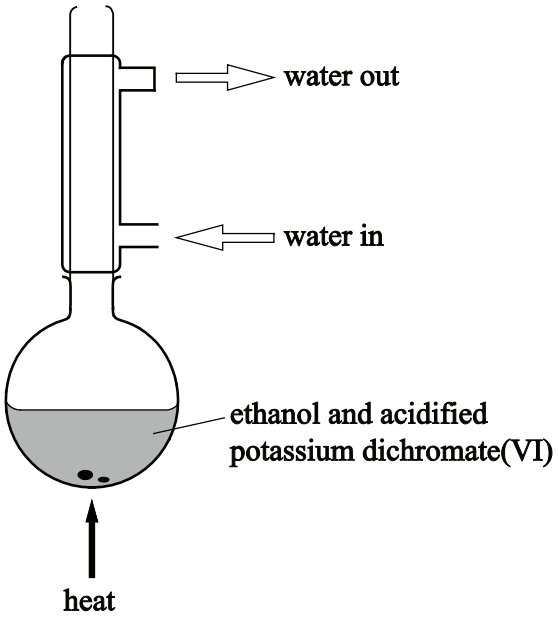
1. Ethanol is oxidised to ethanoic acid using acidified potassium dichromate(IV) solution. The reaction is heated under reflux using the equipment shown in the diagram below.



What is the reason for heating under reflux?

A to ensure even heating

B to prevent any substances escaping

C to boil the mixture at a higher temperature

D to allow efficient mixing

Your answer ☐

[1]

2. CN^- ions react with haloalkanes and with carbonyl compounds.

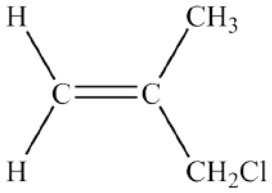
Which row gives the correct mechanisms for the reactions?

	Reaction of CN^- with haloalkanes	**Reaction of CN^- with carbonyl compounds**
A	Electrophilic substitution	Electrophilic addition
B	Electrophilic substitution	Nucleophilic addition
C	Nucleophilic substitution	Electrophilic addition
D	Nucleophilic substitution	Nucleophilic addition

Your answer ☐

[1]

3. Methyl allyl chloride, MAC, is a chemical used in the production of insecticides. The structure of MAC is shown below.



MAC

(a) (i) Give the **molecular** formula of MAC.

…… **[1]**

(ii) Draw the **skeletal** formula of MAC.

[1]

(iii) MAC has several structural isomers.

State what is meant by *structural isomers*.

……

…… **[1]**

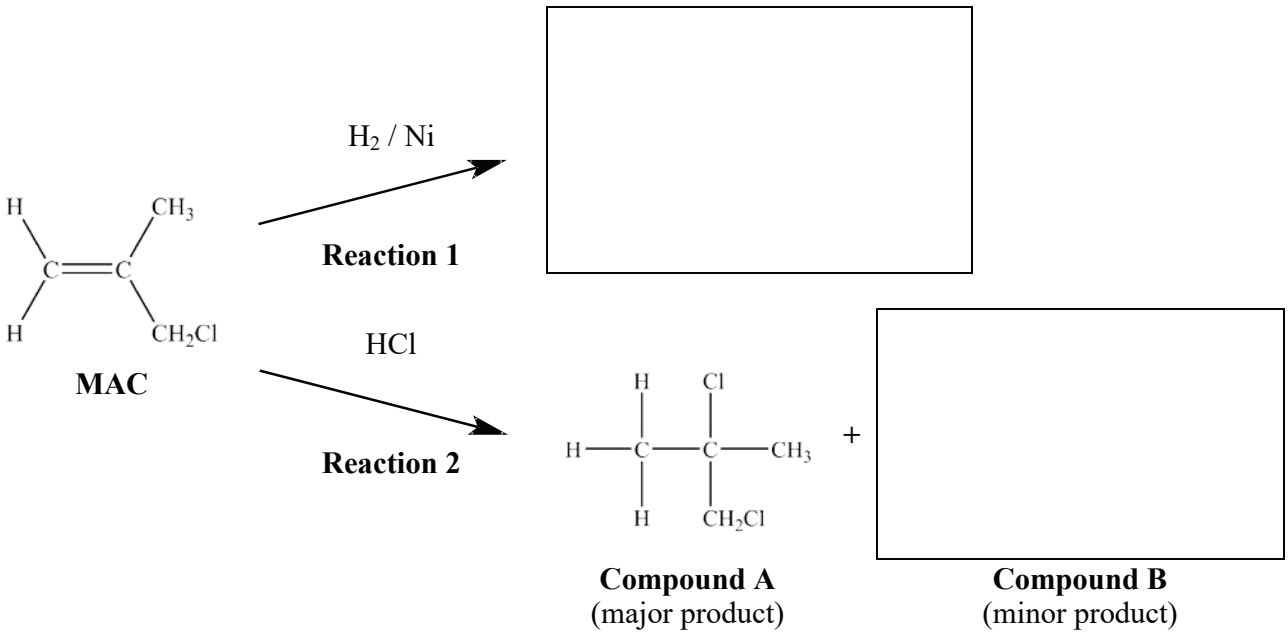
(b) MAC is highly flammable. When MAC burns, one of the products formed is a toxic gas.

1.321 g of this gas occupies 1.053 dm^3 at 100 kPa and 350 K.

Use the information provided to suggest the identity of the gas.

gas = …… **[4]**

(c) The flowchart below shows some reactions of MAC.



(i) Complete the flowchart above.

- Draw the structure of the product of **Reaction 1**.
- Draw the structure of the minor organic product of **Reaction 2** (Compound **B**).

[2]

(ii) **Reaction 2** creates a mixture of compounds. Compound **A** is the major product.

Draw the mechanism for the formation of compound **A**.

Use curly arrows and show relevant dipoles.

[3]

(iii) Explain why compound **B** is the minor product of **Reaction 2**.

……

…… **[1]**

(iv) **MAC** reacts with water in the presence of $AgNO_3(aq)$ and ethanol.

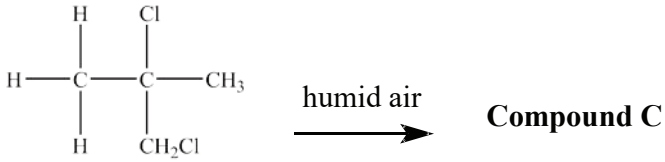
Draw the structure of the organic product of this reaction.

State what you would **observe** in this reaction and identify the compound responsible for the observation.

……

…… **[2]**

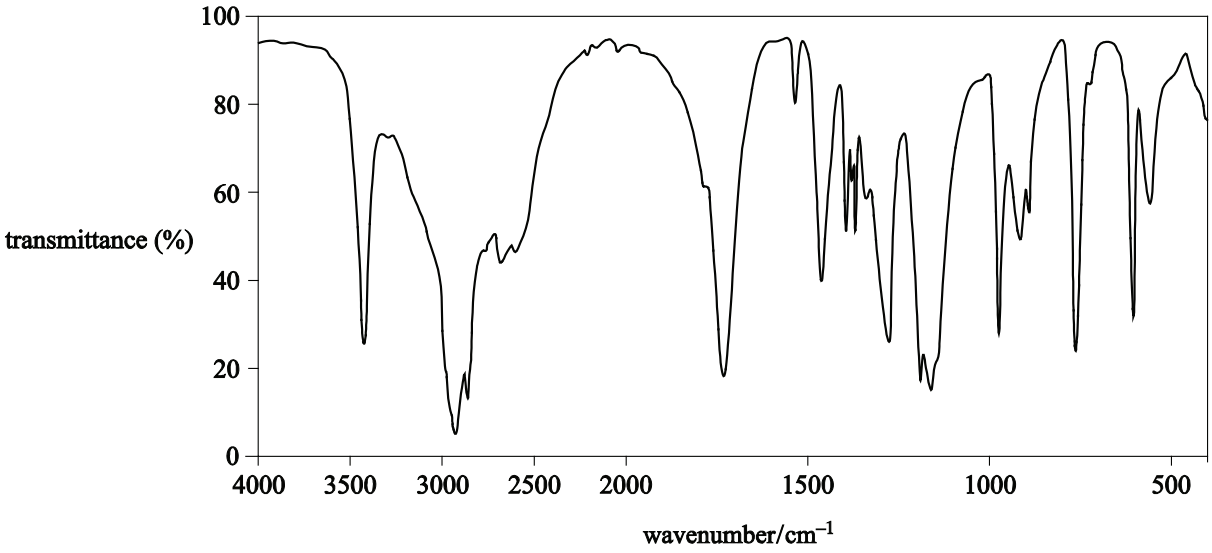
(d) Compound **A** reacts slowly in humid conditions to form compound **C**.



Compound A

Compound **C** contained the following percentage composition by mass:
C, 46.1%; H, 7.7%; O, 46.2%

The infrared spectrum of compound **C** is shown below.



Using the information on the previous page, deduce the structure of compound **C**.

Give your reasoning.

……

……

……

……

……

……

……

……

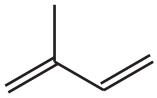
……

……

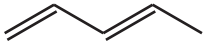
structure = [ ] **[5]**

4. This question is about unsaturated hydrocarbons.

(a) Compound **A** and compound **B** are isomers.



compound A



compound B

Compound **A** has a lower melting point than compound **B**.

Suggest why.

.....

.....

.....

.....

..... **[2]**

(b) Compound **C**, $CH_3CH_2CH{=}CHCH_2CH_2OH$, exists as *cis* and *trans* stereoisomers.

(i) Name compound **C**.

..... **[1]**

(ii) Define the term *stereoisomers*.

.....

.....

.....

..... **[1]**

(iii) Draw the structures of the *cis* and *trans* stereoisomers of compound **C**.

cis	*trans*

[2]

(c) The C=C group in an alkene contains a π-bond.

Complete the diagram below to show how p-orbitals are involved in the formation of a π-bond.

[1]

(d) Compound **D**, shown below, reacts with hydrogen bromide by electrophilic addition. A mixture of two organic compounds, **E** and **F**, is formed.

compound

(i) Suggest how an HBr molecule can act as an electrophile.

.....

.....

..... **[1]**

(ii) Draw the structures of the two organic compounds **E** and **F**.

E	**F**

[2]

(iii) Outline the mechanism of the reaction between compound **D** and hydrogen bromide to form **either** compound **E or** compound **F**.

Include curly arrows and relevant dipoles.

[3]

(iv) Which of **E** or **F** is the major organic product?

Explain your answer.

Major organic product .....

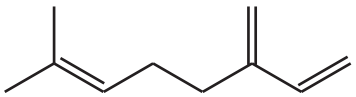
Explanation .....

.....

.....

..... **[1]**

(e) Myrcene, $C_{10}H_{16}$, is a naturally occurring hydrocarbon containing more than one carbon-carbon double bond.



m c n

(i) Reaction of 204 mg of myrcene with hydrogen gas produces a saturated alkane.

Calculate the volume of hydrogen gas, in cm^3 and measured at RTP, needed for this reaction.

Show your working.

volume = ... cm^3 **[2]**

(ii) β-Carotene is a naturally occurring unsaturated hydrocarbon found in carrots.
A β-carotene molecule contains 40 carbon atoms, has two rings, and a branched chain.

0.0200 mol of β-carotene reacts with 5.28 dm^3 of hydrogen gas to form a saturated hydrocarbon.

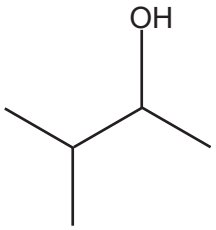
Using molecular formulae, construct a balanced equation for this reaction.

Include relevant calculations and reasoning.

Equation ..... **[4]**

5. This question is about reactions of organic compounds containing carbon, hydrogen and oxygen.

(a) A chemist investigates two reactions of alcohol **A**, shown below.



alcohol A

(i) What is the systematic name of alcohol **A**?

..... **[1]**

(ii) What is the structural formula of alcohol **A**?

..... **[1]**

(iii) The chemist heats alcohol **A** with an acid catalyst to form a mixture containing **two** alkenes.

Draw the structures of the **two** alkenes formed in this reaction.

[2]

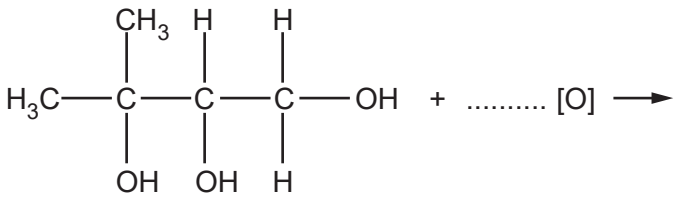
(iv) The chemist heats alcohol **A** with sodium chloride and sulfuric acid.

Construct a balanced equation for this reaction.
Show structures for the organic compounds in your equation.

[2]

(b) Compound **B**, shown below, is refluxed with excess acidified potassium dichromate(VI) to form a single organic product.

Complete the equation for this reaction.

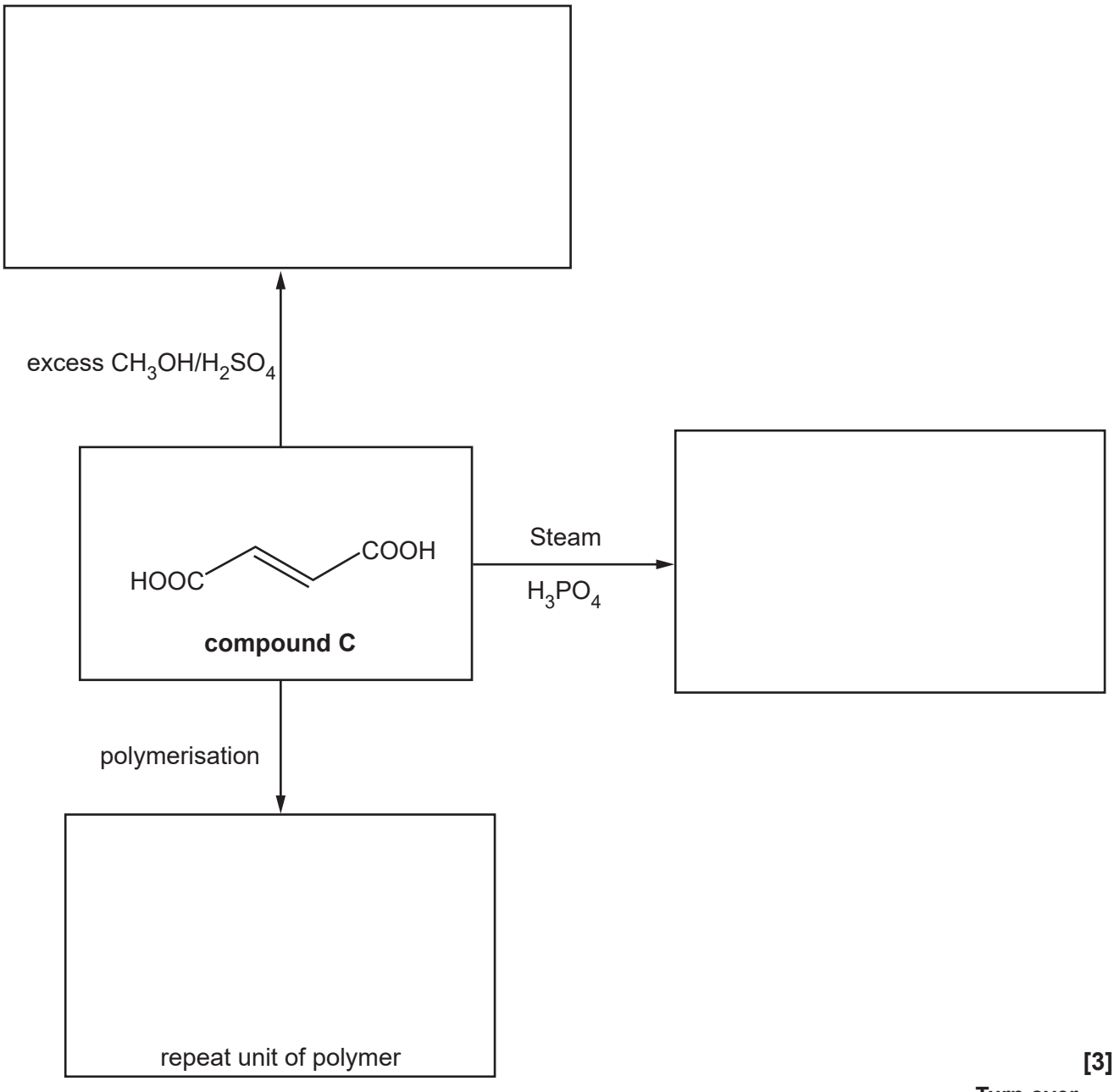


compound B

[2]

(c) The flowchart below shows some reactions of compound **C**.

In the boxes, draw the organic products of these reactions.



[3]