1. How many stereoisomers are there of $CH_3CH=CHCH(OH)CH_2CH=CH_2$?

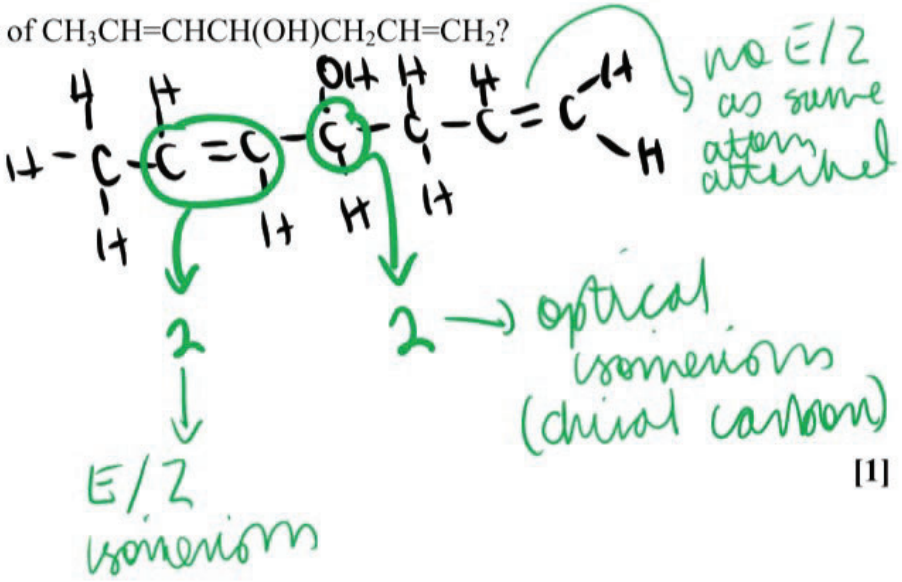
A 2

B 4

C 6

D 8

Your answer B



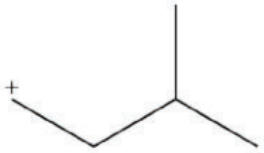
[1]

2. Hydrogen bromide reacts with 3-methylbut-1-ene.

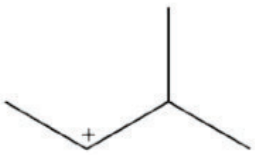
Electrophilic addition

What is the structure of the major intermediate formed in the mechanism?

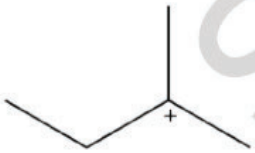
A



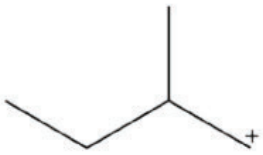
B

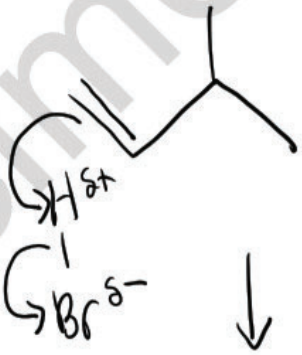


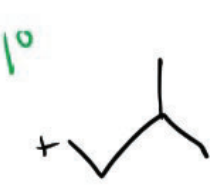
C

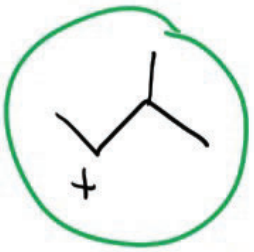


D









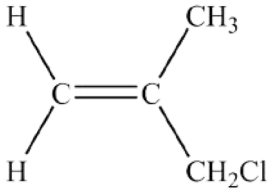
1° 2°

2° carbocations are more stable than 1° ∴ the 2° C⊕ is the major intermediate.

Your answer B

[1]

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

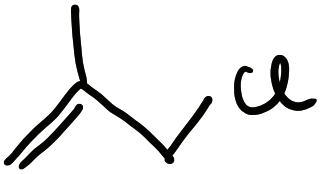


MAC

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]**

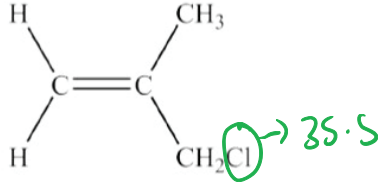
MAC is highly flammable. When MAC burns, one of the products formed is a toxic gas.

1.321 g of this gas occupies 1.053 dm^3 at 100 kPa (100000 Pa) and 350 K ($1.053 \times 10^{-3}\ m^3$).

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

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

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



MAC

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

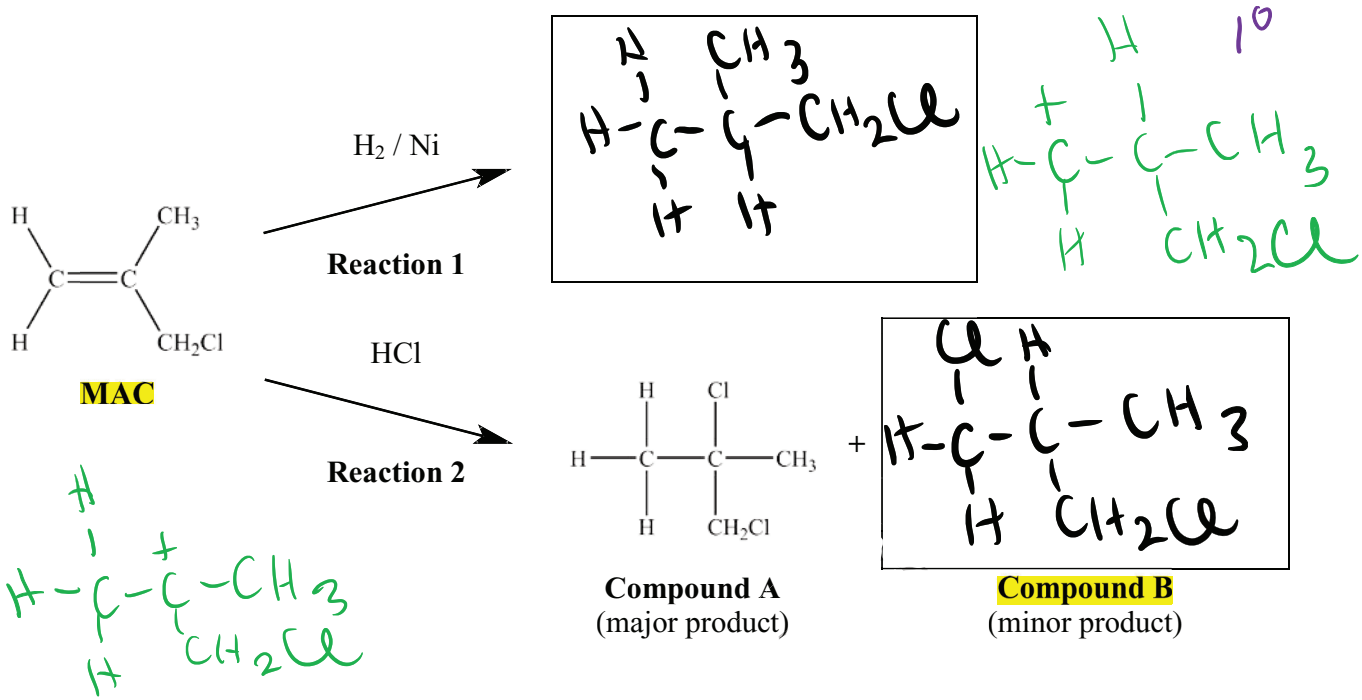
$n = 0.0362\ mol$

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

$HCl = 1 + 35.5 = 36.5$

gas = HCl **[4]**

The flowchart below shows some reactions of MAC.



Complete the flowchart above.

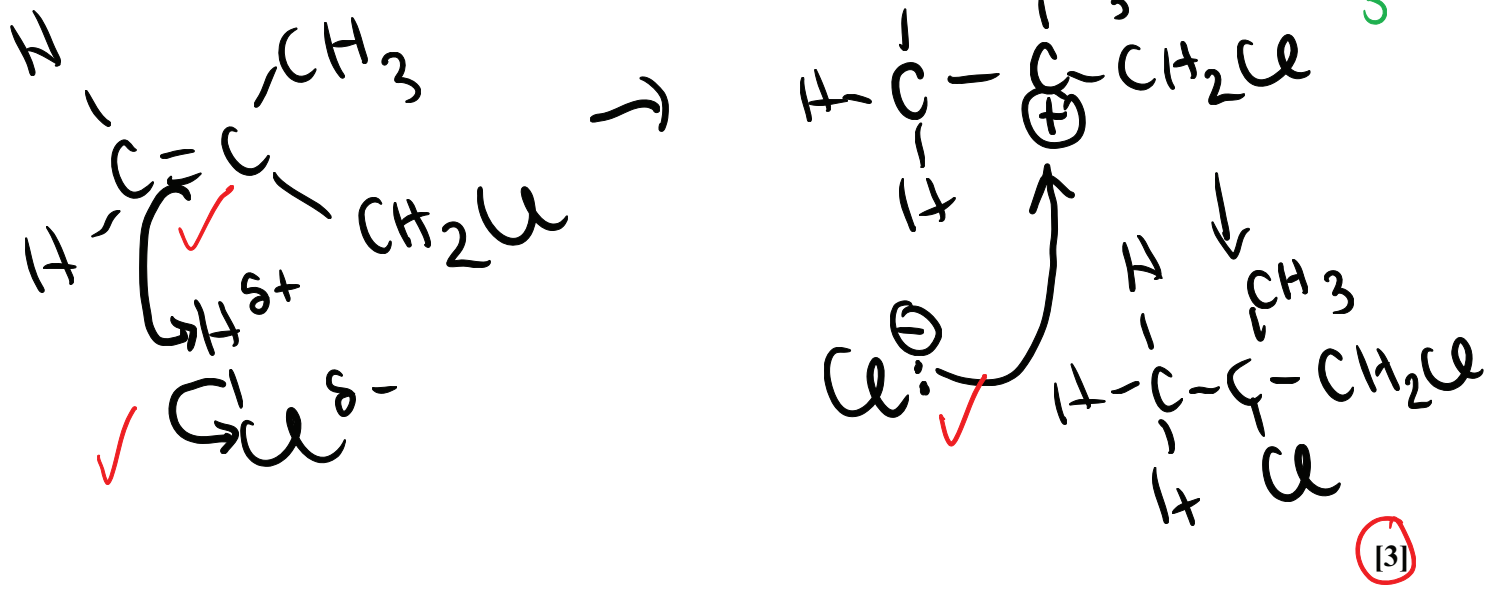
- Draw the structure of the product of **Reaction 1**.
- Draw the structure of the minor organic product of **Reaction 2** (Compound **B**).

[2]

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

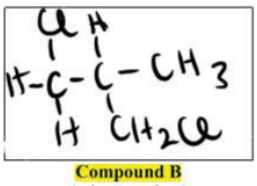
Draw the mechanism for the formation of compound **A**.

Use curly arrows and show relevant dipoles.



[3]

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



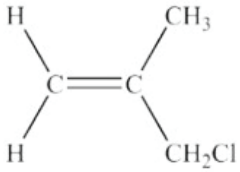
Compound B
(minor product)

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

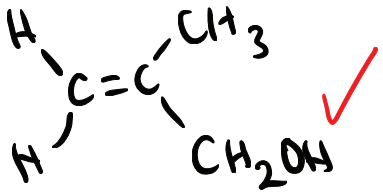
MAC reacts with water in the presence of $AgNO_3(aq)$ and ethanol.

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

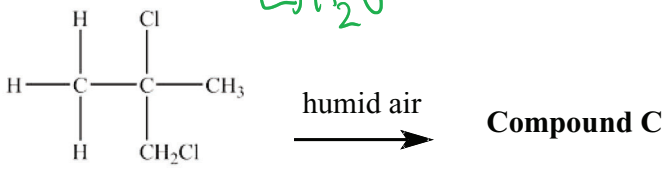


$Cl^{\ominus}$

white precipitate → AgCl (s) ✓

[2]

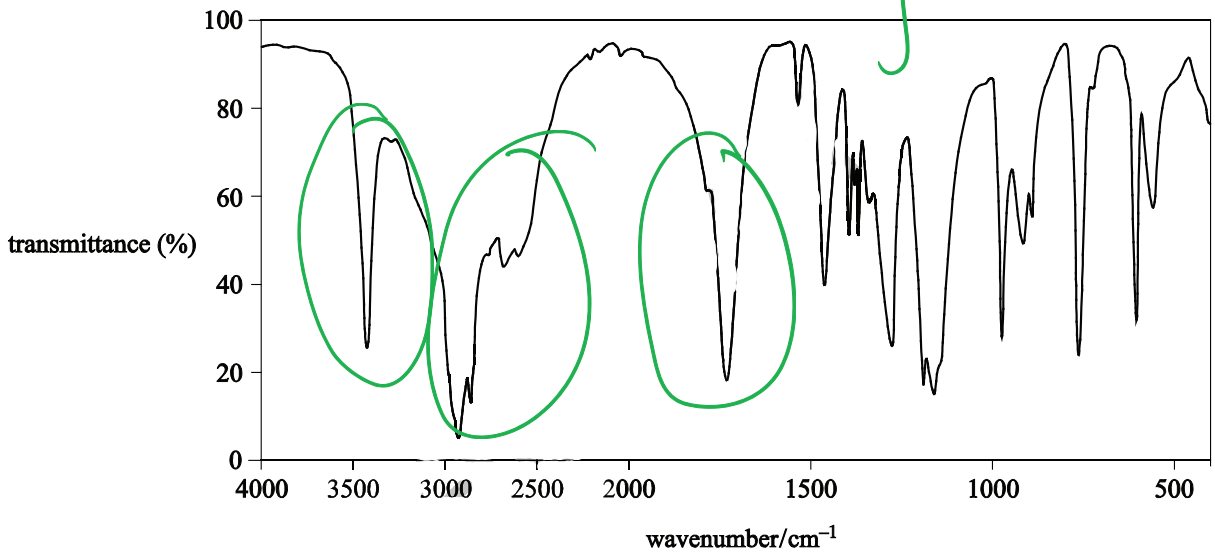
Compound **A** reacts slowly in humid conditions to form compound **C**.



Compound A

Compound **C** 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 ✓
→ ×3	4 :	8 :	3

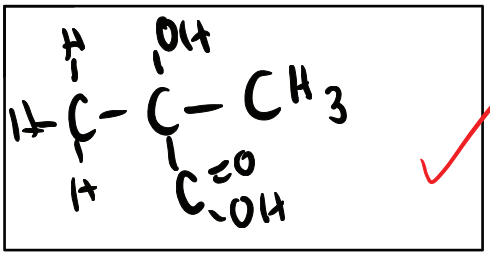
$C_4H_8O_3$ ✓

3450 cm^{-1} = OH alcohol ✓

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

1640 - 1750 cm^{-1} = C=O –C(=O)OH

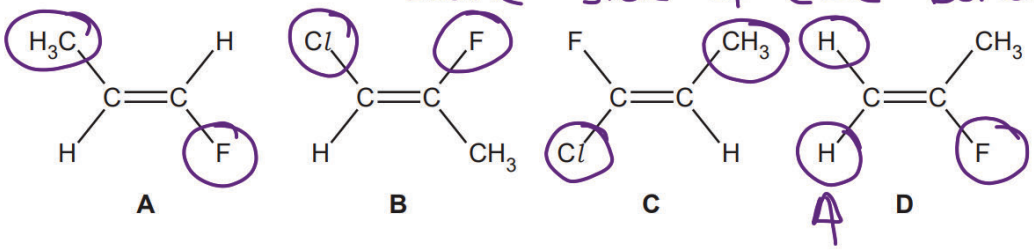
structure =



✓ [5]

4. Which molecule is a Z-isomer?

highest priority groups on same side of C=C bond



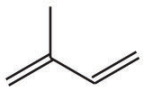
same priority no E-Z isomerism

Your answer B

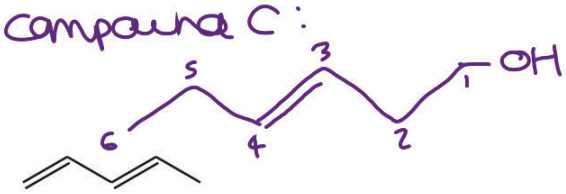
[1]

5. 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.

Compound A is branched meaning it has fewer points of contact and weaker london forces which require less energy to break.

[2]

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

(i) Name compound **C**.

Hex-3-en-1-ol

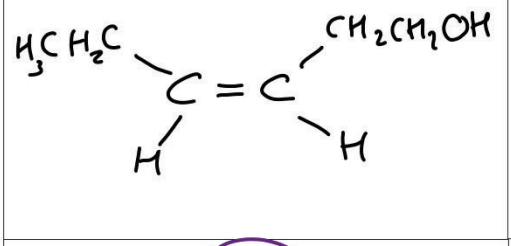
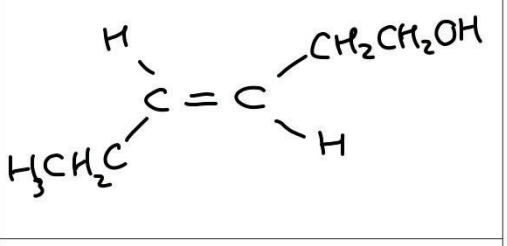
[1]

(ii) Define the term *stereoisomers*.

same structural formula but a different spatial arrangement of atoms.

[1]

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

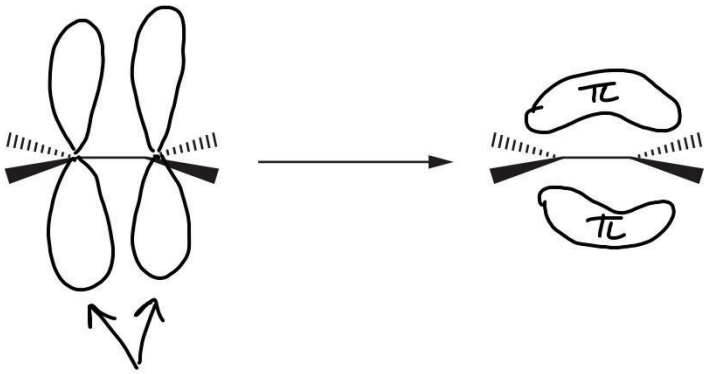
	
cis	*trans*

H on same side of C=C

[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]

a π bond is the sideways overlap of p orbitals.

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

compound D

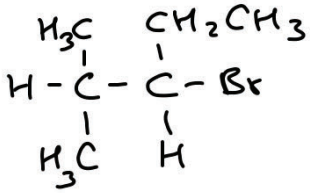
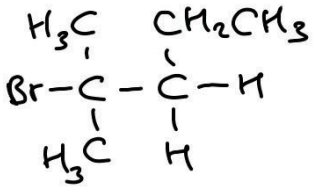
(i) Suggest how an HBr molecule can act as an electrophile.

electron pair acceptor

HBr accepts a pair of electrons

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

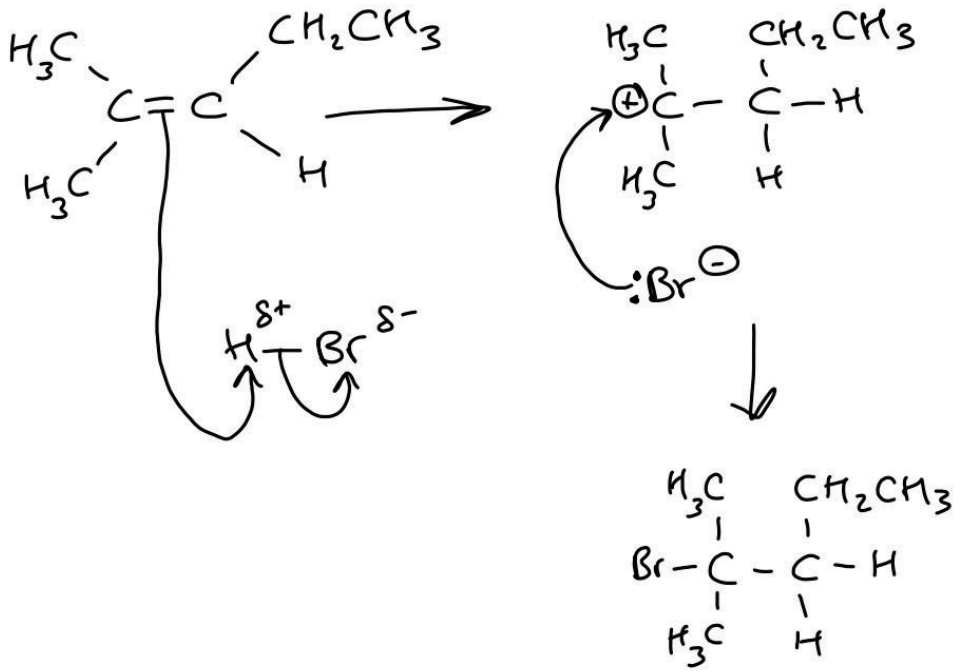
(ii) Draw the structures of the two organic compounds **E** and **F**.

	
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 ....F.....

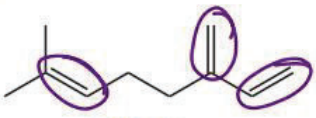
Explanation ....reaction goes via the most stable carbocation intermidiate.....

.....

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

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

$mol = \frac{vol\ (cm^3)}{24000\ cm^3}$



myrcene

3 double bonds so 1:3 molar ratio needed

(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.

$$\text{moles of myrcene} = \frac{204 \times 10^{-3}}{((12 \times 10) + 16)} = 1.5 \times 10^{-3}\ mol$$

$$1.5 \times 10^{-3} \times 3 = 4.5 \times 10^{-3}\ mol$$

$$4.5 \times 10^{-3} \times 24000 = 108\ cm^3$$

volume = 108 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.

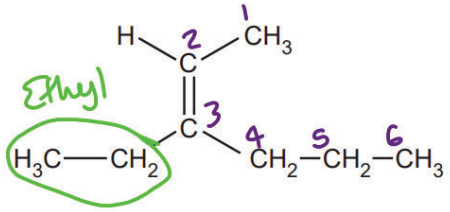
$$\frac{5.28}{24} = 0.22\ mol\ \text{of}\ H_2$$

$$\frac{0.22}{0.02} = 11 \rightarrow 11\ \text{double bonds}$$

$C_{40}H_{78}$

Equation $C_{40}H_{56} + 11H_2 \rightarrow C_{40}H_{78}$ **[4]**

6. What is the name of the compound below?



hex = 6 carbons

~~A~~ 3-Propylpent-2-ene

~~B~~ 3-Propylpent-3-ene

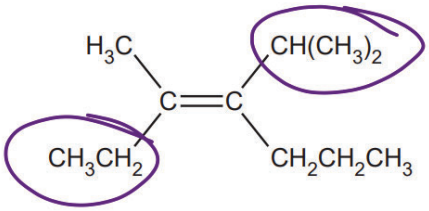
C 3-Ethylhex-2-ene

D 4-Ethylhex-4-ene

Your answer [C]

[1]

7. The structure of a stereoisomer is shown below.

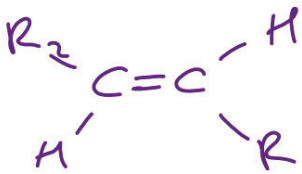


highest priority groups on opposite sides of the C=C bond

Which term correctly describes this stereoisomer?

A *cis-*

B *trans-*

} in terms of 

C *E-*

D *Z-*

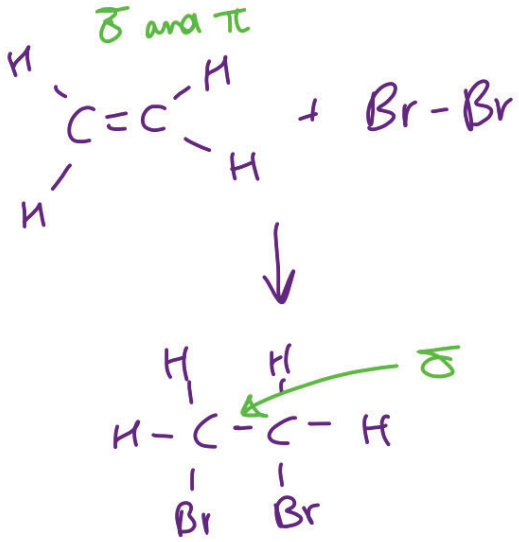
Your answer C

[1]

8. Which types of bonds are broken and formed in the reaction of ethene and bromine?

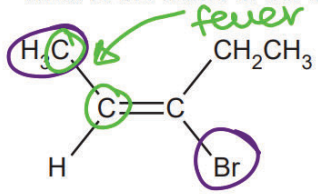
	Types of bond broken	Types of bond formed
A	σ	π
B	π	σ
C	σ and π	π
D	σ and π	σ

Your answer D



[1]

9. What is the name of the compound below?



fewer C's before C=C

Highest priority groups on opposite sides of C=C so E

A *E*-3-bromopent-2-ene

~~**B** *E*-3-bromopent-3-ene~~

~~**C** *Z*-3-bromopent-2-ene~~

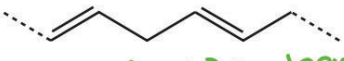
~~**D** *Z*-3-bromopent-3-ene~~

Your answer A

[1]

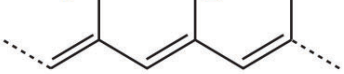
10. Which structure shows a section of poly(propene)?

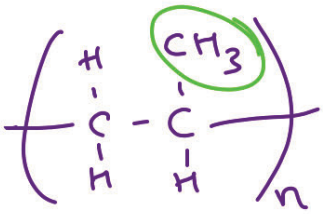
A



no double bond in repeating unit

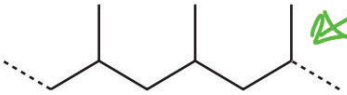
B





C

D



CH_3 Side chain

Your answer D

[1]