

1 In this question, you are asked to suggest structures for several organic compounds.

(a) Compounds **F**, **G** and **H** are **unbranched** alkenes that are isomers, each with a relative molecular mass of 70.0.

Compounds **F** and **G** are *E/Z* stereoisomers.

Compound **H** is a structural isomer of compounds **F** and **G**.

- Explain what is meant by the terms *structural isomer* and *stereoisomer*.
- Explain why some alkenes have *E/Z* isomerism.
- Analyse this information to suggest possible structures for compounds **F**, **G** and **H**.



In your answer you should make clear how each structure fits with the information given above.

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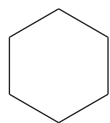
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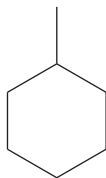
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2 Crude oil is a source of many hydrocarbons.

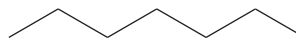
The skeletal formulae of some of these hydrocarbons are shown below.



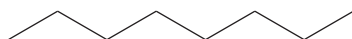
A



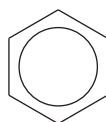
B



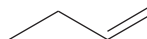
C



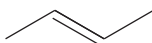
D



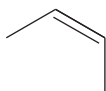
E



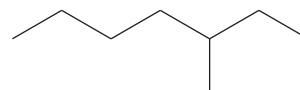
F



G



H



I

(a) Explain why compound **A** is both *saturated* and a *hydrocarbon*.

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..... [2]

(b) What is the empirical formula for compound **A**?

..... [1]

(c) Give the letters, **A**, **B**, **C**, **D**, **E**, **F**, **G**, **H** or **I**, of two hydrocarbons that are structural isomers of each other.

..... and [1]

(d) The petroleum industry processes straight chain alkanes into cyclic hydrocarbons such as **A**, **B** and **E**.

(i) Explain why the petroleum industry processes straight chain alkanes into cyclic hydrocarbons.

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..... [1]

(ii) Hydrocarbon **C** can be processed into the cyclic hydrocarbon **B**.

Construct an equation for this reaction.

[1]

(e) Explain why hydrocarbon **D** has a higher boiling point than hydrocarbon **C**.

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..... [2]

(f) Hydrocarbons **G** and **H** are stereoisomers of each other.

Explain what is meant by the term *stereoisomerism*.

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(g) Construct the equation for the **complete** combustion of hydrocarbon **C**.

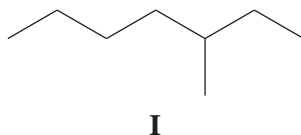
..... [2]

- (h) A hydrocarbon molecule, $C_{16}H_{34}$, is cracked to form an octane molecule and two molecules of but-2-ene.

Construct the equation for this reaction.

..... [1]

- (i) Compound **I** is 3-methylheptane. It does not contain a functional group.



- (i) What is meant by the term *functional group*?

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..... [1]

- (ii) Compound **I** reacts with chlorine in the presence of ultraviolet radiation to give several structural isomers of $C_8H_{17}Cl$.

How many **structural** isomers could be formed in this reaction?

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- (iii) The mechanism of the reaction involves radicals.

What is meant by the term *radical*?

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..... [1]

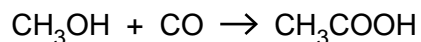
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3 Ethanoic acid, CH₃COOH, is used to make esters.

Some information about two of the processes used to make ethanoic acid is given below.

Process 1

This is a one-step process that involves the reaction of methanol with carbon monoxide.



The conditions used are 180°C and 30 atmospheres pressure. A rhodium/iodine catalyst is used.

The percentage yield for this process is 99%.

Process 2

This involves the oxidation of naphtha, a fraction obtained from crude oil.

Liquid naphtha is oxidised using air at a temperature of 180°C and 50 atmospheres pressure. No catalyst is needed.

A large variety of other products are also formed in this oxidation.

(a) Suggest **three** advantages of making ethanoic acid using **Process 1** rather than **Process 2**.

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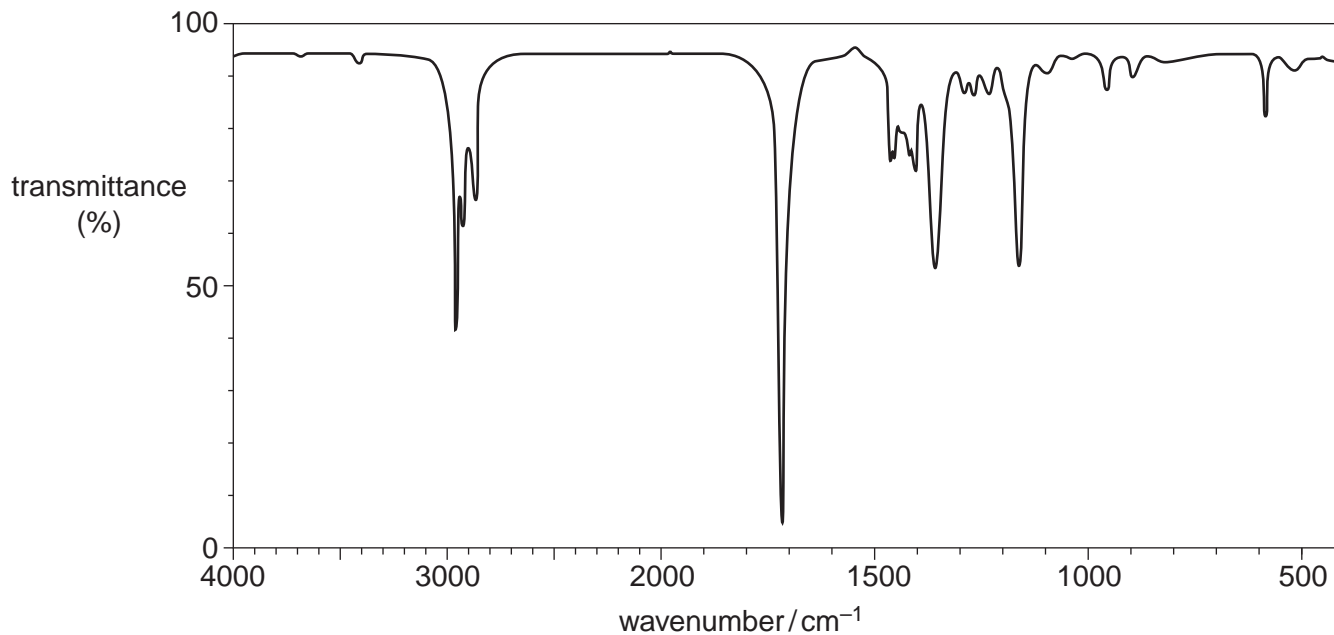
[3]

(b) The other products formed in **Process 2** are carboxylic acids, aldehydes and ketones.

A research chemist investigates some of these other products of **Process 2**.

(i) The research chemist isolates product, **J**.

The infrared spectrum of **J** is shown below.



The chemist also finds that 0.172 g of a pure sample of **J** contains 2.00×10^{-3} mol of **J**.

Suggest, with reasons, **one** possible structure for **J**.



In your answer you should link the evidence with your explanation.

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[5]

(ii) The chemist isolates another product, the carboxylic acid, **K**.

K has the molecular formula $C_4H_8O_2$.

Suggest a possible structure and name for **K**.

structure

name [2]

(c) Ethanoic acid is used in the manufacture of the ester, propyl ethanoate.

Describe how ethanoic acid is converted into propyl ethanoate.

Include an equation in your answer.

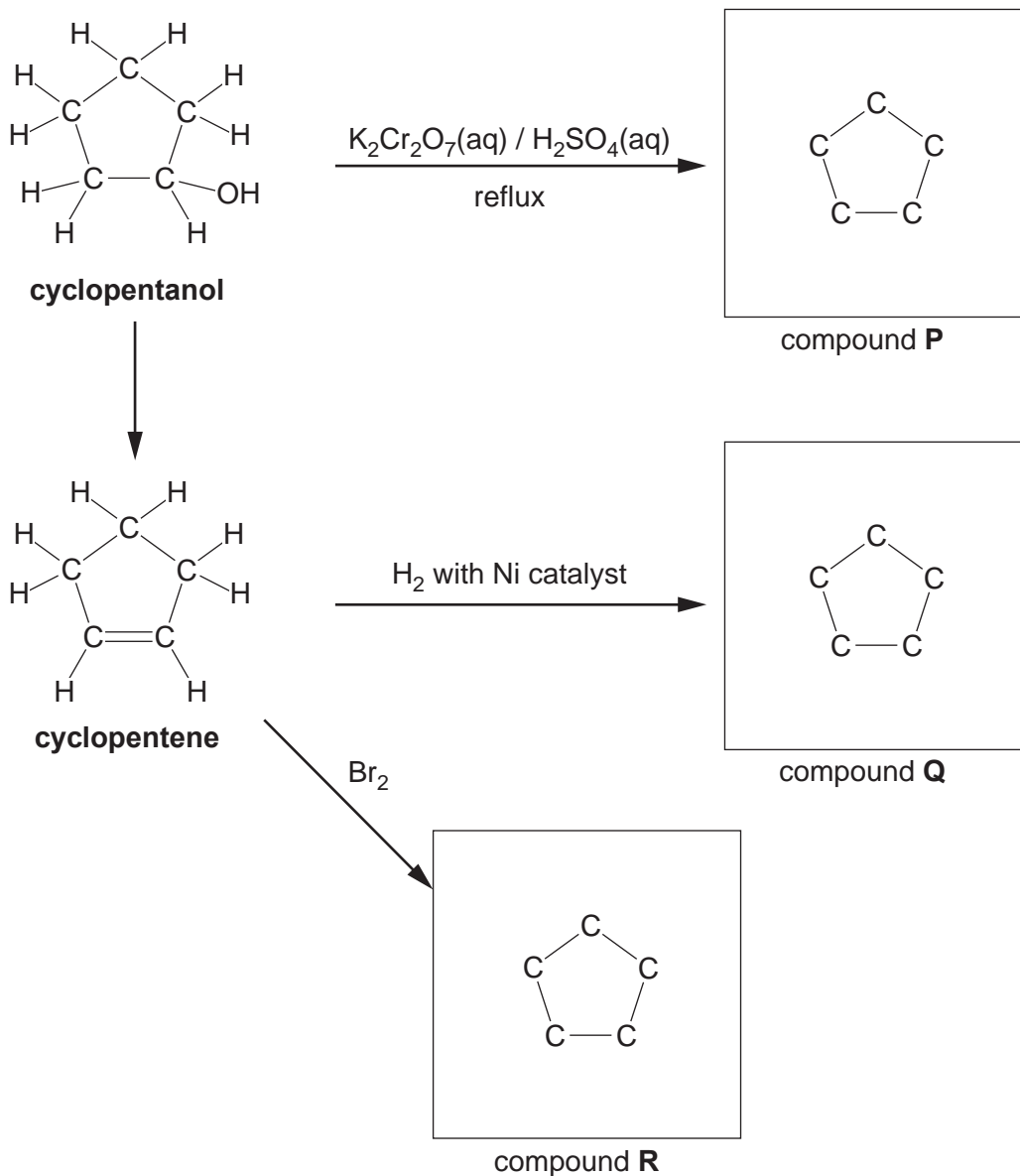
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..... [4]

[Total: 14]

4 Cyclopentene is a cyclic alkene.

(a) The flowchart shows some reactions involving cyclopentene and cyclopentanol.

Complete the partial structures in the boxes to show compounds **P**, **Q** and **R**, the main organic products of the reactions.



[3]

(b) What would be the colour change in the reaction between cyclopentene and bromine?

..... to

[1]

(c) Cyclopentene can be polymerised to give poly(cyclopentene).

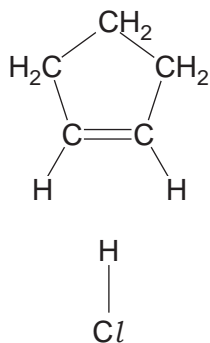
Draw a section of poly(cyclopentene) to show **two** repeat units.

[1]

(d) Cyclopentene reacts with HCl by electrophilic addition.

Use the curly arrow model to complete the mechanism for this reaction.

In your answer include any relevant dipoles, the intermediate and the product.



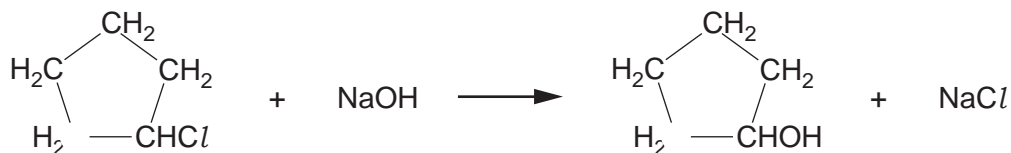
intermediate



product

[5]

(e) Chlorocyclopentane can be hydrolysed by heating with aqueous sodium hydroxide.

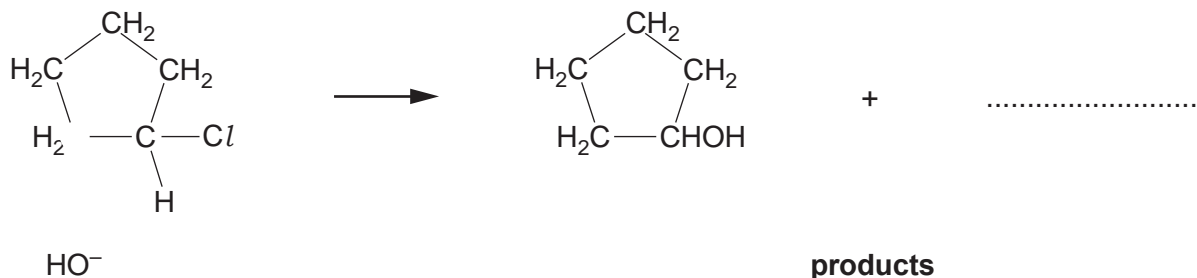


Use the curly arrow model to complete the mechanism for this hydrolysis reaction.

Include in your answer, relevant dipoles, the name of the mechanism and the type of bond fission.



In your answer you should use the correct technical terms, spelled correctly.



name of mechanism

type of bond fission **[5]**

[Total: 15]