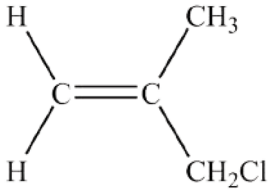
1. Methyl allyl chloride, MAC, is a chemical used in the production of insecticides. The structure of MAC is shown below.

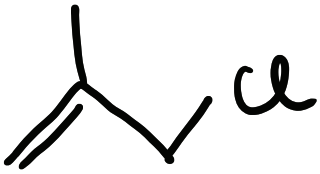


MAC

Give the **molecular** formula of MAC.

C_4H_7Cl [1]

Draw the **skeletal** formula of MAC.



example of skeletal formula showing the C-C backbone. [1]

MAC has several structural isomers.

State what is meant by *structural isomers*.

compounds with the same molecular formulae but different structural formulae. [1]

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 (100000 Pa) and 350 K ($1.053 \times 10^{-3}\ m^3$).

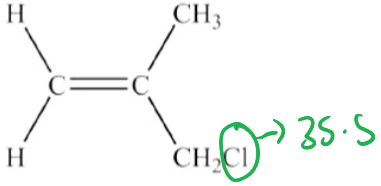
Use the information provided to suggest the identity of the gas.

$PV = nRT$ $\quad Mr = \frac{m}{n}$

$n = \frac{PV}{RT}$ ($R = 8.314\ JK^{-1}mol^{-1}$ (data sheet))

$n = \frac{100000 \times 1.053 \times 10^{-3}}{8.314 \times 350}$

$n = 0.0362\ mol$



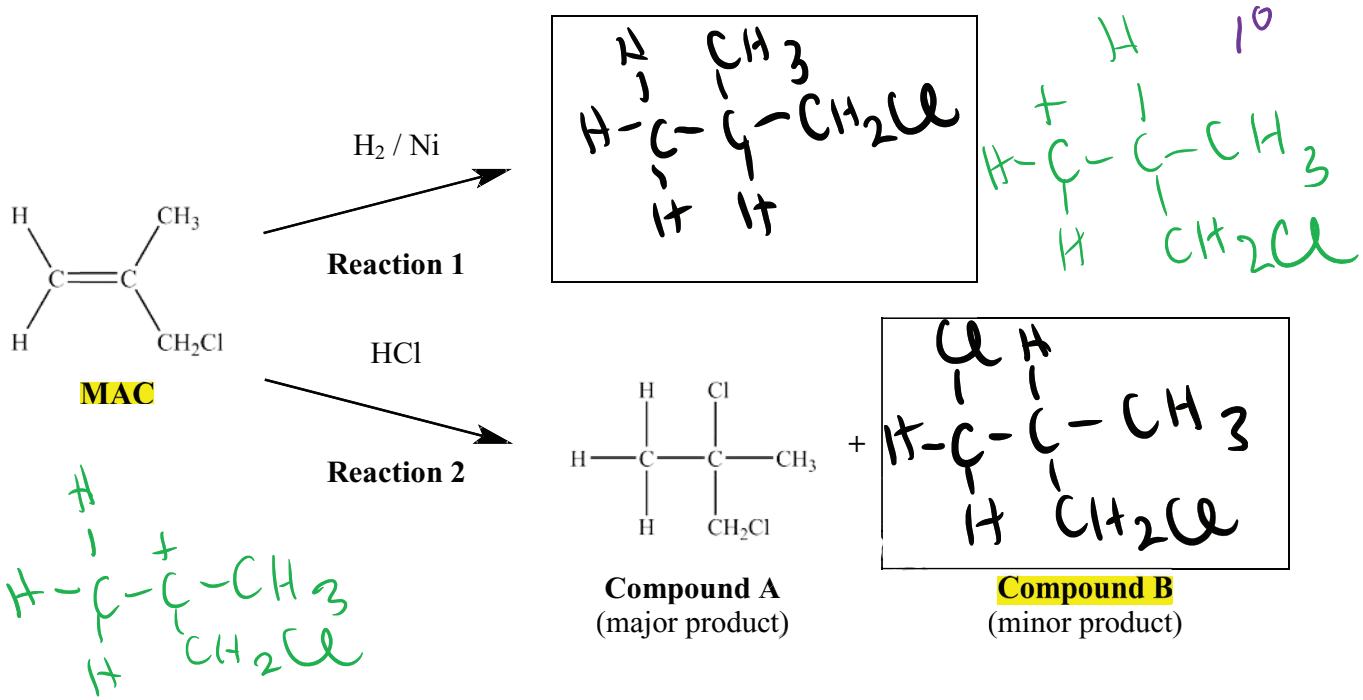
MAC

$Mr = \frac{1.321}{0.0362} = 36.5$

$HCl = 1 + 35.5 = 36.5$

gas = HCl [4]

The flowchart below shows some reactions of MAC.



Complete the flowchart above.

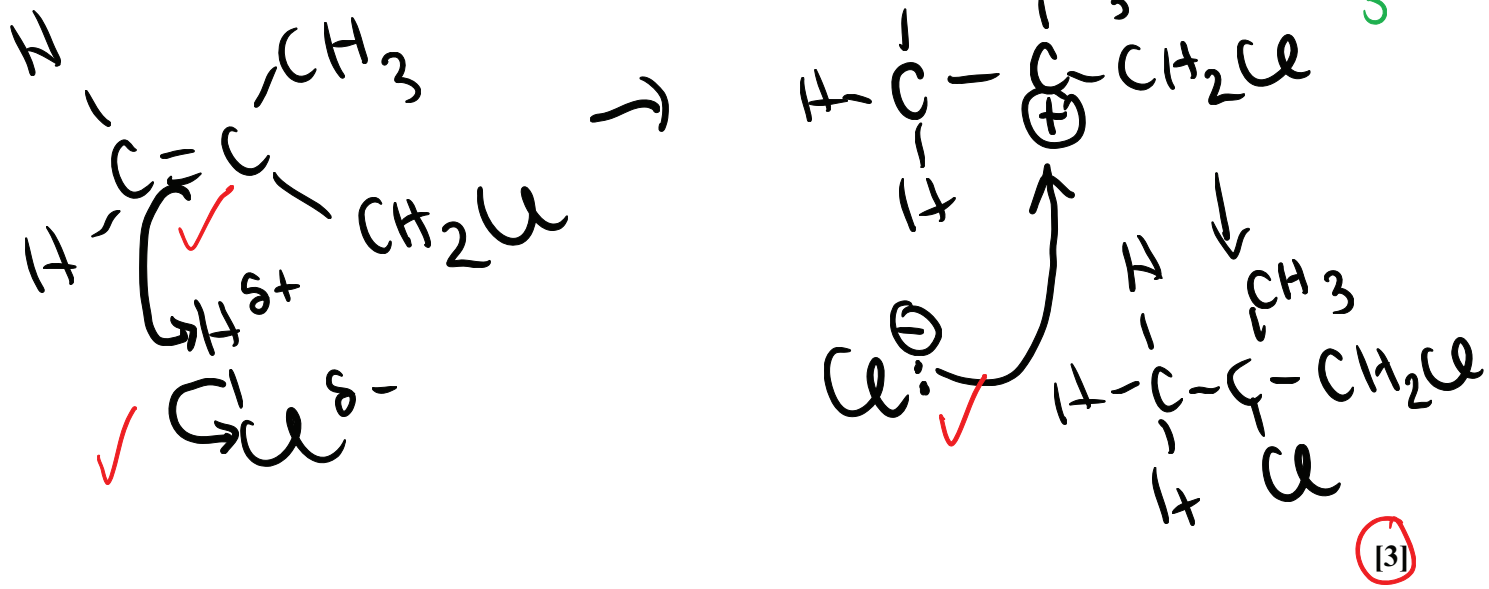
- Draw the structure of the product of **Reaction 1**.
- Draw the structure of the minor organic product of **Reaction 2** (Compound **B**).

[2]

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

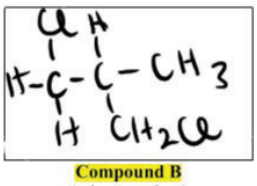
Draw the mechanism for the formation of compound **A**.

Use curly arrows and show relevant dipoles.



[3]

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



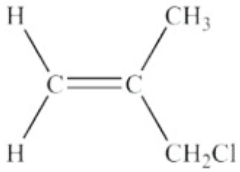
Compound B
(minor product)

Because it had the least stable carbocation intermediate. [1]

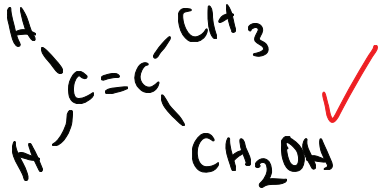
MAC reacts with water in the presence of $AgNO_3(aq)$ and ethanol.

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.



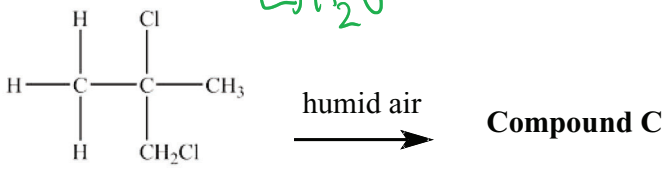
MAC



$Cl^{\ominus}$

white precipitate → $AgCl(s)$ ✓ [2]

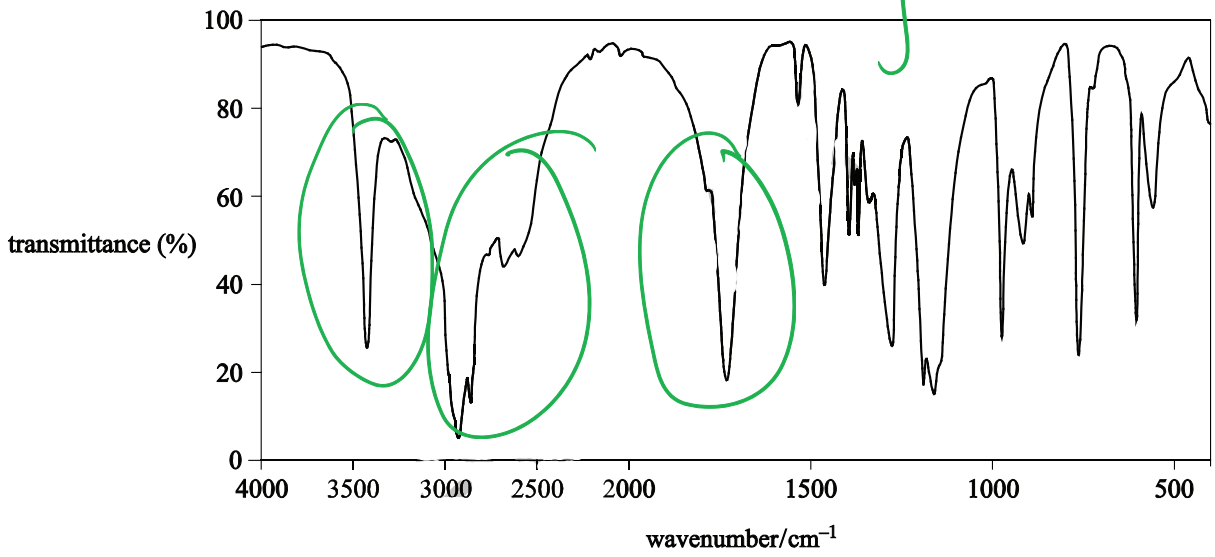
Compound **A** reacts slowly in humid conditions to form compound **C**.



Compound A → **Compound C**

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**.

$n = \frac{m}{A_r}$

Give your reasoning.

	C	H	O
%	46.1	7.7	46.2
n	$\frac{46.1}{12} = 3.84$	$\frac{7.7}{1} = 7.7$	$\frac{46.2}{16} = 2.89$
ratio	1.33 :	2.66 :	1 ✓
→ x3	4 :	8 :	3

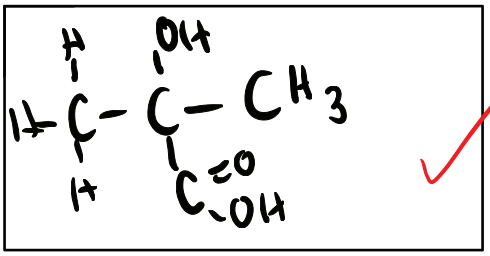
$C_4H_8O_3$ ✓

3450 cm^{-1} = OH alcohol ✓

2500 - 3300 cm^{-1} broad absorption OH → –C(=O)(OH)

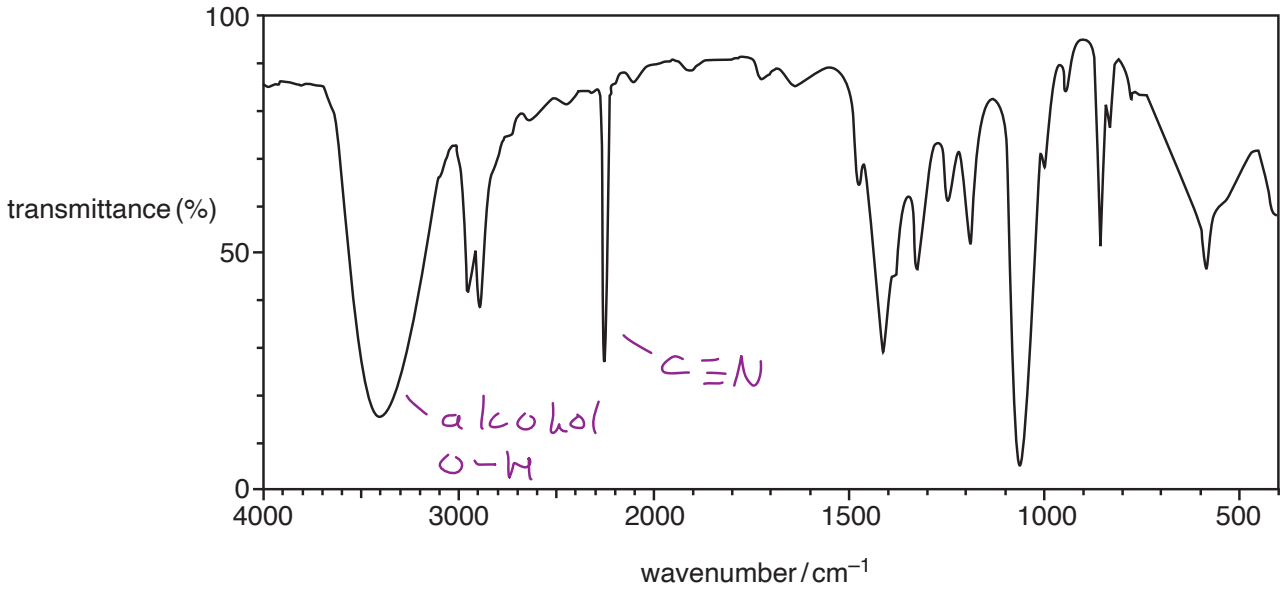
1640 - 1750 cm^{-1} = C=O → C(=O)OH

structure =



[5]

2. Which compound could have produced the IR spectrum below?



~~A~~ CH_3CH_2OH

B $CH_3CHOHCN$

~~C~~ CH_3COOH

~~D~~ CH_3CONH_2

Your answer B

Bond	Location	Wavenumber/cm^{-1}
C–C	Alkanes, alkyl chains	750–1100
C–X	Haloalkanes (X = Cl, Br, I)	500–800
C–F	Fluoroalkanes	1000–1350
C–O	Alcohols, esters, carboxylic acids	1000–1300
C=C	Alkenes	1620–1680
C=O	Aldehydes, ketones, carboxylic acids, esters, amides, acyl chlorides and acid anhydrides	1630–1820
aromatic C=C	Arenes	Several peaks in range 1450–1650 (variable)
C≡N	Nitriles	2220–2260
C–H	Alkyl groups, alkenes, arenes	2850–3100
O–H	Carboxylic acids	2500–3300 (broad)
N–H	Amines, amides	3300–3500
O–H	Alcohols, phenols	3200–3600

[1]