant dipoles and charges.

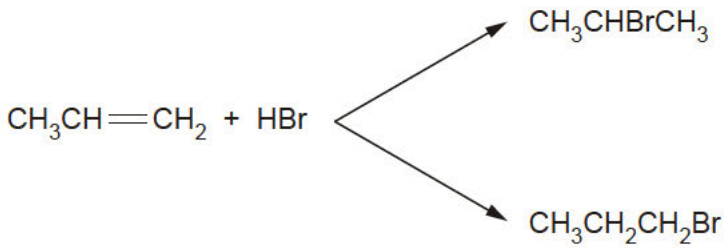
$H_3C — CH ==CH_2$ ⟶ ⟶

Br
|
Br

[4]

[Total 5 marks]

22. Propene, $CH_3CH{=}{=}CH_2$, also reacts with HBr to produce two bromoalkanes that are structural isomers.

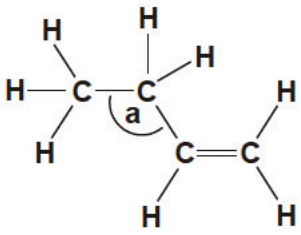


Propyne, $CH_3C{\equiv}CH$, reacts like propene. It reacts with HBr to give three isomers with molecular formula $C_3H_6Br_2$.

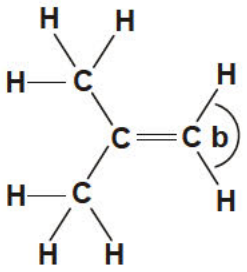
Draw the three isomers with molecular formula $C_3H_6Br_2$.

[Total 3 marks]

23. Alkenes are unsaturated hydrocarbons. The structures of but-1-ene and methylpropene are shown below.



but-1-ene



methylpropene

(i) What is meant by the terms *unsaturated* and *hydrocarbon*?

unsaturated .....

hydrocarbon .....

[2]

(ii) Suggest values for the bond angle **a** in but-1-ene and the bond angle **b** in methylpropene.

angle **a** ..... angle **b** .....

[2]

(iii) Explain, with the aid of a sketch, how p-orbitals are involved in the formation of the C==C double bond.

.....

.....

[2]

[Total 6 marks]

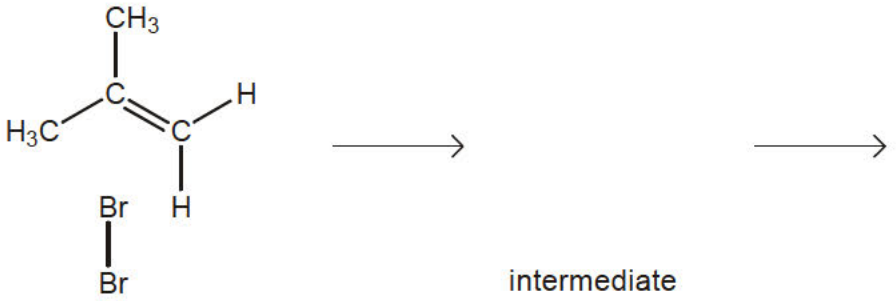
24. Alkenes undergo electrophilic addition reactions to form saturated compounds.

(i) Define the term *electrophile*.

.....

[1]

(ii) The reaction between bromine and methylpropene is an electrophilic addition. Describe, with the aid of curly arrows, the mechanism for this reaction. Show the intermediate and the product along with any relevant dipoles and lone pairs of electrons.

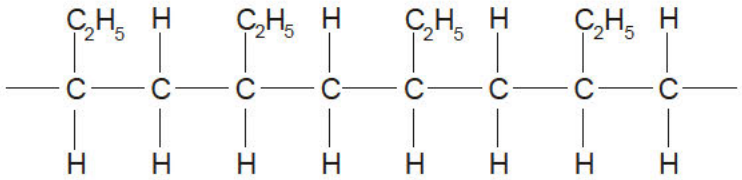


intermediate product

[4]

[Total 5 marks]

25. Polymer **A**, shown below, can be formed from an alkene.



A

polymer **A**

(i) State the type of polymerisation involved in the formation of polymer **A**.

.....

[1]

(ii) Draw a circle around the repeat unit of polymer **A**.

[1]

(iii) Identify the monomer that formed polymer **A**.

[1]

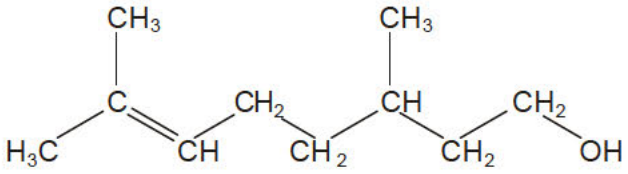
(iv) Name polymer **A**.

.....

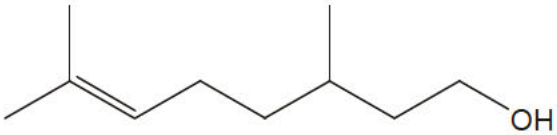
[1]

[Total 4 marks]

26. Citronellol, $C_{10}H_{20}O$, occurs naturally in both rose and geranium oils. The structural and skeletal formulae of citronellol are shown below.



structural formula



skeletal formula

(a) Name the **two** functional groups present in citronellol.

..... and .....

[2]

(b) The functional groups in citronellol can be identified either by chemical tests or by infrared spectroscopy.

(i) State which of the two functional groups you named in (a) is:

1 identified when bromine is added to citronellol, ...

2 more easily identified from the infra-red spectrum. .....

[1]

(ii) State what you would **see** when bromine is added to citronellol.

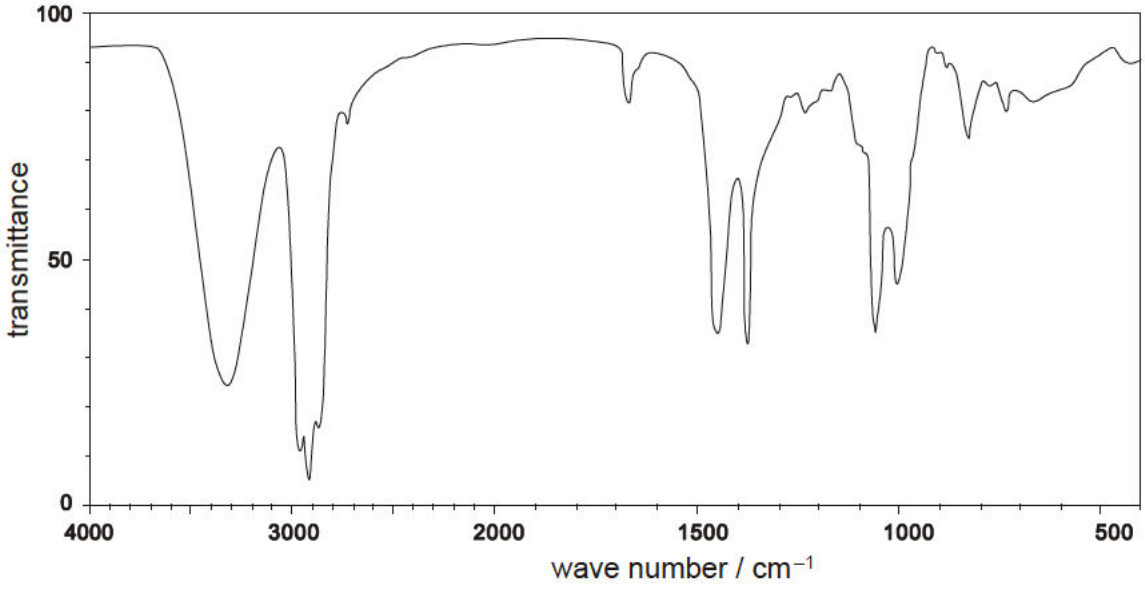
.....

[1]

(iii) Draw the skeletal formula of the organic product formed when bromine is added to citronellol.

[1]

(iv) The infra-red spectrum of citronellol is shown below. Mark on this spectrum, with the letter **X**, the absorption that confirms the presence of the functional group that is most easily identified from this spectrum.



[1]

(c) Reaction of a sample of citronellol, $C_{10}H_{20}O$, with hydrogen in the presence of a catalyst results in the formation of a saturated compound **C**.

(i) Suggest a catalyst for this reaction.

.....

[1]

(ii) Determine the molecular formula of the saturated compound **C**.

.....

[1]

(iii) Construct a balanced equation for this reaction.

.....

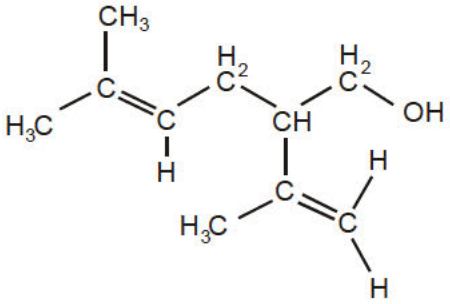
[1]

[Total 9 marks]

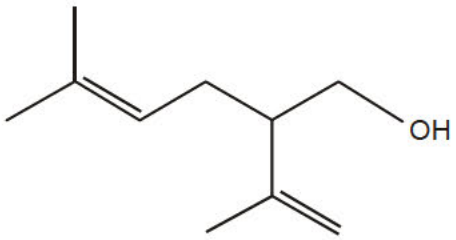
27. But-1-ene can undergo polymerisation. Draw a section of the polymer that can be formed from but-1-ene. Show **two** repeat units.

[Total 2 marks]

28. Lavandulol, $C_{10}H_{18}O$, is a fragrant oil which is found in lavender. The structural and the skeletal formulae of lavandulol are shown below.



structural formula



skeletal formula

(a) (i) Identify **two** different functional groups in lavandulol.

..... and .....

[2]

(ii) Why does lavandulol **not** have *cis-trans* isomerism?

.....

.....

[1]

(b) Lavandulol, $C_{10}H_{18}O$, also reacts with bromine to form a saturated organic product.

State what you would see in this reaction and deduce the molecular formula of the organic product.

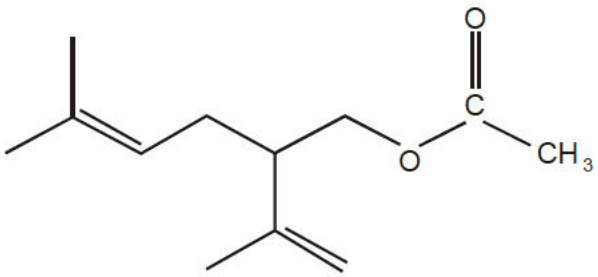
observation .....

[1]

molecular formula .....

[2]

(c) Lavandulol could be converted into an ester **X**, which is also found in lavender oil.



ester **X**

State a reagent and a catalyst that could be used to form ester **X** from lavandulol.

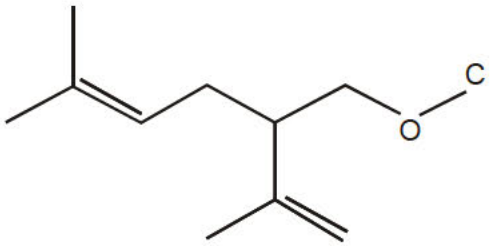
reagent .....

[1]

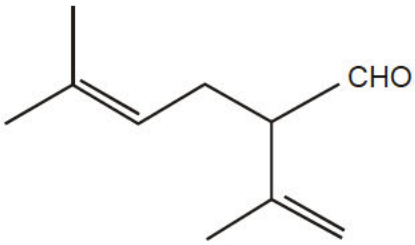
catalyst .....

[1]

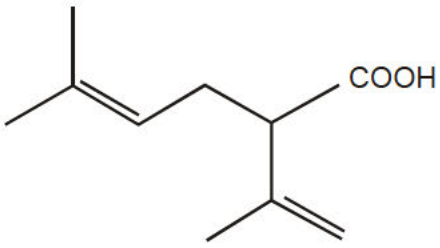
(d) Lavanduloi can be oxidised to produce either compound **Y** or compound **Z**.



lavandulol
$C_{10}H_{18}O$



compound **Y**
$C_{10}H_{16}O$



compound **Z**
$C_{10}H_{16}O_2$

(i) Write a balanced equation for the oxidation of lavandulol to produce compound **Z**. Use the molecular formulae given above and use [O] to represent the oxidising agent.

.....

[2]

(ii) An infra-red spectrum of either compound **Y** or compound **Z** was obtained and was found to contain an absorption between 1680 – 1750 cm^{-1}. However, there was no broad absorption between 2500 – 3300 cm^{-1}.

By referring to your *Data Sheet*, use this information to deduce whether the infra-red spectrum was of compound **Y** or of compound **Z**. Show your reasoning.

The infra-red spectrum was of compound ..... because .....

.....

.....

.....

[2]

[Total 12 marks]