Answer **all** the questions.

1 The table below lists the boiling points of some alkanes.

alkane	number of carbon atoms	molecular formula	boiling point / °C
butane	4	C_4H_{10}	0
pentane	5	C_5H_{12}	36
hexane	6		69
heptane	7	C_7H_{16}	99
octane	8	C_8H_{18}	
nonane	9	C_9H_{20}	152
decane	10	$C_{10}H_{22}$	175

(a) What is the molecular formula of hexane? .....[1]

(b) **(i)** State the trend in the boiling points of the alkanes.

.....

.....[1]

(ii) Explain the trend in the boiling points of the alkanes.

.....

.....[1]

(iii) Predict the boiling point of octane. ..... °C [1]

(c) Long chain alkanes, such as nonane, can be cracked into shorter chain alkanes and alkenes.

(i) Write a balanced equation for the cracking of nonane into heptane and ethene.

.....[1]

(ii) Much of the ethene is then converted into ethanol.

Write a balanced equation for the conversion of ethene into ethanol. State the essential conditions.

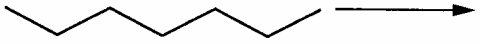
equation .....[1]

conditions .....

.....[2]

(d) Heptane can be isomerised to produce branched chain alkanes such as 2-methylhexane or 2,3-dimethylpentane.
The equation below shows the isomerisation of heptane into 2-methylhexane.

(i) Using skeletal formulae, complete the balanced equation for the isomerisation of heptane into 2,3-dimethylpentane.



[1]

(ii) The boiling point of 2,3-dimethylpentane is 84 °C.

Predict the boiling point of 2-methylhexane. ..... °C [1]

(e) Heptane can be reformed to produce methylcyclohexane which is a cycloalkane.
Write a balanced equation to show the reforming of heptane to obtain methylcyclohexane.

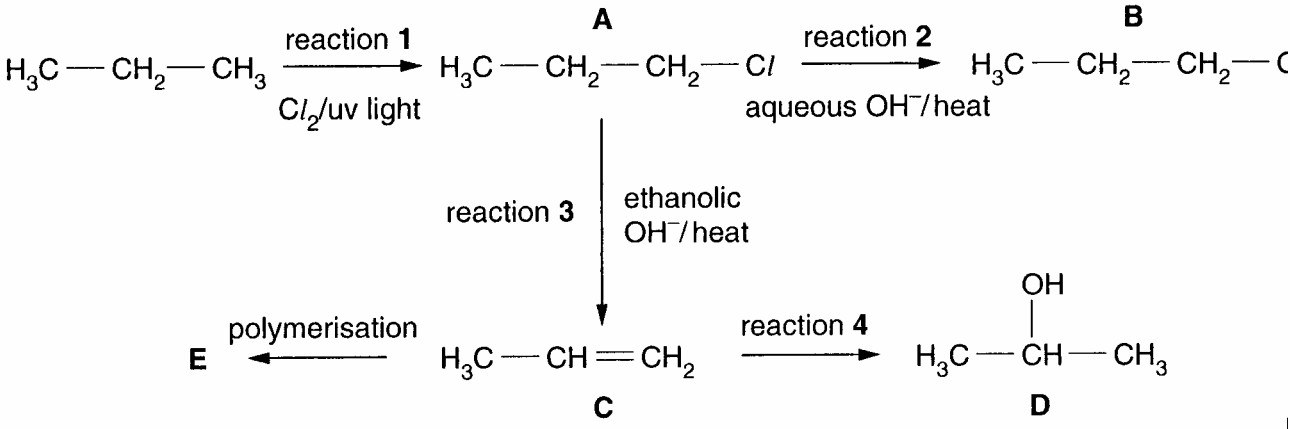
[2]

(f) State why branched chain alkanes and cycloalkanes are more useful than straight chain alkanes.

.....[1]

[Total: 13]

2 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]

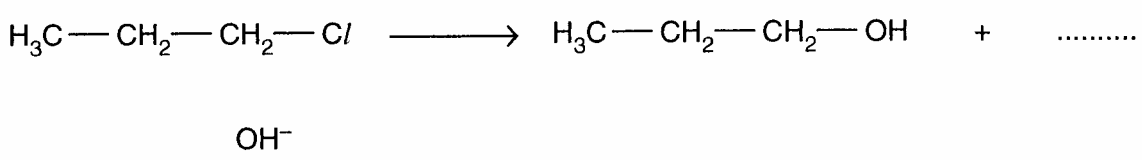
(iii) elimination. reaction ..... [1]

(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.



[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]

3 Acrolein, CH_2=CHCHO, and acrylic acid, CH_2=CHCOOH, are both used in industry for the manufacture of plastic resins and polymers. Both acrolein and acrylic acid can be made from prop-2-en-1-ol, CH_2=$CHCH_2OH$.

(a) **(i)** Draw the structures of prop-2-en-1-ol and acrolein. Clearly display the functional groups in each compound.

prop-2-en-1-ol	**acrolein**

[2]

(ii) Name the functional group common to **both** prop-2-en-1-ol and acrolein.

.....[1]

(b) Prop-2-en-1-ol can be oxidised to form either acrolein or acrylic acid.

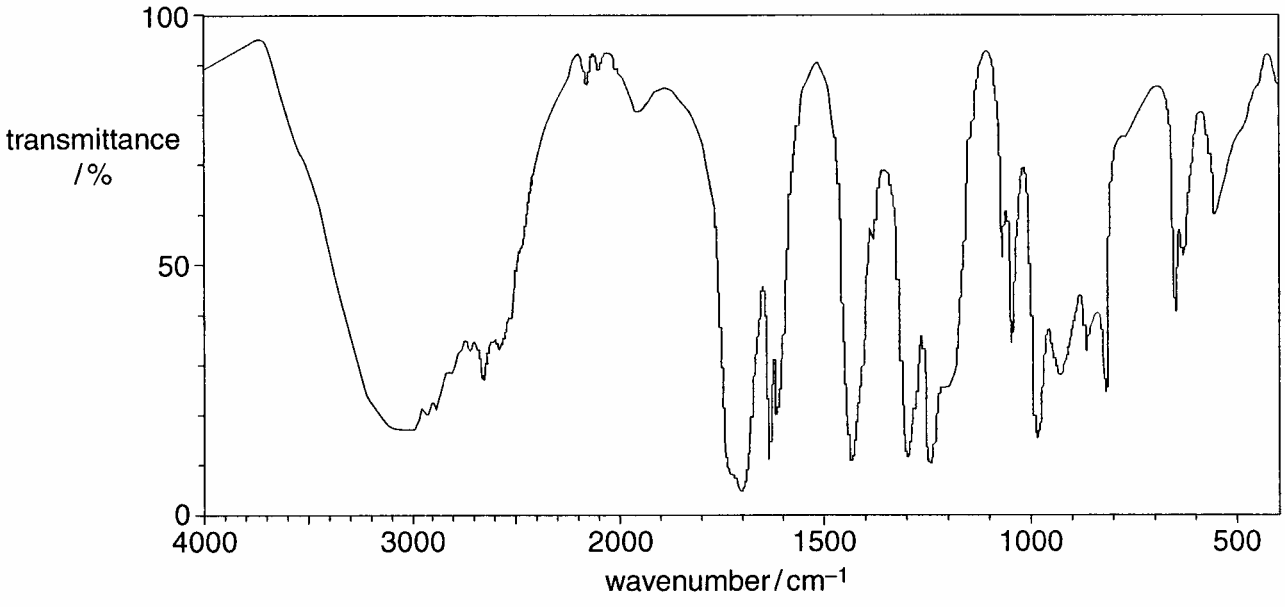
(i) Identify a suitable oxidising mixture.

.....[2]

(ii) Write a balanced equation for the oxidation of prop-2-en-1-ol into acrolein. Use [O] to represent the oxidising agent.

.....[1]

(c) A sample of prop-2-en-1-ol was oxidised and an infra-red spectrum of the organic product was obtained.



By referring to your *Data Sheet*, decide whether acrolein, CH_2=CHCHO, or acrylic acid, CH_2=CHCOOH, was formed.

The infra-red spectrum above is of .....

because .....

.....

.....

.....

.....[3]

(d) Acrylic acid reacts with prop-2-en-1-ol to produce an ester.

(i) Complete the balanced equation for this reaction.

CH_2=CHCOOH + CH_2=CHCH_2OH $\rightarrow$ ..... + ... [2]

(ii) Draw the structure of the ester. Clearly display **all** of the functional groups.

[2]

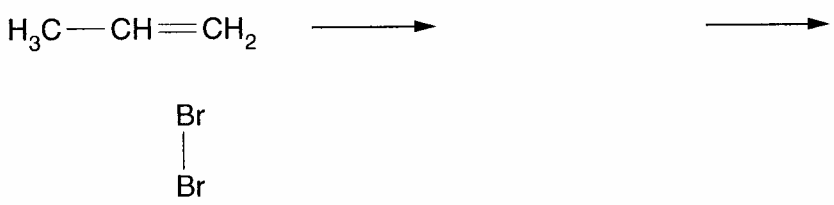
[Total: 13]

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

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

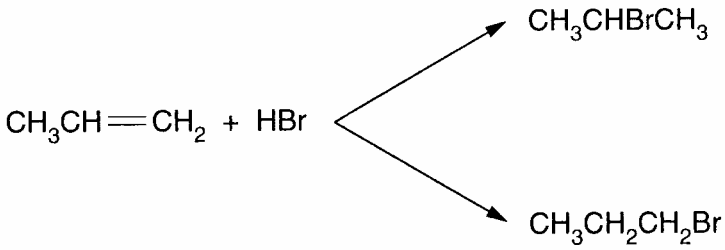
.....[1]

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



[4]

(b) 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 $C_3H_6Br_2$.

[3]

[Total: 8]

5 In this question, one mark is available for the quality of spelling, punctuation and grammar.

(a) The rates of hydrolysis of chloroethane, bromoethane and iodoethane are different.

- Describe how you would monitor the reaction rates.
- Explain why chloroethane, bromoethane and iodoethane react at different rates.

Use suitable equations in your answer.

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(b) In 1930, an American engineer, Thomas Midgley, demonstrated a new refrigerant. As part of his demonstration, he inhaled a lung full of dichlorodifluoromethane, CCl_2F_2, and used it to blow out a candle.

Use Midgley's demonstration to suggest **two** properties of CCl_2F_2. Explain, with a reason, **two** other uses of chemicals such as CCl_2F_2, other than as a refrigerant.

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.....[4]

Quality of Written Communication [1]

[Total: 11]

END OF QUESTION PAPER