

(b) Dichloromethane, CH_2Cl_2 , has been an important material in many paint strippers.

(i) Describe how it can be made from chloromethane and chlorine in the presence of ultraviolet light.

Your answer should include:

- the type of bond fission occurring in the initiation stage;
- a description of the initiation stage including an equation;
- **two** equations representing the propagation stage;
- an equation for the termination stage giving dichloromethane.

[6]

(QWC) [1]

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(ii) The mass spectrum of the products obtained by making dichloromethane in (i) shows a molecular ion peak at m/e 98. The compound giving this molecular ion contains two ^{35}Cl atoms in each molecule.

Suggest a molecular formula and a displayed (structural) formula for this compound, explaining how it might be formed. [3]

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Total [15]

- (b) 1-Bromobut-2-ene can be made from but-2-en-1-ol.



boiling temperatures/°C 121

98

- (i) Use the infrared absorption frequencies given in the **Data Sheet** to explain how you would know if a sample of 1-bromobut-2-ene contains unreacted but-2-en-1-ol. [2]

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- (ii) Use your understanding of intermolecular forces to explain why but-2-en-1-ol has a higher boiling temperature than 1-bromobut-2-ene.

Your answer should include:

- a description of **all** the intermolecular forces present for each compound;
- the relative strengths of the intermolecular forces present.

[6]

(QWC) [2]

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Total [15]

9. (a) Compound **A** contains carbon, hydrogen and oxygen only. It has a molar mass of 88.1 g mol^{-1} . Quantitative analysis of the compound shows that its percentage composition by mass contains 54.5% carbon and 9.10% hydrogen. Calculate both the empirical and molecular formulae of compound **A**. [4]

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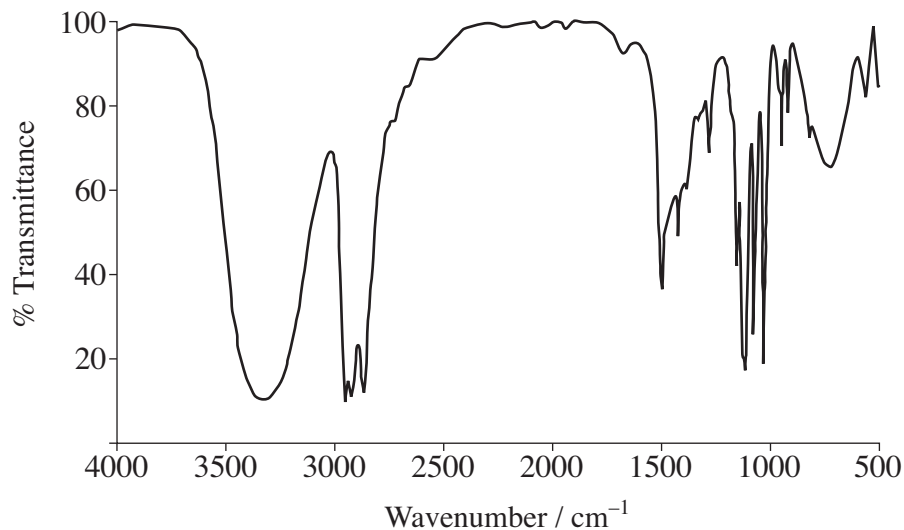
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- (b) Propan-1-ol has the infrared spectrum below.



- (i) Using the data sheet, state how this spectrum confirms which functional group is present in propan-1-ol. [1]

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- (ii) Propan-1-ol can be completely oxidised to form compound **B**. Name compound **B** and state how you would expect its infrared spectrum to differ from that of propan-1-ol. [2]

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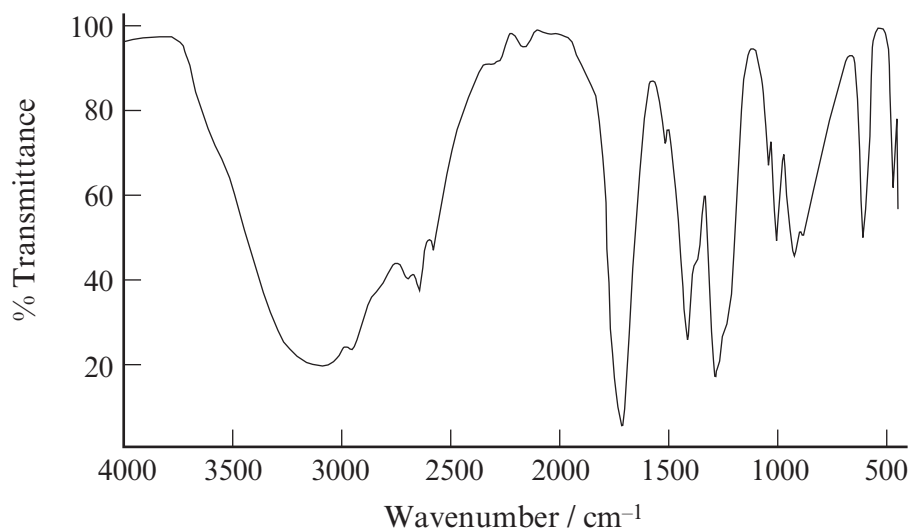
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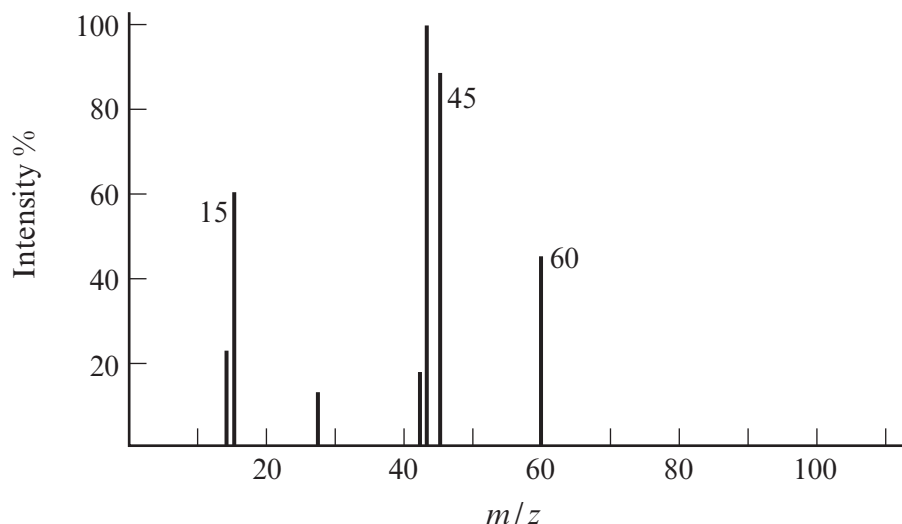
- (c) Propan-1-ol can also form propene by a dehydration reaction. Name a suitable reagent for this reaction. [1]

9. Ethanoic acid, CH_3COOH , commonly known as acetic acid, is an organic acid that gives vinegar its sour taste and pungent smell.

(a) Ethanoic acid contains C—O , C=O and O—H bonds and has the infrared spectrum shown below. Using the Data Sheet, label the characteristic absorptions for **each** of these **three** bonds on the spectrum. [2]



(b) The mass spectrum of ethanoic acid is shown below.



Explain how this shows that the formula for ethanoic acid is CH_3COOH . [2]

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SECTION A

Answer all questions in the spaces provided.

1. 'Smart' alloys have an increasing importance in many applications. State how 'smart' alloys differ from other alloys in the way in which they act when used for a particular purpose. [2]

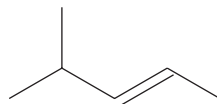
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2. A small piece of sodium metal is added to water. Give the equation for this reaction and suggest a pH value for the resulting solution. [2]

Equation

pH of solution

3. The skeletal formula of a hydrocarbon is shown below.



Give the **systematic name** of this hydrocarbon. [1]

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4. Police use a breathalyser to test motorists for the presence of alcohol.
- (a) An early type of breathalyser required the motorist to breathe into a tube that contained acidified potassium dichromate. The alcohol in their breath was oxidised to ethanal and ethanoic acid. State the colour change that occurred if the test was positive. [1]

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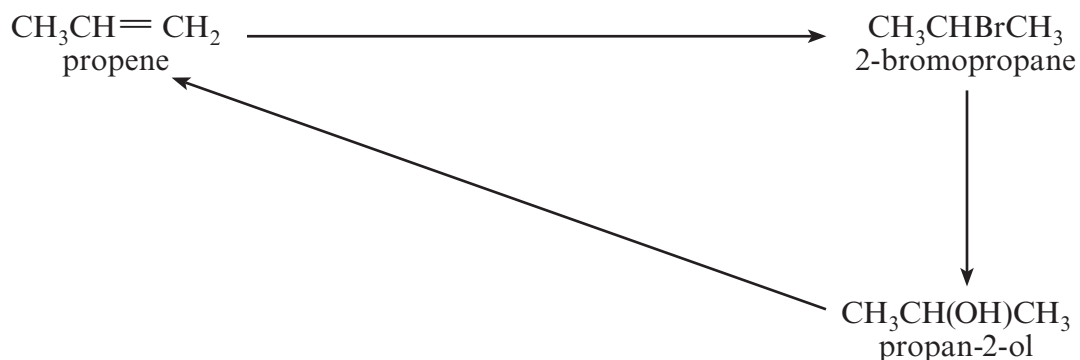
- (b) Modern breathalysers use infrared spectroscopy to detect and measure the concentration of alcohol in breath. An absorption frequency at 2940cm^{-1} is used rather than the frequency caused by the O—H bond, as this is also present in water.

- (i) Use the Data Sheet to identify the bond that causes the absorption at 2940cm^{-1} . [1]

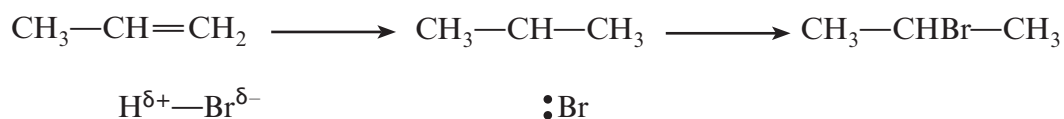
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10. (a) This question is about the compounds and reactions shown in the diagram below.



- (i) The addition of hydrogen bromide to propene gives 2-bromopropane as the main product. Complete the outline mechanism below, inserting curly arrows and charges where appropriate. [2]



- (ii) The reaction of 2-bromopropane to give propan-2-ol is an example of a nucleophilic substitution reaction. Suggest a nucleophile that can be used for this reaction and give a reason why this is classed as a substitution reaction. [2]

Nucleophile

Reason

- (iii) The production of propene from propan-2-ol is an example of an elimination reaction. Another elimination reaction is the reaction of bromoethane with sodium hydroxide.



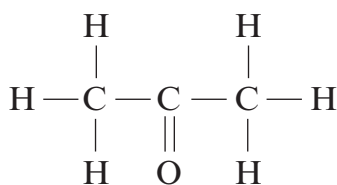
Complete the equation by giving the formulae of the other products. [1]



(ii) State which **one** of the following correctly describes any change in the absorption at 2940 cm^{-1} if the concentration of alcohol in the breath increases. [1]

- A the frequency decreases to 2900 cm^{-1}
 B the frequency increases to 3000 cm^{-1}
 C the intensity of the absorption at 2940 cm^{-1} increases
 D the absorption covers the range 2900 to 3000 cm^{-1}

(iii) A false breathalyser reading can be given by a person who exhales propanone, as a result of an illness.



propanone

Identify the bond that would distinguish the infrared spectrum of propanone from that of an alcohol. Using the Data Sheet, state the absorption frequency of this bond. [1]

5. 'Superglue' is a liquid containing methyl 2-cyanopropenoate. In the presence of moisture this alkene rapidly polymerises, in a similar way to ethene. Complete the table showing the structure of the repeating unit. [1]

Monomer	Repeating unit
$ \begin{array}{ccc} \text{H} & & \text{CN} \\ & \diagdown & / \\ & \text{C} = \text{C} & \\ & / & \diagdown \\ \text{H} & & \text{COOCH}_3 \end{array} $	

Total Section A [10]



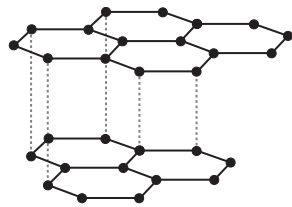
- (b) A primary alcohol was oxidised to a carboxylic acid. The mass spectrum of the acid showed a molecular ion at m/z 88.
Use the information provided to write a displayed formula for the acid. [3]

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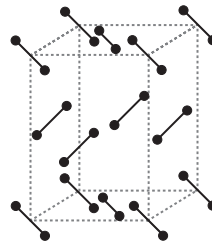
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- (c) Both carbon and iodine are non-metallic elements. The crystalline structures of graphite and iodine are shown below.



graphite



iodine

Solid iodine exists as a molecular crystal, I_2 .

Explain why graphite is able to conduct electricity but iodine is a non-conductor.
Your answer should focus on the bonding present in each solid element.

[5]
QWC [2]

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Total [15]

Section B Total [70]



8. (a) Compound **X** is a straight-chain hydrocarbon that consists of 85.7% carbon by mass.

(i) Find the **empirical** formula of compound **X**. [3]

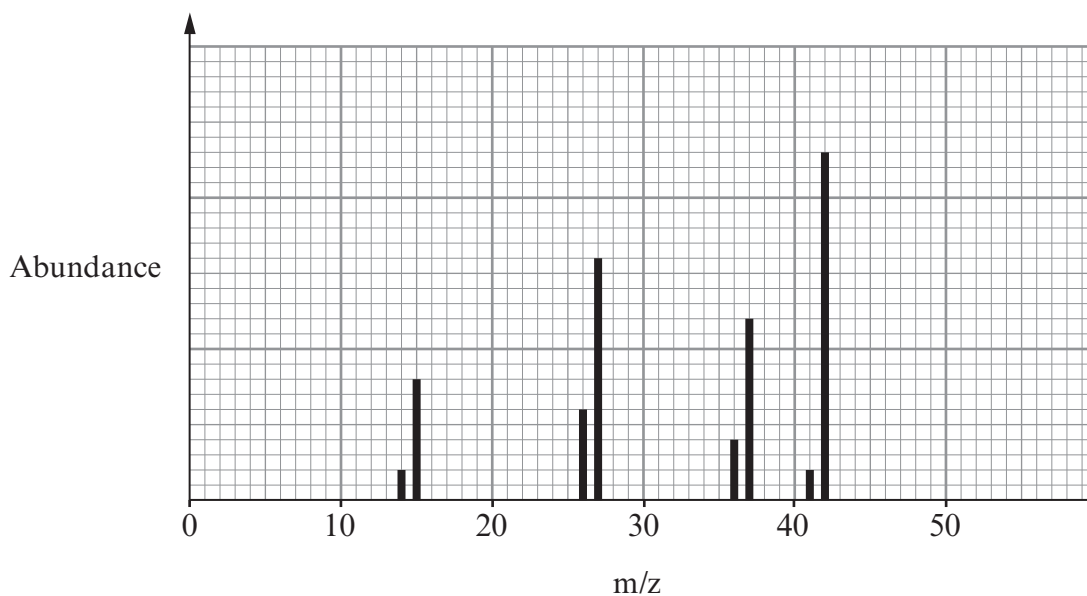
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(ii) Some peaks from the mass spectrum of **X** are shown below.



Use the empirical formula and the mass spectrum to find the molecular formula of **X**. Show your workings. [2]

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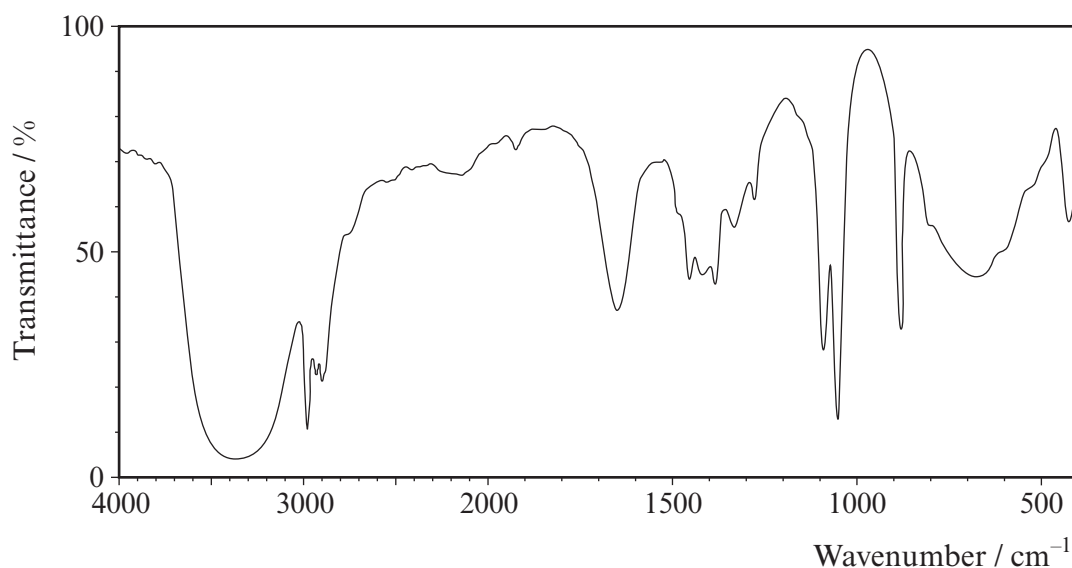
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(iii) Suggest what information the presence of the peak at m/z 15 gives about the structure of **X**. [1]

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- (ii) Another method uses IR spectroscopy. The IR spectrum for ethanol is shown below.



- I State which functional group is shown to be present in ethanol by the absorption at about 3350 cm^{-1} . [1]

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- II A student suggested that this absorption should be used to test for the presence of ethanol in breath. Give a reason why this suggestion is not valid. [1]

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- (c) If ethanol, in a drink such as wine, is left in an open bottle and exposed to air it becomes 'sour' and unpleasant to taste. This is because it forms ethanoic acid.

- (i) Draw the **displayed** formula of ethanoic acid. [1]

- (ii) What significant change would be noticed if the IR spectrum of this product was compared with that of ethanol? Give the reason for this change. [2]

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Total [9]



- (iii) Propene can be produced from the product in part (ii) by using sodium hydroxide.
Give the condition(s) required for this reaction. [1]

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- (c) But-2-ene can exist as *E*- and *Z*-isomers.

- (i) Explain why but-2-ene can form *E*- and *Z*-isomers whilst propene and butane cannot. [2]

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- (ii) Draw the **skeletal** formula for *Z*-but-2-ene. [1]

- (d) In industry, butan-2-ol can be produced from but-2-ene. This uses the same reagent(s) and condition(s) as the production of ethanol from ethene.

- (i) Give the reagent(s) and condition(s) used for this reaction. [2]

Reagent(s)

Condition(s)

- (ii) Explain how infrared spectroscopy can be used to distinguish between butan-2-ol and but-2-ene. [1]

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Total [13]

Total Section B [70]

END OF PAPER



8. (a) In March 2012 the UK Government proposed a minimum price of 40p per unit of alcohol in an effort to ‘turn the tide’ against binge drinking.

State **one** effect on the human body and **one** effect on society of the excessive use of alcoholic drinks. [2]

Effect on the human body

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Effect on society

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(b) Butan-1-ol can be prepared by warming 1-chlorobutane with aqueous sodium hydroxide.

(i) Classify the type of reaction occurring and give the mechanism for the reaction. [4]

Reaction type

Mechanism

(ii) Use the infrared absorption frequencies given in the Data Sheet to explain how you would know if all the 1-chlorobutane has been converted into butan-1-ol. [2]

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12. (a) Petroleum (crude oil) is separated into useful parts by fractional distillation.

(i) Briefly describe how *fractional distillation* can be carried out.

[2]

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(ii) A fraction is treated further to give a **branched-chain** alkane. The mass spectrum of this alkane shows a molecular ion, M^+ , at m/z 72.

Use this information to give the molecular formula and then suggest a displayed formula for this alkane.

[2]

(b) Cracking is a process that is used in the petroleum industry to obtain smaller alkanes and alkenes from larger alkanes.

(i) State why this process of making smaller molecules is carried out.

[1]

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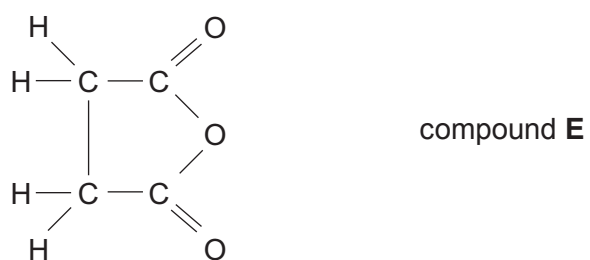
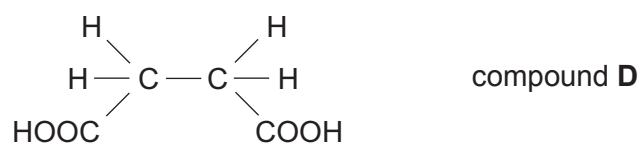
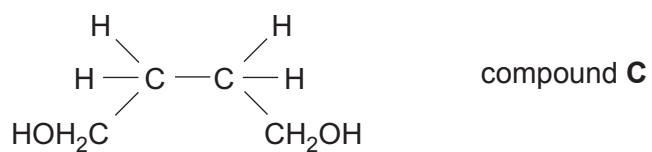
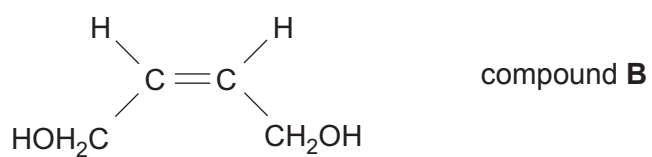
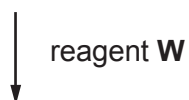
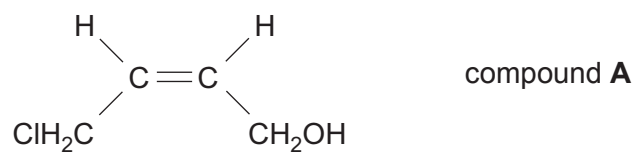
(ii) Methane is one of the products when nonane, C_9H_{20} , is cracked. The other products are butane and butadiene, C_4H_6 .

Give an equation that represents this reaction.

[1]

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(d) Study the reaction sequence below and then answer the questions that follow.



- (i) Compound **A** is a (*Z*)-isomer.

Write the displayed formula of the (*E*)-isomer of compound **A**.

[1]

- (ii) State the name of reagent **W** and the solvent in which it is dissolved.

[1]

- (iii) State the name of a catalyst used in the hydrogenation of compound **B** to produce compound **C**.

[1]

- (iv) The infrared spectra of compounds **D** and **E** are taken.

Use the Data Sheet to explain how the infrared spectra can be used to distinguish between compounds **D** and **E**.

[2]

Total [14]

Total Section B [70]**END OF PAPER**

(b) Compound **C** is a compound of carbon, hydrogen and bromine only. Bromine has two isotopes, ^{79}Br and ^{81}Br , in equal abundance. Use all the information below to deduce the structure of compound **C**, giving your reasoning.

[6]

QWC [1]

- Compound **C** contains 29.8% carbon, 4.2% hydrogen and 66.0% bromine by mass.
- The mass spectrum of compound **C** contains peaks at m/z of 15, 41 and a pair of peaks at 120 and 122.
- The infrared spectrum of compound **C** has absorptions at 550 cm^{-1} , 1630 cm^{-1} and 3030 cm^{-1} .
- Compound **C** is a Z-isomer.

Total [12]

Section B Total [70]**END OF PAPER**