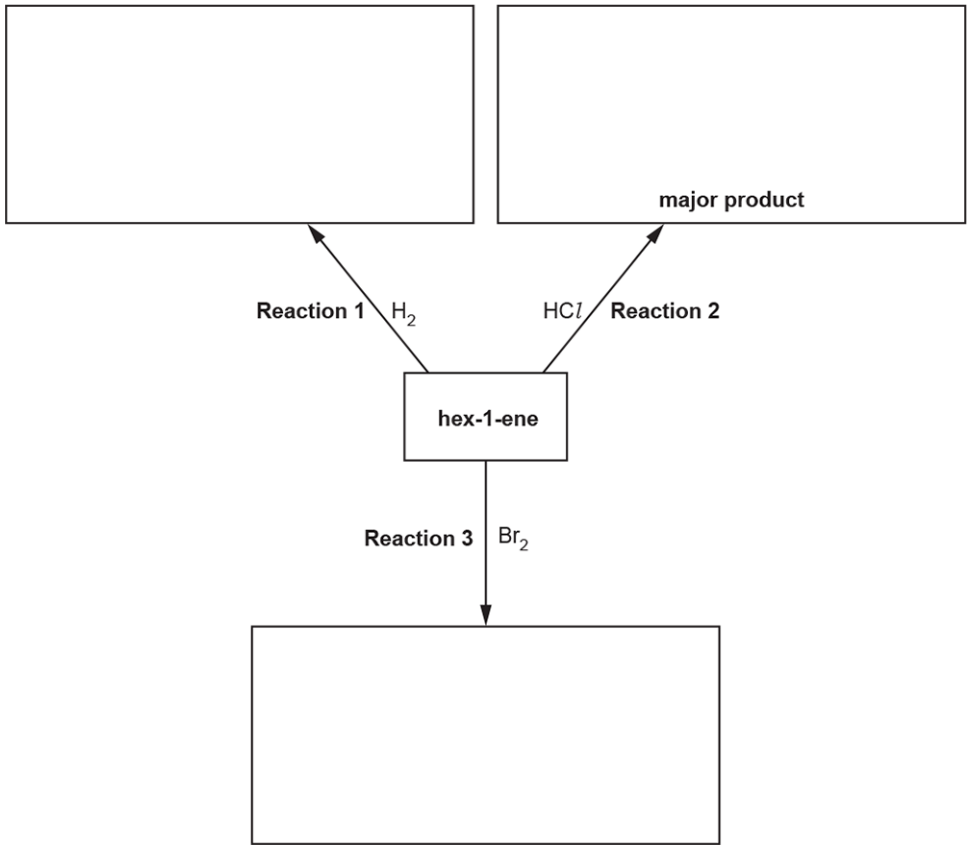
Alkenes

1. This question is about hex-1-ene, $CH_3CH_2CH_2CH_2CH=CH_2$.

Hex-1-ene is reacted with H_2, HCl and Br_2 as shown in the flowchart below.

i. Complete the flowchart to show the structures of the organic products of these reactions.



[3]

ii. State the catalyst needed in **reaction 1.**

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[1]

iii. What would you observe in **reaction 3**?

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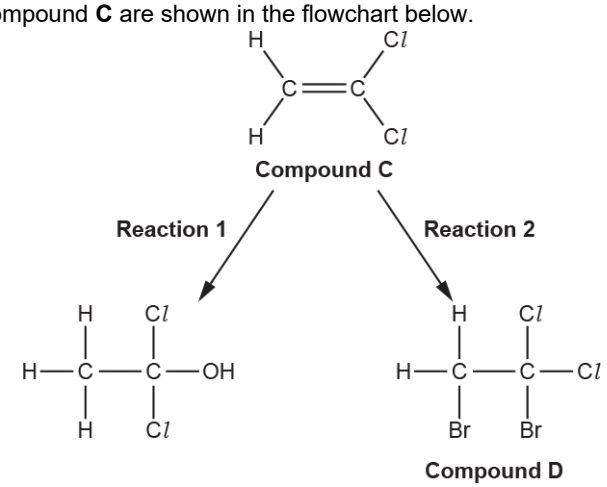
[1]

2(a). Two reactions of compound **C** are shown in the flowchart below.



State the reagents and conditions for **reaction 1**.

---

[1]

(b). In **reaction 2**, compound **C** reacts with bromine to form compound **D**.

i. Give the systematic name of compound **D**.

---

[1]

ii. Outline the mechanism for **reaction 2**.

Include curly arrows, charges and relevant dipoles.

[3]

(c). Compound **C** forms an addition polymer **E**.

i. Write a balanced equation for this reaction.

Show displayed formulae.

[2]

ii. State **one** advantage and **one** disadvantage of using combustion as a method for the disposal of waste polymer **E**.

Advantage

Disadvantage

---

[2]

3. Iodine monobromide, I–Br, is a polar molecule.

Heterolytic fission of the I–Br bond forms an electrophile.

State the meaning of the term *electrophile* and suggest the formula of the electrophile formed from IBr.

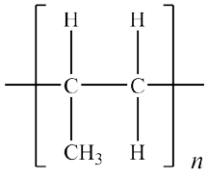
---

[2]

4. A large proportion of the world's output of organic chemicals is used to make addition polymers. These polymers have a variety of uses.

Poly(propene) is used to make packaging, textiles and rope.

A repeat unit for poly(propene) is shown below.



i. Explain why poly(propene) is a *saturated* hydrocarbon.

---

[1]

ii. State the bond angle around each carbon atom in poly(propene).

---

[1]

iii. After polymers have been used for packaging, the waste polymers need to be processed to save resources, for example, by recycling.

Describe **two** other ways in which waste poly(propene) can be processed in a sustainable way.

---

[2]

5(a). 2-chloropropene can be polymerised to form poly(2-chloropropene).

i. Write a balanced equation for the formation of this polymer.
The equation should include the structure of the repeat unit of the polymer.

[2]

ii. After their useful life, waste polymers can be disposed of by combustion.

State **one** particular problem with disposal of poly(2-chloropropene) by combustion.

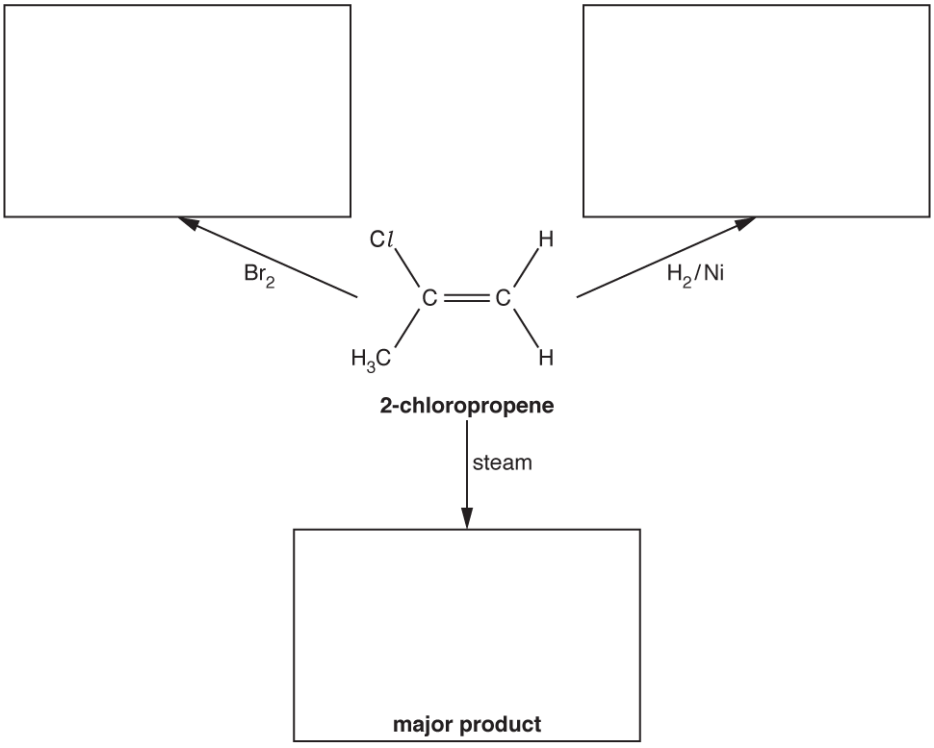
---

[1]

(b). This question is about 2-chloropropene, C_3H_5Cl.

Three reactions of 2-chloropropene are shown in the flowchart below.

i. Complete the flowchart to show the organic products formed in the reactions.



[3]

ii. The reaction of 2-chloropropene with steam requires a catalyst.

State a suitable catalyst for this reaction.

---

[1]

6. Cyclohexene is reacted with bromine to prepare the organic compound **F**.

Give the structure of compound **F** and outline the mechanism for this reaction.

Include curly arrows, charges and relevant dipoles.

[4]

7(a). Hex-2-ene shows *E*/*Z* isomerism.

i. Draw the skeletal formulae of *E*-hex-2-ene and *Z*-hex-2-ene.

E-hex-2-ene	*Z*-hex-2-ene

[2]

ii. State and explain the features of a hex-2-ene molecule that lead to *E* and *Z* isomers.

_____

_____

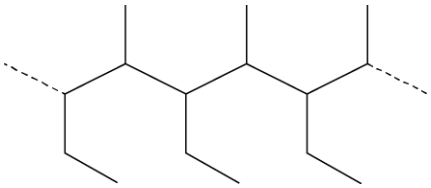
_____

_____

_____

_____ **[2]**

(b). A section of a polymer that can be made from an unsaturated hydrocarbon **B** is shown below.



i. Add brackets to the section of the polymer to show **one** repeat unit.

[1]

ii. Draw the structure of hydrocarbon **B**.

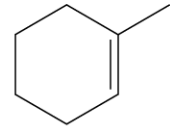
[1]

iii. The polymer has a relative molecular mass of 50,000.

Calculate the number of monomer molecules required to make one molecule of the polymer.

number of monomer molecules = ... **[1]**

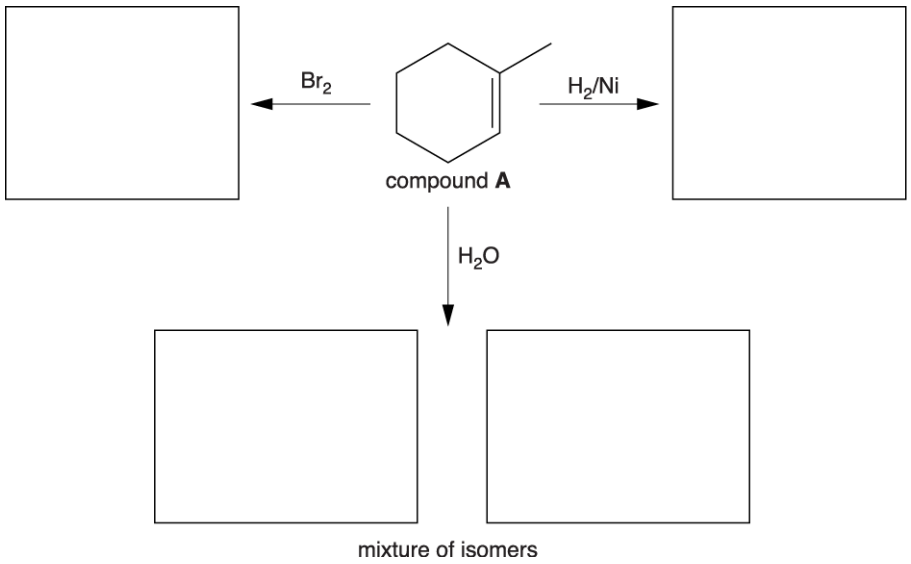
8. Compound **A** is an unsaturated hydrocarbon that can be used as the starting material for the production of organic compounds.



compound **A**

The flowchart shows three **addition** reactions of compound **A**.

i. In the boxes below, show the structures of the organic products formed in the reactions.



[4]

ii. What are the essential conditions for the reaction of compound **A** with H_2O?

---

[2]

iii. Using curly arrows, outline the mechanism for the reaction of compound **A** with Br_2.

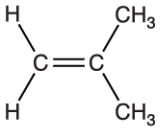
[3]

iv. Name the mechanism in part **(iii)**.

---

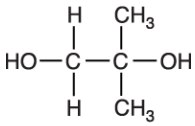
[1]

9(a). Compound **B**, shown below, can be used to synthesise organic compounds with different functional groups.



Compound B

The structure of compound **F** is shown below.



Compound F

i. What is the empirical formula of compound **F**?

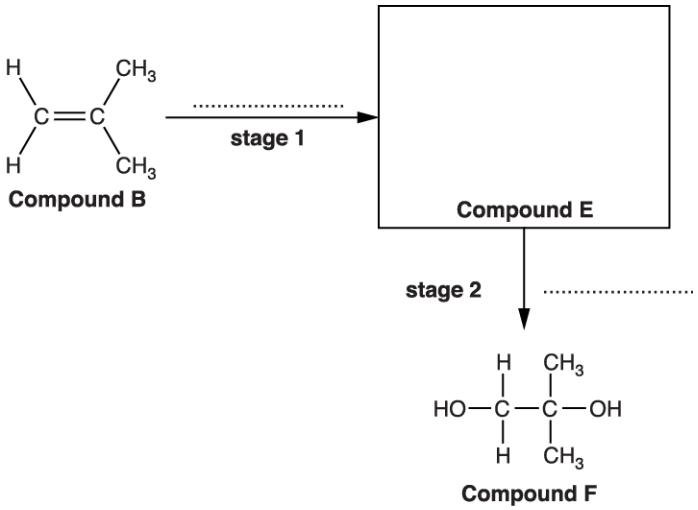
---

[2]

ii. A student plans a two-stage synthesis for preparing compound **F** from compound **B.**

The synthesis first prepares compound **E**, as shown in the flowchart.

Draw the structure of compound **E** in the box and state the reagents for each stage on the dotted lines.



[3]

(b). i. Compound **B** is a member of a homologous series.

Name the homologous series and state its general formula.

Homologous series

.....

General formula

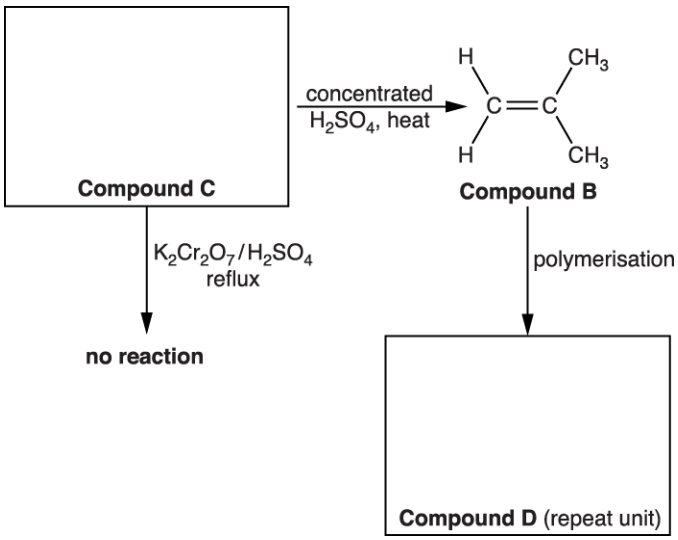
.....

ii. What reagents and conditions are needed to convert compound **B** into a saturated hydrocarbon?

[1]

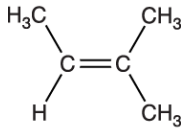
(c). Some reactions involving compound **B** are shown in the flowchart below.

Complete the flowchart, showing the structures of organic compounds **C** and **D**.



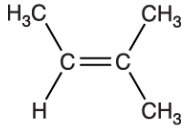
[2]

10(a). Compound **A** is an alkene.



compound **A**

*Compound **A** reacts with hydrogen bromide to form a mixture of two different organic products.



compound **A**

Give the structures of the **two** possible organic products of the reaction.

Outline the mechanism, using the 'curly arrow'model, for the formation of one of the organic products from compound **A**.

Explain which of the two organic products is more likely to be formed.

---

[6]

(b). The C=C bond in a molecule of compound **A** has restricted rotation because it comprises a σ bond and a π bond.

i. Describe **one** difference between the σ bond and the π bond.

---**[1]**

ii. Explain why compound **A** does **not** have *E*/*Z* isomers.

---**[1]**

iii. A structural isomer of compound **A** has *E*/*Z* isomers.

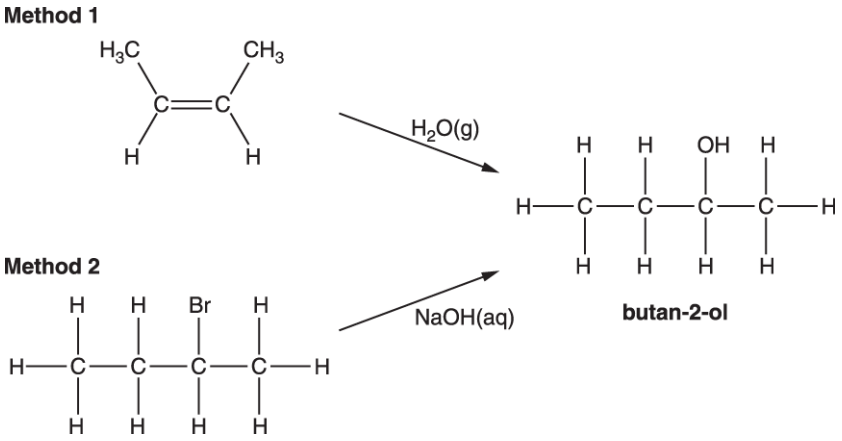
Draw the structure of the *Z* isomer and then name this isomer.

structure of *Z* isomer

name .....

[2]

11. Butan-2-ol can be prepared using two different methods.



State the catalyst required for **Method 1**.

_____ **[1]**

12(a). Allyl bromide, $CH_2=CHCH_2Br$, is used in the production of polymers.

Part of the C=C double bond in allyl bromide is called a π-bond.

Draw a labelled diagram to show the formation of the π-bond.

[2]

(b). Allyl bromide, $CH_2=CHCH_2Br$, reacts with bromine, Br_2.

i. Outline the mechanism of this reaction.

Include curly arrows, relevant dipoles and the structures of the intermediate and final product(s).

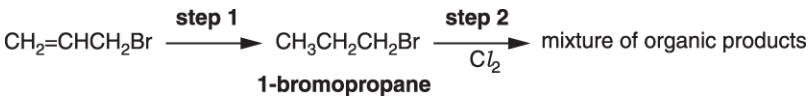
[4]

ii. Name the type of mechanism.

---

[1]

(c). Allyl bromide is reacted as shown below.



i. State the reagents and conditions for **step 1**.

---

[1]

ii. In **step 2**, 1-bromopropane reacts with chlorine by radical substitution.

Outline the mechanism for the monochlorination of 1-bromopropane.
In your mechanism, you can show the formula of 1-bromopropane as C_3H_7Br.

Include the names of the three stages in this mechanism, state the essential conditions and all termination steps.

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[5]

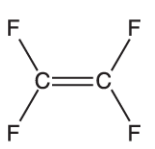
iii. Radical substitution produces a mixture of organic products.

Suggest **two** reasons why.

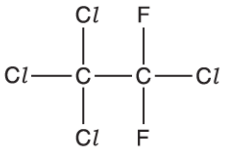
---

[2]

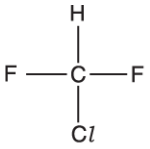
13(a). This question is about the compounds shown below.



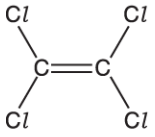
B



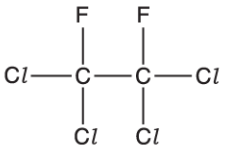
C



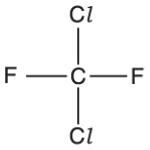
D



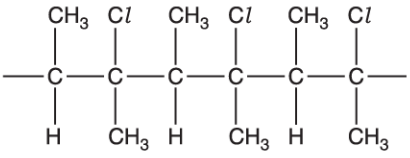
E



F



G



H

Which compound, **B** to **H**, could be used to make the polymer PTFE?

---

[1]

(b). Polymer **H** can be disposed of by combustion. One environmental problem is the production of toxic gases, such as CO.

i. Draw the structure of the monomer needed to produce polymer **H**.

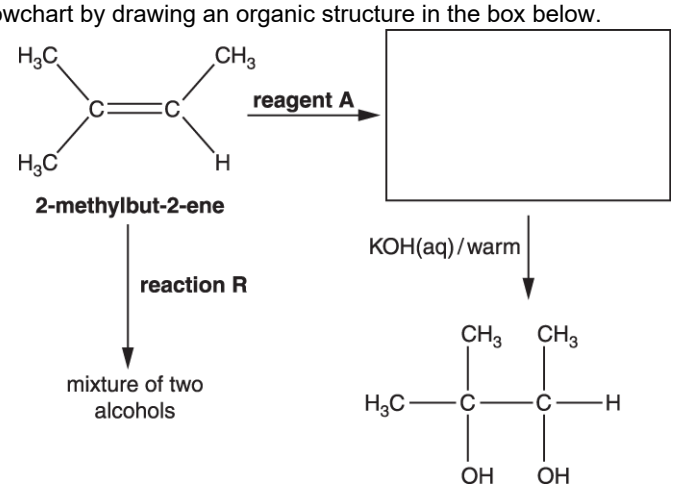
[1]

ii. Give the formula of an acidic toxic gas that could form during combustion of polymer **H**.

[1]

14(a). The flowchart shows how 2-methylbut-2-ene can be converted into a number of organic products.

Complete the flowchart by drawing an organic structure in the box below.



[1]

(b). Identify reagent **A**.

[1]

(c). In the flowchart, **reaction R** forms a mixture of two alcohols that are structural isomers of $C_5H_{12}O$.

i. State the reagents and conditions needed for **reaction R**.

[1]

ii. What is meant by the term *structural isomers*?

---**[1]**

iii. Draw the two structural isomers of $C_5H_{12}O$ formed in **reaction R**.

[2]

iv. Suggest why 2-methylbut-2-ene is less soluble in water than either of the structural isomers formed.

---**[2]**

15(a). Chloroethene, CH_2CHCl, can be polymerised to form poly(chloroethene).

Write an equation, using displayed formulae, to show the formation of this polymer.

[2]

(b). Incineration of plastics containing poly(chloroethene) produces waste gases that can damage the environment.

Incineration carried out in the presence of oxygen produces carbon dioxide, carbon monoxide and hydrogen chloride as waste gases and one other non-toxic product.

i. Write an equation for the incineration of the monomer, chloroethene, with oxygen.

[1]

ii. Chemists have developed ways of removing hydrogen chloride from these waste gases. Sodium hydrogencarbonate, $NaHCO_3(s)$, is frequently used in industry for this purpose.

Explain how sodium hydrogencarbonate removes hydrogen chloride.

---**[1]**

16(a). Propene reacts with bromine, Br_2. In this reaction, bromine acts as an electrophile.

i. Outline the mechanism of this reaction.
Include curly arrows, relevant dipoles and the structures of the intermediate and final product(s).

[4]

ii. What does a curly arrow represent in a reaction mechanism?

---

[1]

(b). Pent-1-ene, $CH_3CH_2CH_2CH=CH_2$, is an alkene with molecular formula C_5H_{10}.

i. Pent-1-ene does **not** show stereoisomerism.
Explain why.

---

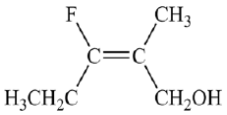
[1]

ii. A structural isomer of pent-1-ene shows *cis—trans* stereoisomerism.
Draw structures for the *cis* and *trans* isomers of this structural isomer of pent-1-ene.

cis isomer	*trans* isomer

[2]

(c). The following molecule shows *E/Z* isomerism.

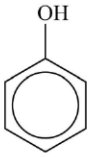
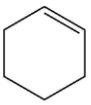
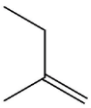
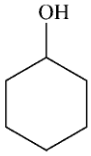


Use the Cahn—Ingold—Prelog priority rules to identify whether this alkene is an *E* or *Z* stereoisomer. Explain how you came to your decision.

---

[1]

17(a). The organic compounds in the table below can be termed, aliphatic, alicyclic or aromatic.

E	**F**	**G**
		
H	**I**	**J**
		

Identify, using letters **E**, **F**, **G**, **H**, **I**, **J**, the compound(s) which are the following types.

Each response may contain more than one letter.

aliphatic .....

alicyclic .....

aromatic .....

[3]

(b). Compound **I** has one alkyl group.

What is the general formula of alkyl groups?

---

[1]

(c). Compound **H** can be prepared in an elimination reaction by heating compound **J** with an acid catalyst.

A student carries out this preparation using 7.65 g of compound **J**.

The student obtains 2.05 g of compound **H**.

i. Write an equation for this reaction, using molecular formulae.

Calculate the percentage yield of compound **H**.

Give your answer to **one** decimal place.

percentage yield = ... % **[4]**

ii. Describe a simple test that the student could carry out to confirm the presence of the functional group in compound **H**.

Draw the structure of the organic product from the test.

test: _____

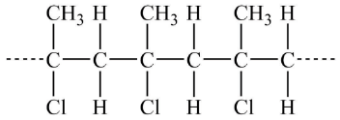
_____

organic product =

[2]

18. This question looks at organic halogen compounds.

A section of a halogenated polymer is shown.



i. Draw the structure of the monomer that could be used to make this polymer.

[1]

ii. Combustion of this polymer produces HCl, which is a toxic gas.

Describe how HCl is removed from the waste gases produced.

[1]

iii. Polymers made from natural foods such as corn starch are replacing halogenated polymers.

An advantage of this is that these polymers do not produce toxic gases on combustion.

State **one** other advantage of using polymers made from natural foods.

[1]

19. Every year, two million tonnes of ethanol are produced worldwide by hydration of ethene obtained from crude oil.

$$C_2H_4(g) + H_2O(g) \rightleftharpoons C_2H_5OH(g) \qquad \Delta H = -45 \text{ kJ mol}^{-1}$$

This reaction is typically carried out using a catalyst at 300 °C and 6000 kPa.

The catalyst allows the reaction to reach equilibrium more quickly at the given temperature and pressure.

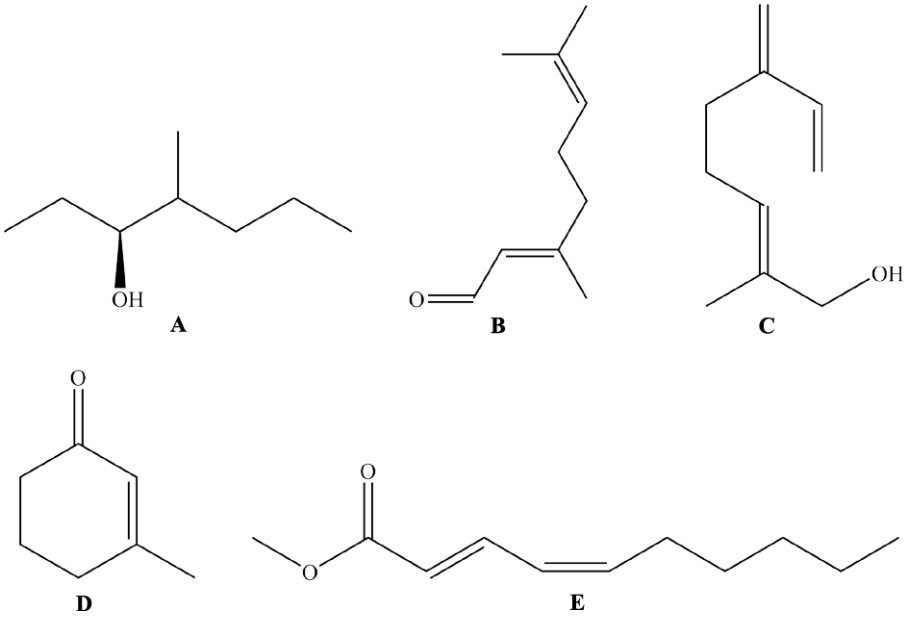
i. State the catalyst used in this reaction.

[1]

ii. Outline how a catalyst increases the rate of a chemical reaction.

[2]

20. The organic compounds labelled **A** to **E** below are all produced by living organisms.



Compound **D** reacts readily with hydrogen chloride in an addition reaction. Two products are formed in this reaction, but one of the products is formed in much greater amounts than the other.

i. Draw the structure of **both** possible addition products of this reaction.

product 1	product 2

[2]

ii. State and explain which of the two possible products will be formed in greater amounts. Include a diagram of the intermediate in the mechanism of this reaction in your answer.

---

[2]

iii. 4.125 g of compound **D** is reacted with an excess of hydrogen chloride. The mixture of products contains 95% by mass of one product and 5% by mass of the other product.

Calculate the mass of each product formed.

[2]

END OF QUESTION PAPER