

Alkanes

1. Under suitable conditions, butane, C_4H_{10} , reacts with chlorine by radical substitution. A mixture of organic compounds is formed, including C_4H_9Cl , and compounds **D** and **E**.

- i. Complete the table below to show the mechanism for the initiation and propagation stages of the reaction of C_4H_{10} with chlorine to form C_4H_9Cl .

In your equations, use molecular formulae and 'dots' (\cdot) with any radicals.

Initiation	Equation ----- Conditions -----
Propagation	----- \rightarrow ----- ----- \rightarrow -----

[3]

- ii. Organic compound **D** is formed by substitution of **all** the H atoms in butane by Cl atoms.

Write the equation for the formation of compound **D** from butane.

Use molecular formulae.

----- [1]

- iii. Organic compound **E** is formed by the substitution of **some** of the H atoms in butane by Cl atoms.

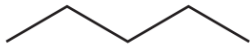
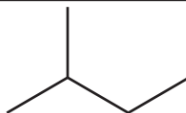

A chemist found that 0.636 g of compound **E** has a volume of 78.0 cm^3 .
Under the conditions used, the molar gas volume is $32.5 \text{ dm}^3 \text{ mol}^{-1}$.

Determine the molecular formula of compound **E**.

molecular formula = [3]

2(a). This question is about saturated hydrocarbons.

Compounds **A**, **B** and **C** are saturated hydrocarbons.
The structures and boiling points of **A**, **B** and **C** are shown below.

	Isomer	Boiling point /°C
A		36
B		28
C		9

- Use the structures to explain what is meant by the term structural isomer.
- Explain the trend in boiling points shown by **A**, **B** and **C** in the table.

[5]

(b). Compounds **A**, **B** and **C** all react with chlorine in the presence of ultraviolet radiation to form organic compounds with the formula $C_5H_{11}Cl$.

- i. Name the mechanism for this reaction.

----- **[1]**

- ii. Complete the table to show the number of structural isomers of $C_5H_{11}Cl$ that could be formed from the reaction of chlorine with **A** and **B**.

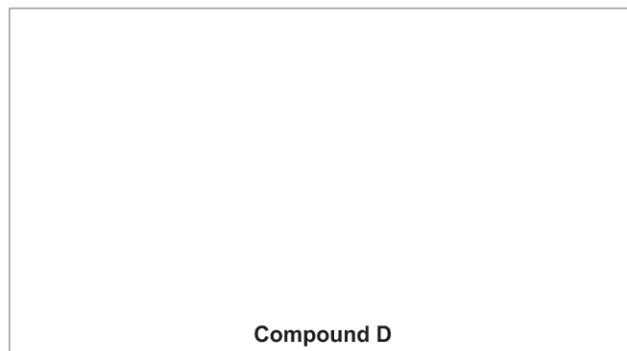
4.1.2 Alkanes

	A	B
Number of structural isomers

[2]

- iii. The reaction of compound **A** with excess chlorine forms a compound **D**, which has a molar mass of 175.5 g mol^{-1} .

Draw a possible structure for compound **D** and write the equation for its formation from compound **A**. Use molecular formulae in the equation.



Equation

[2]

3. 2-Chloropropanoic acid, $\text{CH}_3\text{CHClCOOH}$, can be made by reacting propanoic acid with chlorine in a radical substitution reaction.

- i. State the conditions for the reaction.

..... [1]

- ii. Write the overall equation for the reaction.

..... [1]

- iii. The first step in the reaction mechanism involves homolytic fission of a chlorine molecule to form two chlorine radicals.

Why is this step an example of *homolytic fission*?

..... [1]

4.1.2 Alkanes

- iv. Write **two** equations to show the propagation steps in the mechanism for this reaction.
Use dots,•, to show the unpaired electrons on radicals.

----- [2]

- v. Draw the displayed formula of the radical formed in the first propagation step.
Use a dot,•, to show the position of the unpaired electron.

- vi. Further substitution forms a mixture of organic products.

Draw the structure of an organic product formed from 2-chloropropanoic acid by further substitution.

4. At room temperature and pressure, the first four members of the alkanes are all gases but the first four alcohols are all liquids.

Explain this difference in terms of intermolecular forces.

----- [2]

- ii. The initiation step involves homolytic fission.

Explain why the initiation step is an example of *homolytic fission*.

----- [1]

- (d). The reaction between cyclohexane and bromine in (f) also forms $C_6H_{10}Br_2$.

- i. Write an equation, using molecular formulae, for the reaction of cyclohexane and bromine in the presence of ultraviolet radiation to form $C_6H_{10}Br_2$.

----- [1]

- ii. Name **one** of the structural isomers of $C_6H_{10}Br_2$ formed in the reaction between cyclohexane and bromine.

----- [1]

7. A student carries out the following experiment to investigate the reaction between hexane and chlorine. The chlorine is made by reaction of aqueous sodium chlorate(I) with dilute hydrochloric acid.

Procedure	Observations
1 cm ³ of hexane is mixed with 1 cm ³ dilute aqueous sodium chlorate(I) in a test-tube.	The mixture forms two colourless layers.
1 cm ³ dilute hydrochloric acid is slowly added to the mixture.	The acid mixes with the lower layer, which turns a pale green colour.
The tube is then stoppered and shaken.	The pale green colour moves to the upper layer, leaving the lower layer colourless.
The tube is placed under a bright light and shaken at regular intervals for about 10 minutes. The stopper is loosened regularly to release any pressure.	The pale green colour slowly disappears leaving two colourless layers after about 10 minutes.

The reaction of hexane with chlorine took place when the bright light was switched on.

- i. Give the skeletal formula of **one** possible organic product of this reaction.

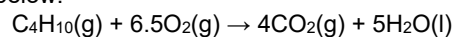
[1]

4.1.2 Alkanes

- ii. Explain why this type of mechanism is likely to produce a mixture of organic products.

----- [1]

8. Butane, C₄H₁₀, is a highly flammable gas, used as a fuel for camping stoves. Butane reacts with oxygen as in the equation below:



- i. The use of portable heaters in enclosed spaces can result in potential dangers if incomplete combustion takes place.
Explain the potential danger of incomplete combustion.

----- [1]

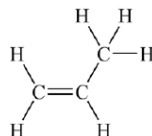
- ii. A portable heater is lit to heat a room.
The heater burns 600 g of butane and consumes 1.50 m³ of O₂, measured at room temperature and pressure.
Determine whether this portable heater is safe to use.
Show **all** your working.

conclusion, with
reason: -----

----- [3]

9. This question is about alkenes.

Propene, drawn below, contains both σ - and π -bonds. The C–H and C–C single bonds are σ -bonds. The C=C double bond is made up of a σ -bond and a π -bond.



- i. Describe how a σ -bond forms.

----- [1]

- ii. State the bond angle and shape around each carbon atom of the C=C double bond in propene.

bond
angle:

shape:

[1]

10. This question looks at alkanes.

Ethane reacts with chlorine by radical substitution.

Describe fully, with equations, the mechanism for this reaction.

[5]

END OF QUESTION PAPER