Answer **all** the questions.

1(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.

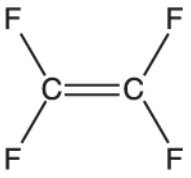
[1]

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.

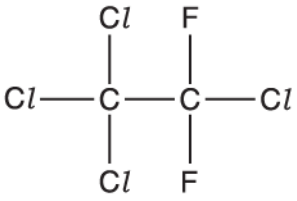
Explain how sodium hydrogencarbonate removes hydrogen chloride.

[1]

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



B



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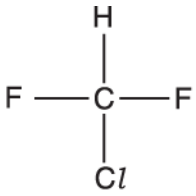
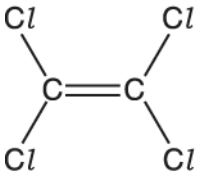
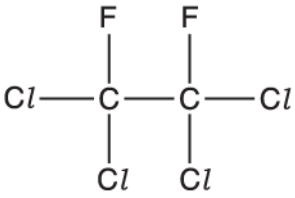


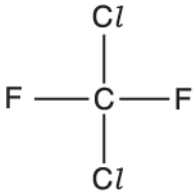
D



E



F



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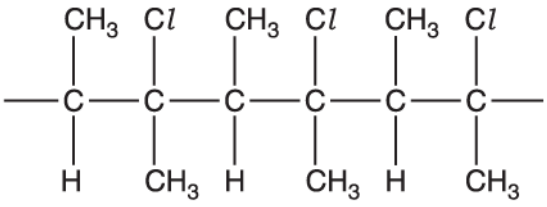


H

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]

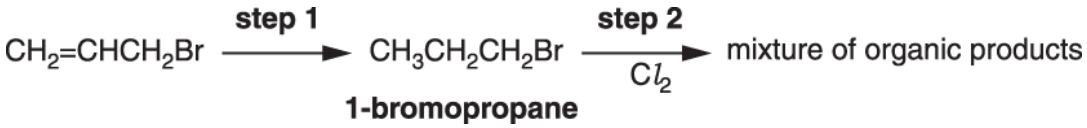
ii. Give the formula of an acidic toxic gas that could form during combustion of polymer **H**.

---

[1]

3. Allyl bromide, $CH_2{=}CHCH_2Br$, is used in the production of polymers.

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.

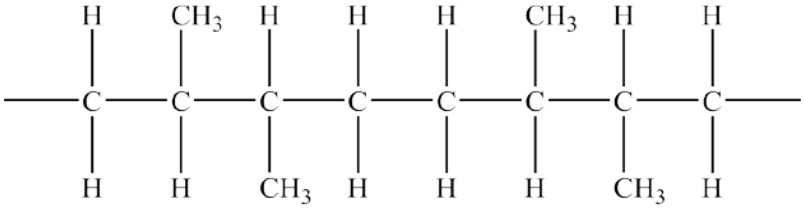
[5]

iii. Radical substitution produces a mixture of organic products.

Suggest **two** reasons why.

[2]

4. A section of a polymer chain is shown below.



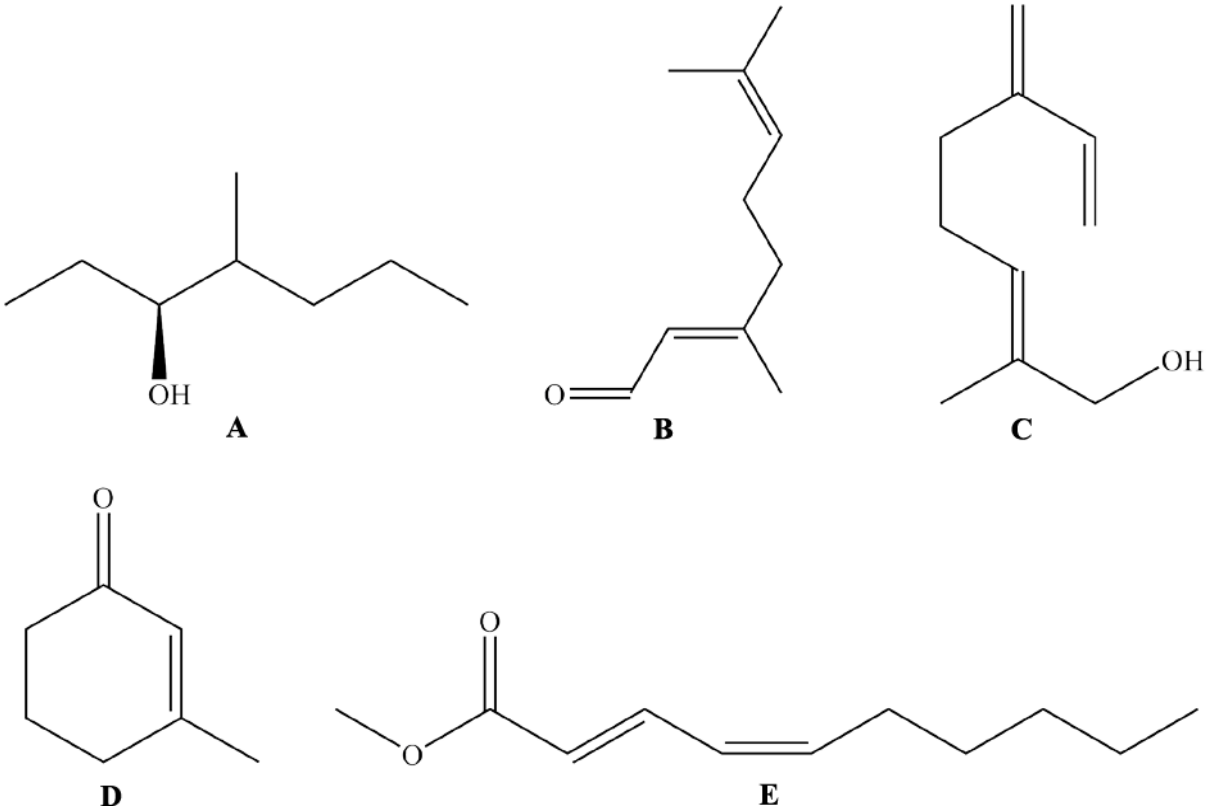
Identify the monomer that would give rise to this section of addition polymer.

A. *E*-But-2-ene
B. *Z*-But-2-ene
C. Methylpropene
D. Propene

Your answer ☐

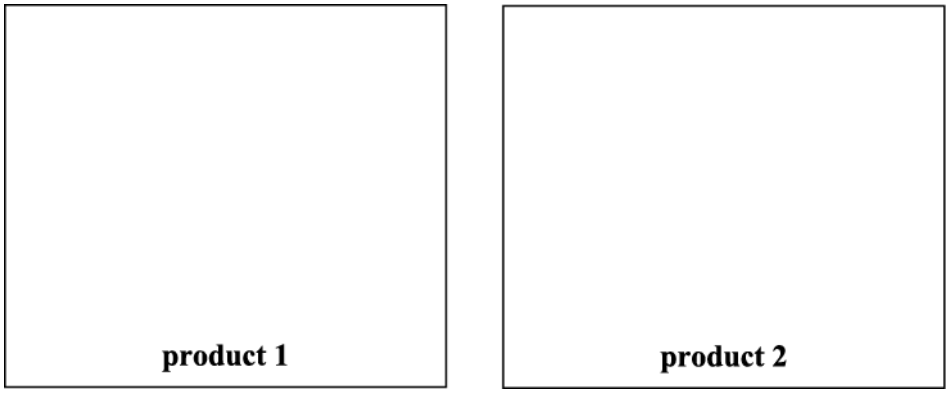
[1]

5. 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.



[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]

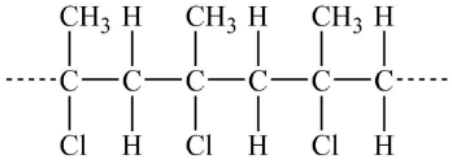
iii. 4.125 g of compound **D** is reacted with an excess of hydrogen chloride. The mixture of products contains 95% by mass of one product and 5% by mass of the other product.

Calculate the mass of each product formed.

[2]

6. 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.

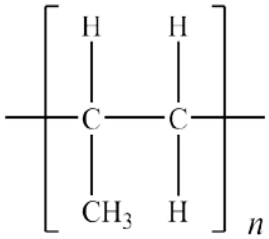
State **one** other advantage of using polymers made from natural foods.

[1]

7. 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]

8. Alkenes can be used to make polymers.

i. Phenylethene, $C_6H_5CHCH_2$, undergoes addition polymerisation.

Write a balanced equation for the addition polymerisation of phenylethene.

You should show the structures of the monomer and polymer clearly.

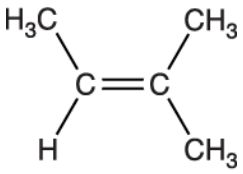
[2]

ii. Waste polymers are often put into landfill sites.

State **one** way of processing waste polymers usefully, other than landfill and recycling.

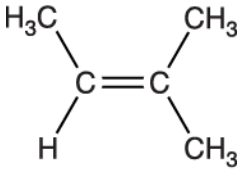
[1]

9. Compound **A** is an alkene.



compound **A**

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



compound **A**

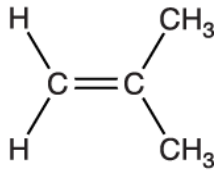
Give the structures of the **two** possible organic products of the reaction.

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]

10. Compound **B**, shown below, can be used to synthesise organic compounds with different functional groups.



Compound B

i. Compound **B** is a member of a homologous series.

Name the homologous series and state its general formula.

Homologous series
.....

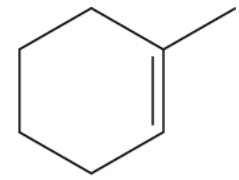
General formula
.....

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

.....

[1]

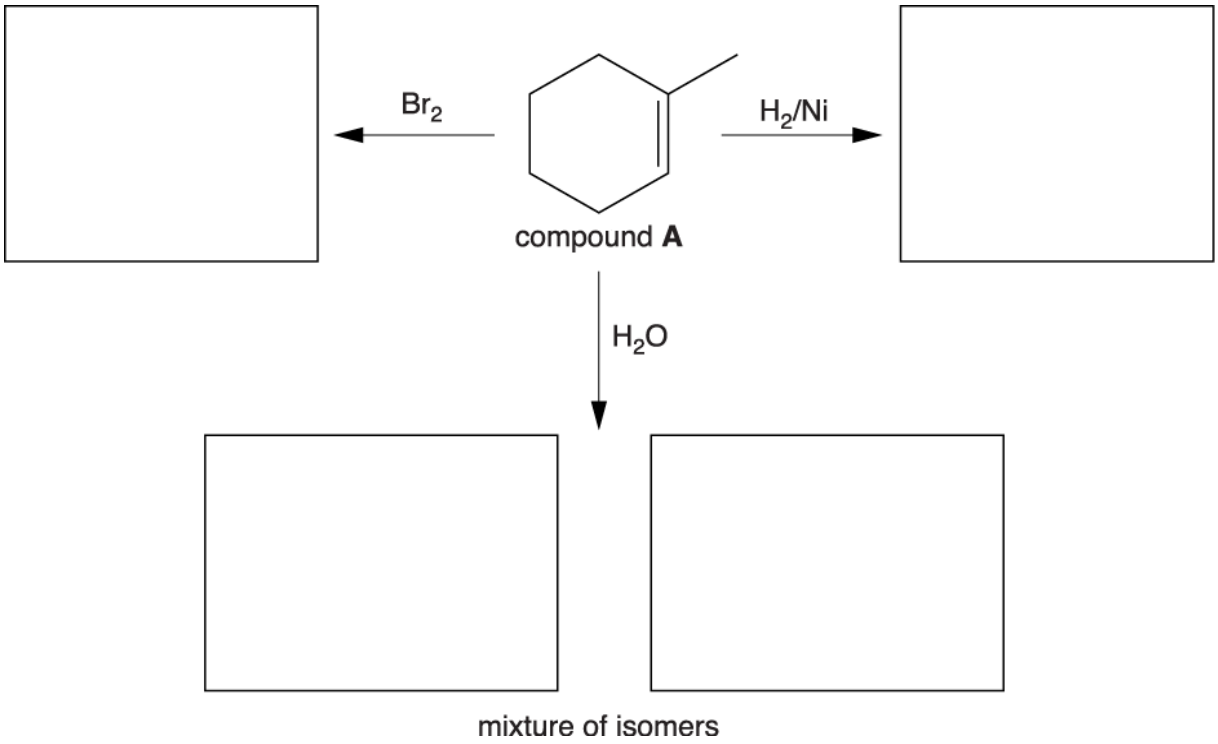
11. Compound **A** is an unsaturated hydrocarbon that can be used as the starting material for the production of organic compounds.



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]

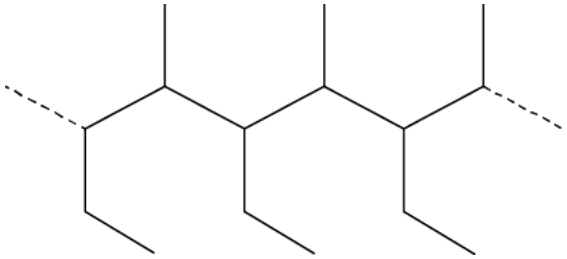
iii. Using curly arrows, outline the mechanism for the reaction of compound **A** with Br_2.

[3]

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

[1]

12. 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]**

13. Which bond angle(s) is/are present in a molecule of but-2-en-1-ol?

1. 120°
2. 109.5°
3. 104.5°

A 1, 2 and 3
B Only 1 and 2
C Only 2 and 3
D Only 1

Your answer ☐

[1]