

Modified Enlarged 24pt
OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Monday 16 June 2025 – Morning

A Level Chemistry A

**H432/02 Synthesis and
analytical techniques**

**Time allowed: 2 hours 15 minutes
plus your additional time allowance**

YOU MUST HAVE:

**the Data Sheet for Chemistry A
the Insert for Question 23(a) and 23(b)
(with this document)**

YOU CAN USE:

**a ruler (cm/mm)
a scientific or graphical calculator
an HB pencil**

Please write clearly in black ink.

Centre number

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Candidate number

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First name(s) _____

Last name _____

READ INSTRUCTIONS OVERLEAF



INSTRUCTIONS

Use black ink. You can use an HB pencil, but only for graphs and diagrams.

Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.

Answer ALL the questions.

Where appropriate, your answer should be supported with working. Marks might be given for using a correct method, even if your answer is wrong.

INFORMATION

The total mark for this paper is 100.

The marks for each question are shown in brackets [].

Quality of extended response will be assessed in questions marked with an asterisk (*).

ADVICE

Read each question carefully before you start your answer.

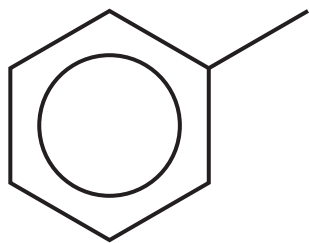
SECTION A

You should spend a MAXIMUM of 20 MINUTES plus your additional time allowance on this section.

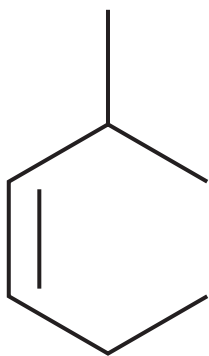
Write your answer to each question in the box provided.

- 1 Which compound shown opposite is alicyclic AND unsaturated? [1]**

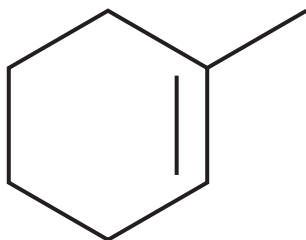
A



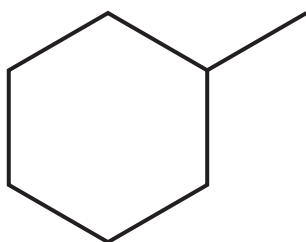
B



C



D

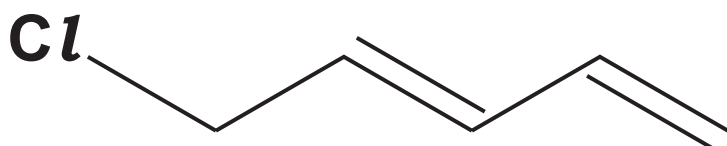


Your answer

5

- 2 0.0200 mol of the compound below reacts with $\text{Br}_2(\text{aq})$ to make a saturated compound.

How many grams of Br_2 are needed for this reaction? [1]

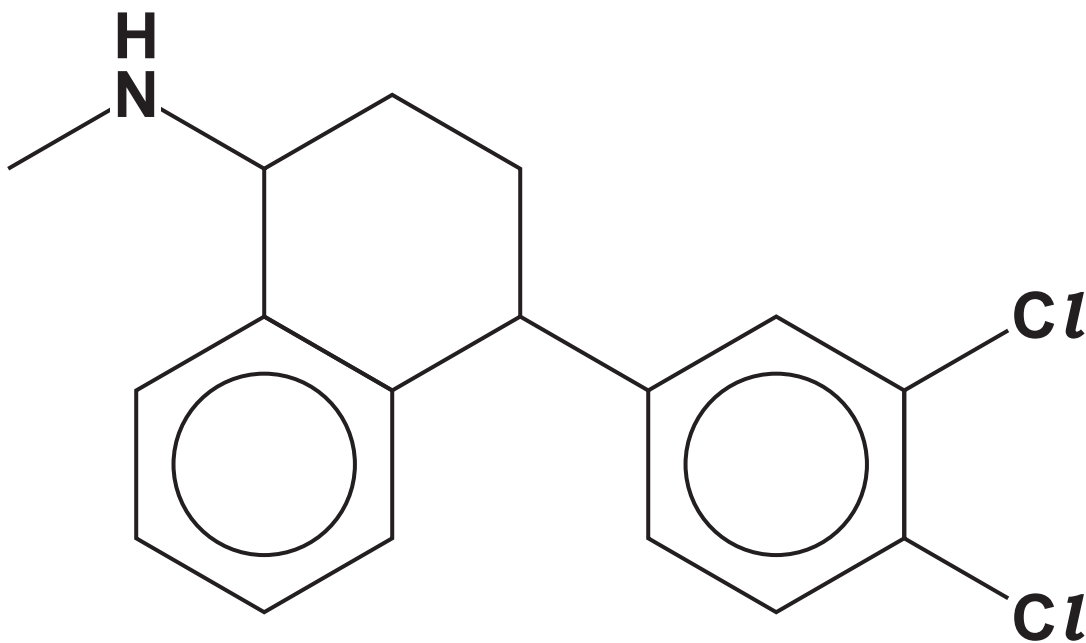


- A 3.20
B 6.39
C 7.99
D 12.80

Your answer

3 The skeletal structure of a medicinal drug is shown below.

How many hydrogen atoms are in its molecular formula? [1]



A 14

B 15

C 17

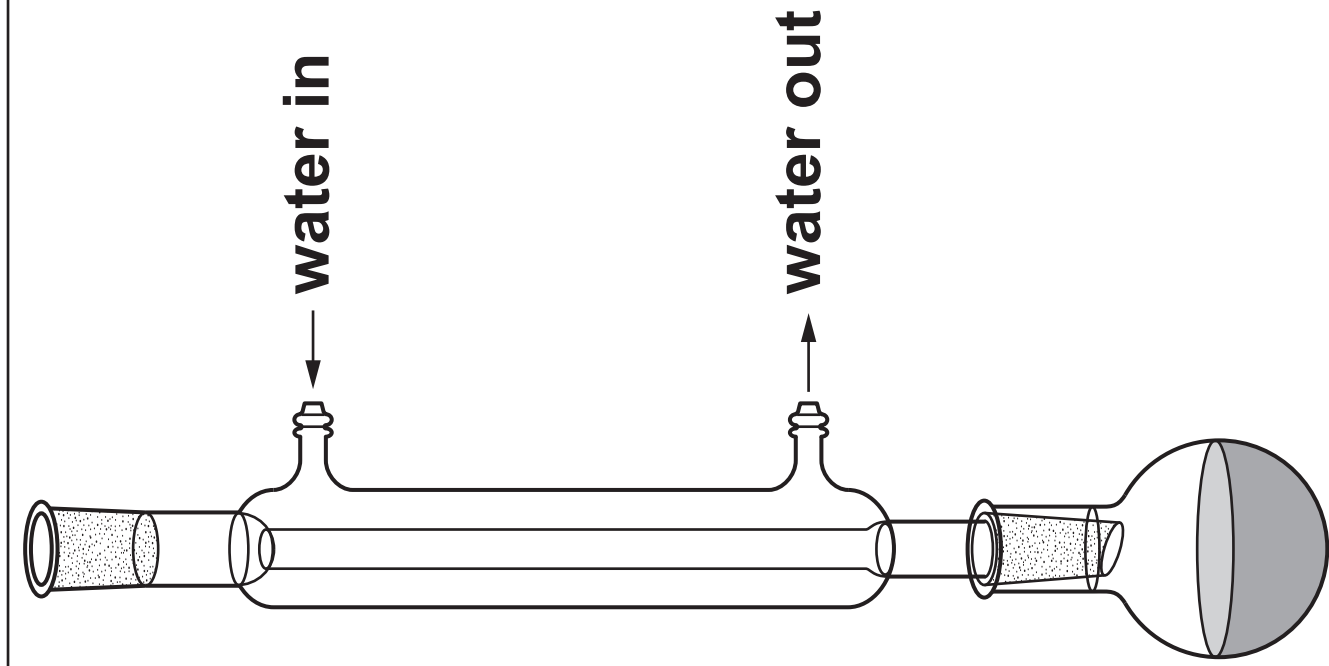
D 19

Your answer

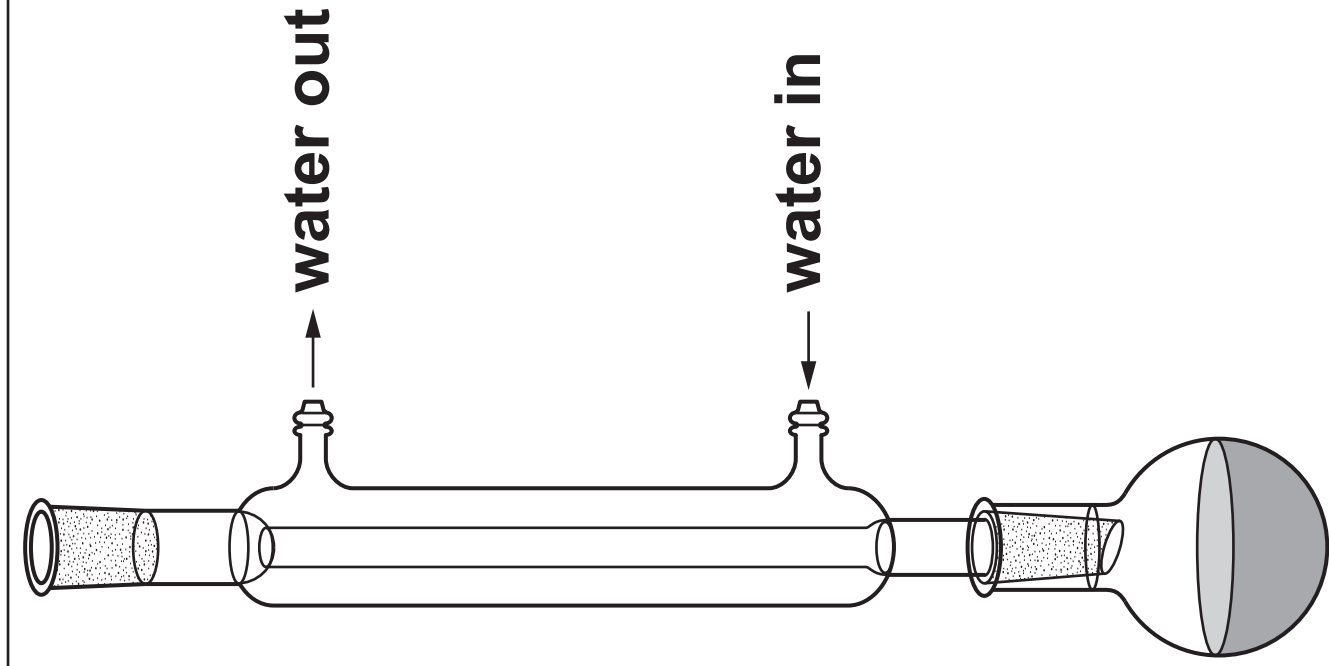
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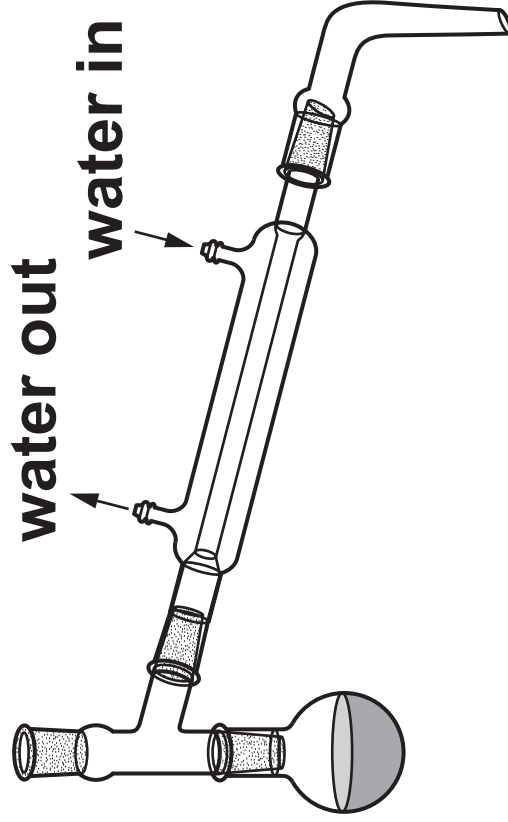
4 Which diagram shown on the following pages shows the correct way to set up apparatus for converting ethanol to ethanoic acid? [1]

B

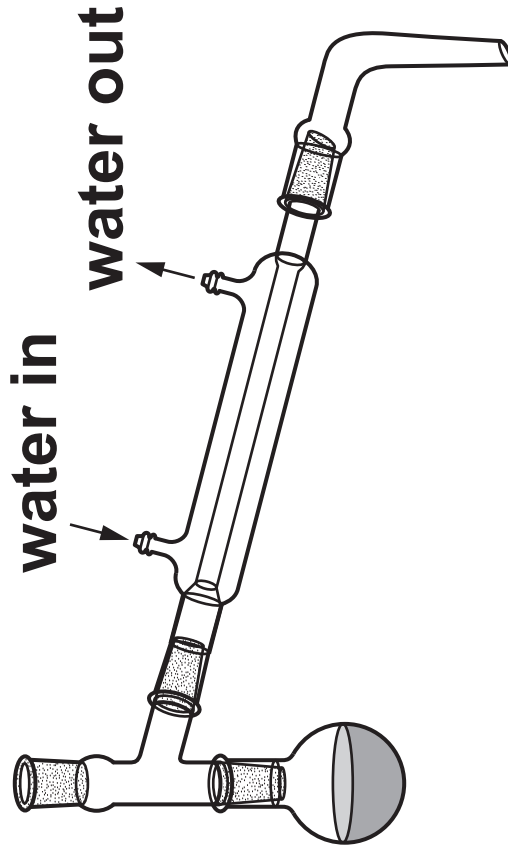


A





C



D

Your answer

5 0.200 mol of $\text{HOOCCH}_2\text{CH}_2\text{COOH}$ is reacted with 0.300 mol NaOH .

How many water molecules are formed? [1]

A 1.204×10^{23}

B 1.806×10^{23}

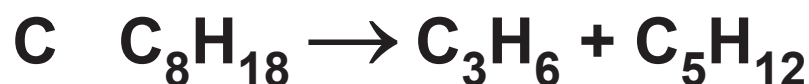
C 2.408×10^{23}

D 3.612×10^{23}

Your answer

6 Propene can be prepared using the reactions shown.

Which reaction has the LOWEST atom economy? [1]



Your answer

7 What are the **ORGANIC** products of the **ACID** hydrolysis of $\text{CH}_3\text{CH}_2\text{CONHCH}_3$? [1]



Your answer

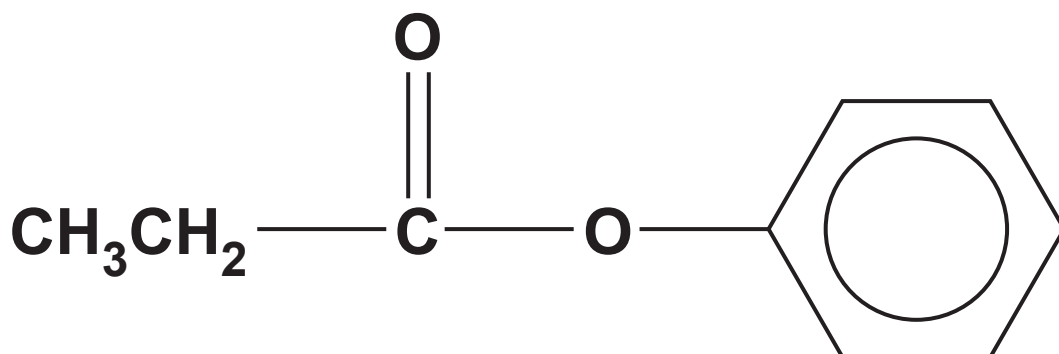
8 Ethene can be reacted with hydrogen bromide.

Which statement about this reaction is correct? [1]

- A H^- acts as a nucleophile.**
- B Br^+ acts as an electrophile.**
- C $\text{H}^{\delta+}-\text{Br}^{\delta-}$ acts as an electrophile.**
- D $\text{H}^{\delta+}-\text{Br}^{\delta-}$ acts as a nucleophile.**

Your answer

- 9 Which reagents shown opposite could a student use to prepare the ester shown? [1]



A	$\text{CH}_3\text{CH}_2-\overset{\text{O}}{\parallel}{\text{C}}-\text{OH} + \text{HO}-\text{C}_6\text{H}_5$
B	$\text{CH}_3\text{CH}_2-\text{OH} + \text{HOOC}-\text{C}_6\text{H}_5$
C	$\text{CH}_3\text{CH}_2\text{CH}_2-\text{OH} + \text{HOOC}-\text{C}_6\text{H}_5$
D	$\text{CH}_3\text{CH}_2-\overset{\text{O}}{\parallel}{\text{C}}-\text{Cl} + \text{HO}-\text{C}_6\text{H}_5$

Your answer

10 How many stereoisomers does the compound $\text{CH}_3\text{CH}(\text{Br})\text{CH}=\text{CHCH}(\text{Cl})\text{CH}_3$ have? [1]

A 2

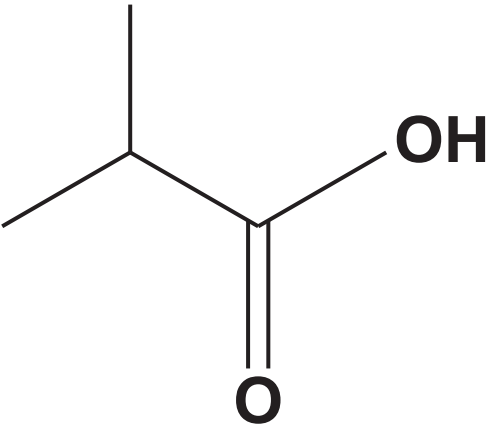
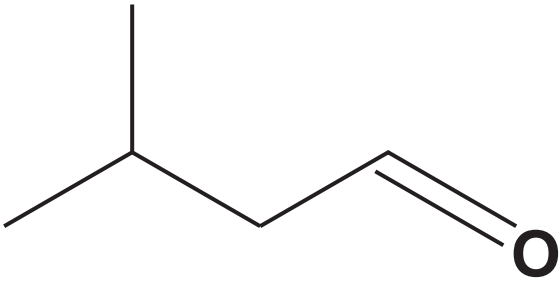
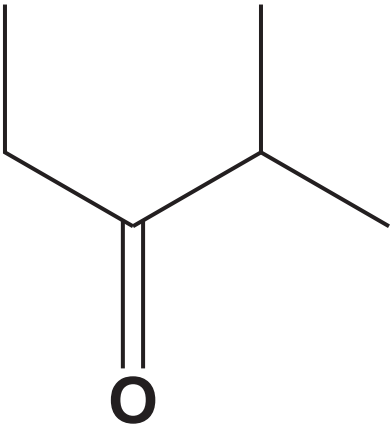
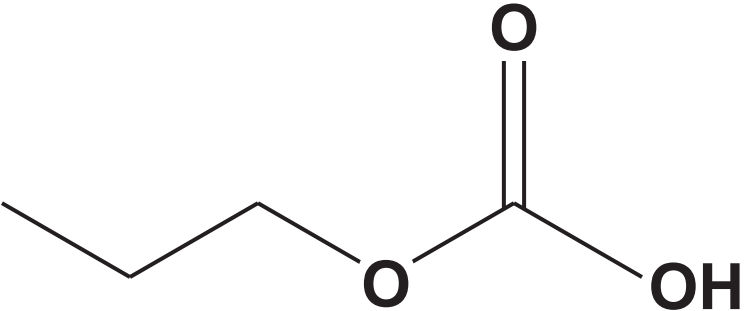
B 4

C 6

D 8

Your answer

11 Which molecule shown opposite does NOT produce a mass spectrum containing a peak at $m/z = 29$? [1]

A	
B	
C	
D	

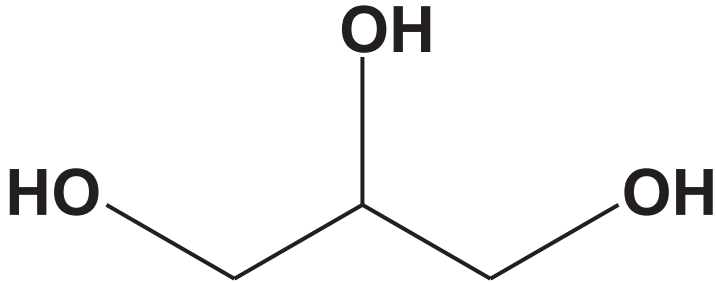
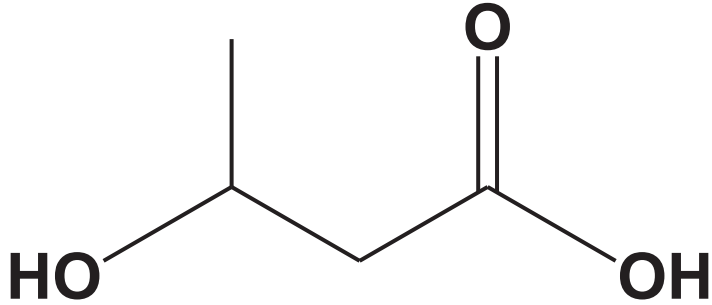
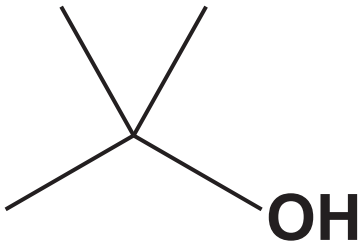
Your answer

12 Which process does NOT involve infrared radiation? [1]

- A Catalytic ozone depletion**
- B Monitoring toxic gases in the air**
- C Measuring ethanol in breathalyser tests**
- D Global warming**

Your answer

13 Which molecule(s) would form a ketone group when oxidised? [1]

1	
2	
3	

A 1, 2 and 3

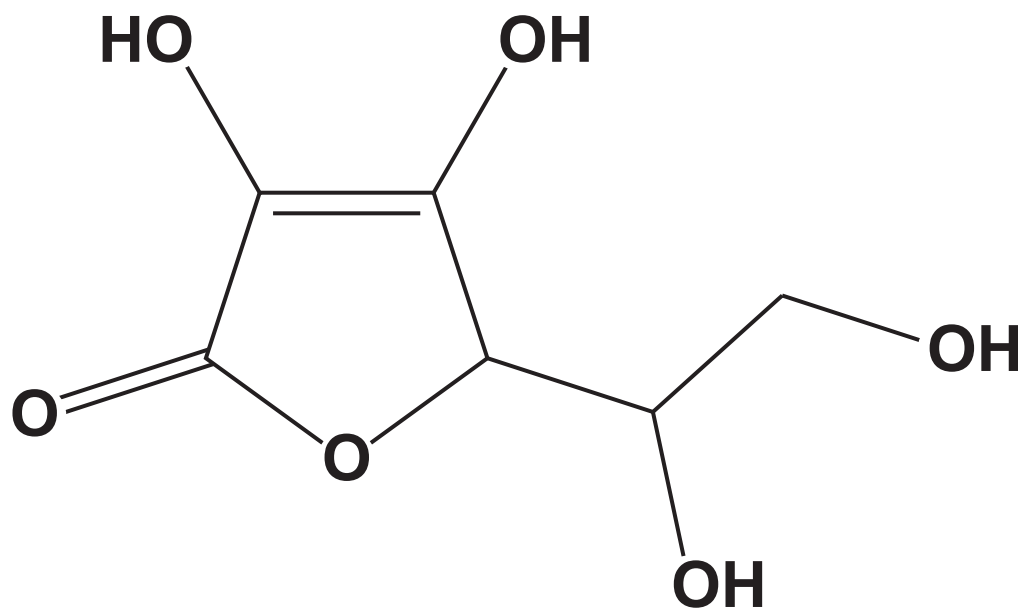
B Only 1 and 2

C Only 2 and 3

D Only 1

Your answer

14 The structure of vitamin C is shown.

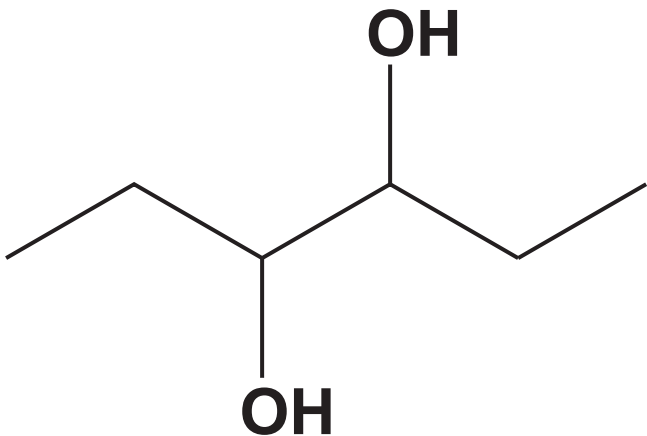
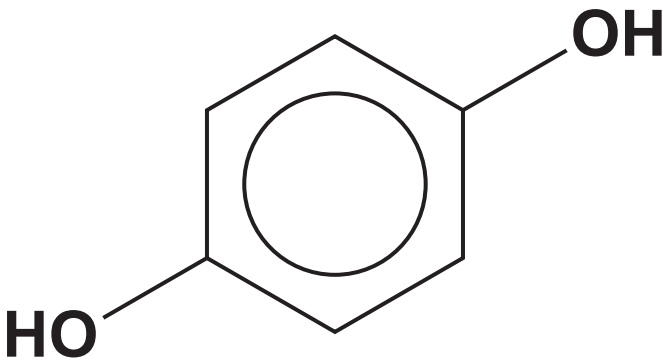
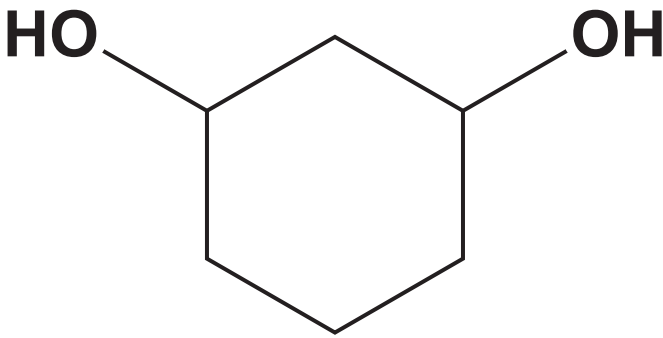


Which reagent(s) will react with vitamin C? [1]

- 1 Aqueous bromine water**
 - 2 Acidified potassium dichromate(VI)**
 - 3 Aqueous silver nitrate in ethanol**
-
- A 1, 2 and 3**
 - B Only 1 and 2**
 - C Only 2 and 3**
 - D Only 1**

Your answer

15 Which compound(s) has/have THREE peaks in their ^{13}C NMR spectrum? [1]

1	 <chem>CCC(O)C(O)CC</chem>
2	 <chem>OCC1CCCCC1O</chem>
3	 <chem>OCC1CCC(CC1)O</chem>

A 1, 2 and 3

B Only 1 and 2

C Only 2 and 3

D Only 1

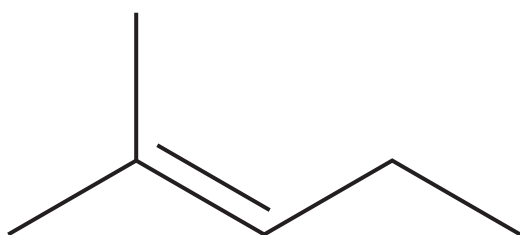
Your answer

SECTION B

16 This question is about hydrocarbons with six carbon atoms.

(a) Compound A is a hydrocarbon:

COMPOUND A

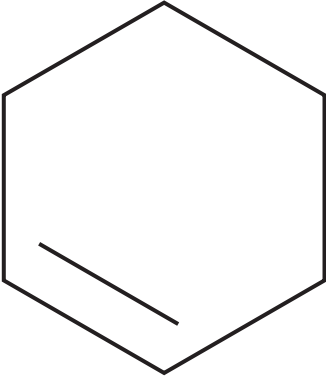


What is the systematic name of compound A?

_____ [1]

(b) The table opposite shows incomplete information about two hydrocarbons.

Complete the table opposite. [3]

Skeletal formula		
Molecular formula		
Number of σ bonds		
Number of π bonds		

(c) Compound B, $\text{CH}_3\text{CH}=\text{C}(\text{CH}_3)\text{CH}_2\text{CH}_3$, exists as *E* and *Z* stereoisomers.

(i) Draw the structures of the *E* and *Z* stereoisomers of compound B. [2]

<i>E</i>	<i>Z</i>

(ii) Explain why compound B can form *E* and *Z* stereoisomers.

[2]

(d) Hexane, C_6H_{14} , is used as a fuel.

1.0 mol of hexane is mixed with 6.0 mol of oxygen and combusted.

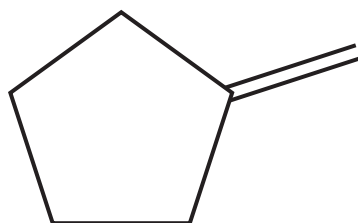
Construct an equation for the INCOMPLETE combustion of 1.0 mol of hexane with 6.0 mol of oxygen.

[1]

(e) The flowchart opposite shows some reactions of compound C.

Complete the flowchart opposite to show the missing reagent, catalyst and the structures of the organic products. [3]

COMPOUND C



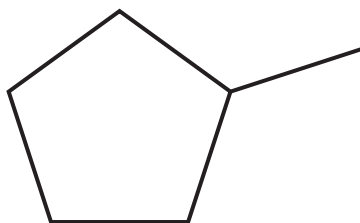
Br₂

HCl

MAJOR product

reagent: _____

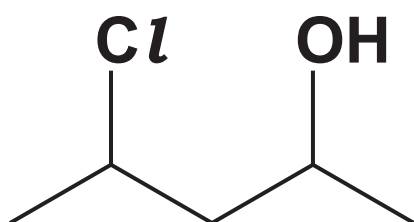
catalyst: _____



17* This question is about an organic synthesis.

A student plans a two-stage synthesis of compound F from compound D, as shown below.

COMPOUND D

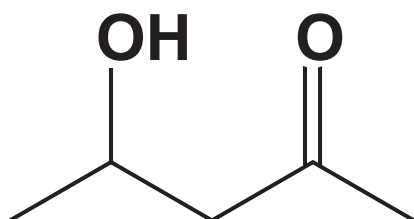


↓ **STAGE 1**

COMPOUND E

↓ **STAGE 2**

COMPOUND F



Plan a two-stage synthesis for the preparation of 2.50 g of compound F from compound D.

The overall percentage yield of compound F from compound D is 31.5%.

In your answer include the mass of compound D required, reagents and equations for each step. [6]

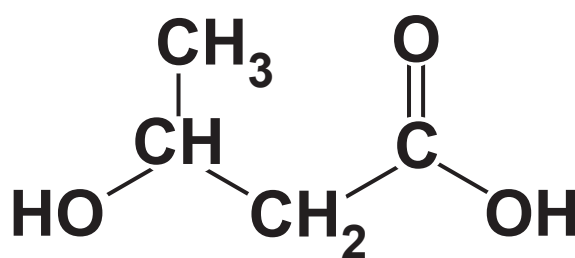
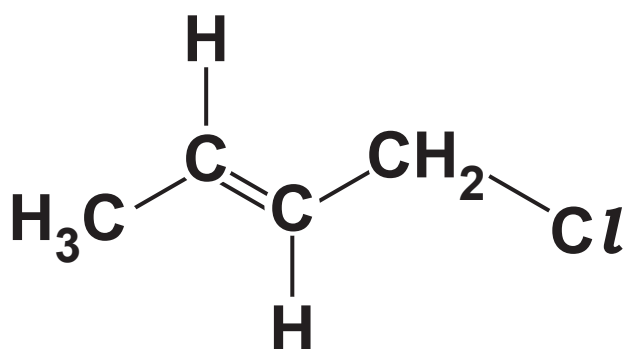
[illegible]

Extra answer space if required.

18 This question is about polymers.

The structures of 1-chlorobut-2-ene and 3-hydroxybutanoic acid are shown.

**1-CHLOROBUT-2-ENE 3-HYDROXYBUTANOIC
ACID**



- (a) 1-Chlorobut-2-ene and 3-hydroxybutanoic acid can both form polymers.**

Draw TWO repeat units of each of the polymers formed.

State the type of polymerisation reaction that takes place for each compound. [4]

TWO repeat units of polymer of 1-chlorobut-2-ene

Type of polymerisation _____

TWO repeat units of polymer of 3-hydroxybutanoic acid

Type of polymerisation _____

(b) The disposal of polymers containing chlorine is a major challenge.

(i) Suggest why a polymer made from monomers containing chlorine, such as 1-chlorobut-2-ene, is difficult to dispose of by incineration.

[1]

(ii) The polymer formed from 3-hydroxybutanoic acid can be hydrolysed. This makes the polymer biodegradable.

Suggest what feature in the structure of this polymer allows this hydrolysis.

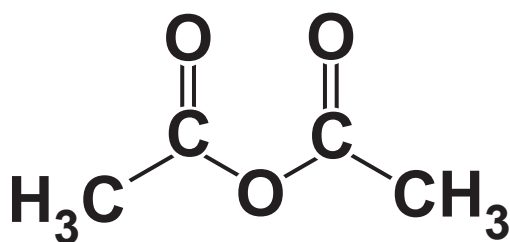
[1]

(c) 3-Hydroxybutanoic acid reacts with ethanoic anhydride, $(\text{CH}_3\text{CO})_2\text{O}$.

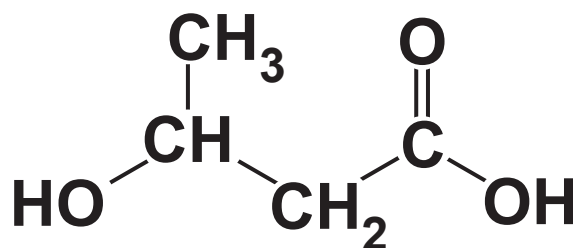
Complete the equation for this reaction.

Show the structures of the organic compounds. [2]

ETHANOIC
ANHYDRIDE



3-HYDROXYBUTANOIC
ACID



+



+

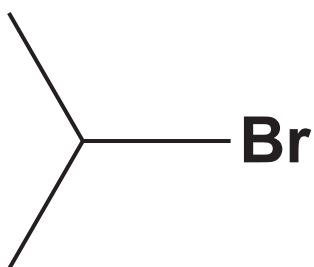


19 This question is about reactions of haloalkanes.

(a) Haloalkanes can react with potassium cyanide to form new carbon–carbon bonds.

- (i) Outline the mechanism for the reaction of 2-bromopropane with cyanide ions.

Show curly arrows, relevant dipoles and products. [3]



(ii) Name this type of mechanism.

_____ **[1]**

(b) The table below shows the boiling points of propan-1-ol and 1-bromopropane.

	Propan-1-ol	1-Bromopropane
Boiling point/°C	97	71

Propan-1-ol can be reacted to form 1-bromopropane.

(i) Suggest suitable reagents for this reaction.

_____ **[1]**

- (ii) The reaction to form 1-bromopropane from propan-1-ol is carried out in a flask.

After the reaction, the flask contains a mixture of an organic layer (density = 1.35 g cm^{-3}) and an aqueous layer (1.04 g cm^{-3}).

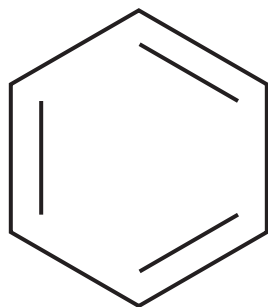
Describe how to obtain pure 1-BROMOPROPANE from the mixture.

[4]

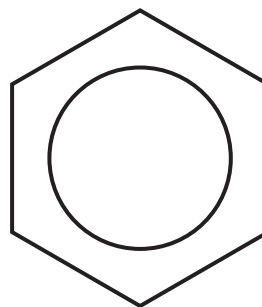
20 This question is about aromatic compounds.

(a) The diagrams show the Kekulé and delocalised models of benzene.

KEKULÉ



DELOCALISED



One piece of evidence for the delocalised model is that benzene does NOT decolourise aqueous bromine.

Suggest TWO OTHER pieces of evidence which support the delocalised model of benzene. [2]

(b) A student investigates the reactions of benzene and phenol with excess bromine.

The student's observations are given in TABLE 20.1.

TABLE 20.1

Compound	Benzene	Phenol
Observation with excess bromine	no change	decolourises and forms a white precipitate

(i) Explain the difference in the relative reactivities of benzene and phenol with bromine.

[3]

(ii) The white precipitate has a relative molecular mass of 330.7.

Construct an equation for the reaction of phenol with excess bromine shown in TABLE 20.1.

Show the structure of the organic species. [2]

- (c) Compound G is an organic compound used in the production of pesticides.**

Compound G can be synthesised from benzene in the two-stage process shown on page 51.

- (i) Suggest a reagent and halogen carrier that could be used in STAGE 1 of SYNTHESIS 1.**

[1]

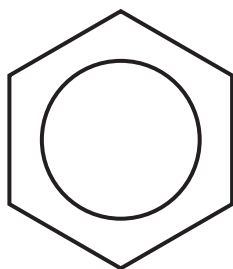
(ii) STAGE 2 of SYNTHESIS 1 is the conversion of methylbenzene to compound G.

Outline the mechanism for the reaction in STAGE 2.

Show the role of H_2SO_4 as a catalyst. [5]

SYNTHESIS 1

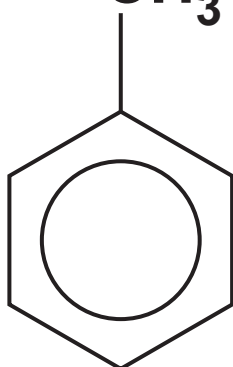
BENZENE



STAGE 1

METHYLBENZENE

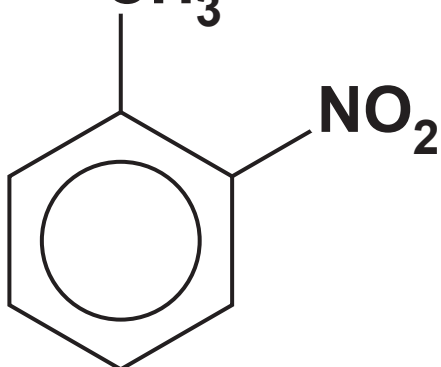
CH₃



STAGE 2

COMPOUND G

CH₃



(iii) A student suggested an alternative two-stage synthesis of compound G from benzene.

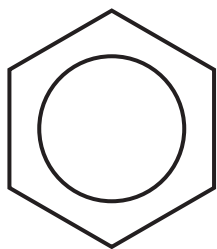
When SYNTHESIS 2 opposite is attempted, the synthesis is NOT successful and a different organic compound from compound G is produced.

Suggest why SYNTHESIS 1 is successful but SYNTHESIS 2 is NOT successful.

Suggest the structure of the different organic compound that is formed in SYNTHESIS 2. [2]

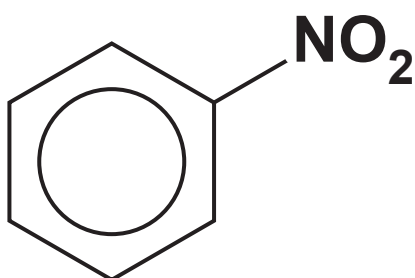
SYNTHESIS 2

BENZENE



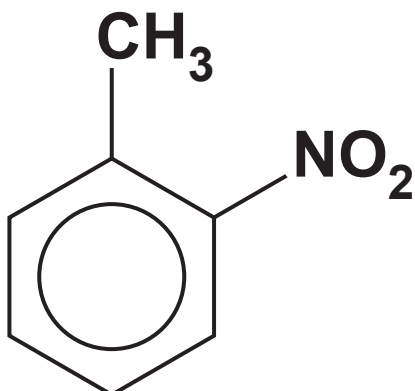
STAGE 1

NITROBENZENE



STAGE 2

COMPOUND G



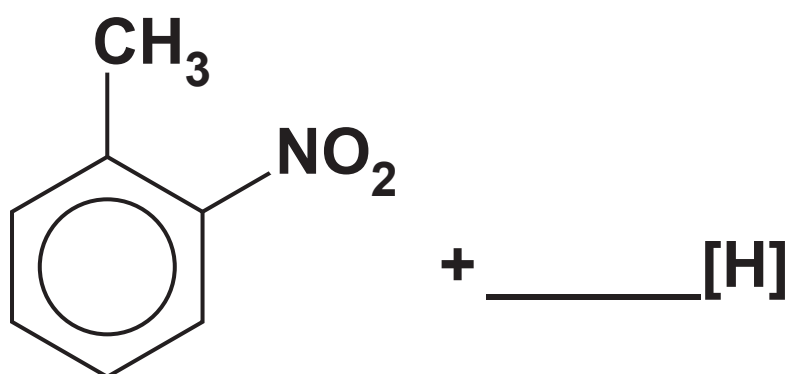
(iv) In the production of a pesticide, compound G is reduced to amine H.

Suggest suitable reagents and complete the equation for this reduction. [2]

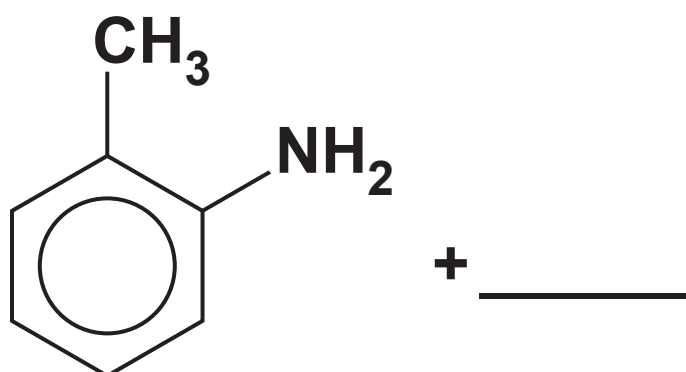
Reagents _____

Equation:

COMPOUND G



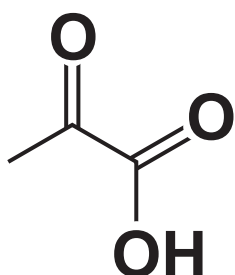
AMINE H



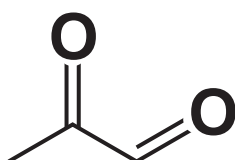
21 This question is about carbonyl compounds.

The three compounds below each contain a ketone and one other functional group.

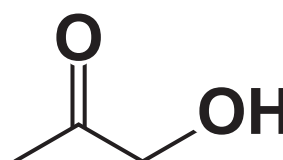
**PYRUVIC
ACID**



METHYLGLYOXAL



ACETOL



(a) What is a FUNCTIONAL GROUP?

[1]

(b) A chemical test is carried out which gives a positive result for ALL THREE compounds.

Suggest the reagent and observation of this chemical test.

Reagent _____

Observation _____

[2]

(c) A student is provided with three unlabelled sample tubes, containing either pyruvic acid, methylglyoxal or acetol.

The student carries out three chemical tests on each sample.

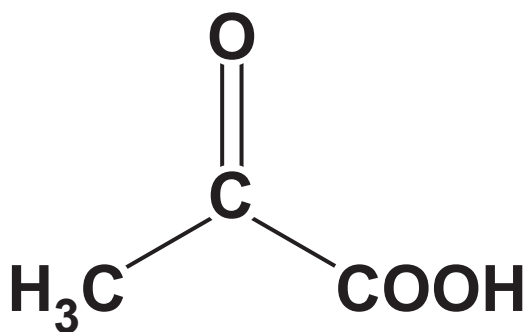
Complete the table with the expected observations, including 'no change' where appropriate. [3]

Chemical test	Expected observations		
	Pyruvic acid	Methylglyoxal	Acetol
Tollens' reagent			
$\text{Na}_2\text{CO}_3(\text{aq})$			
$\text{Cr}_2\text{O}_7^{2-}(\text{aq})/\text{H}^+(\text{aq})$			

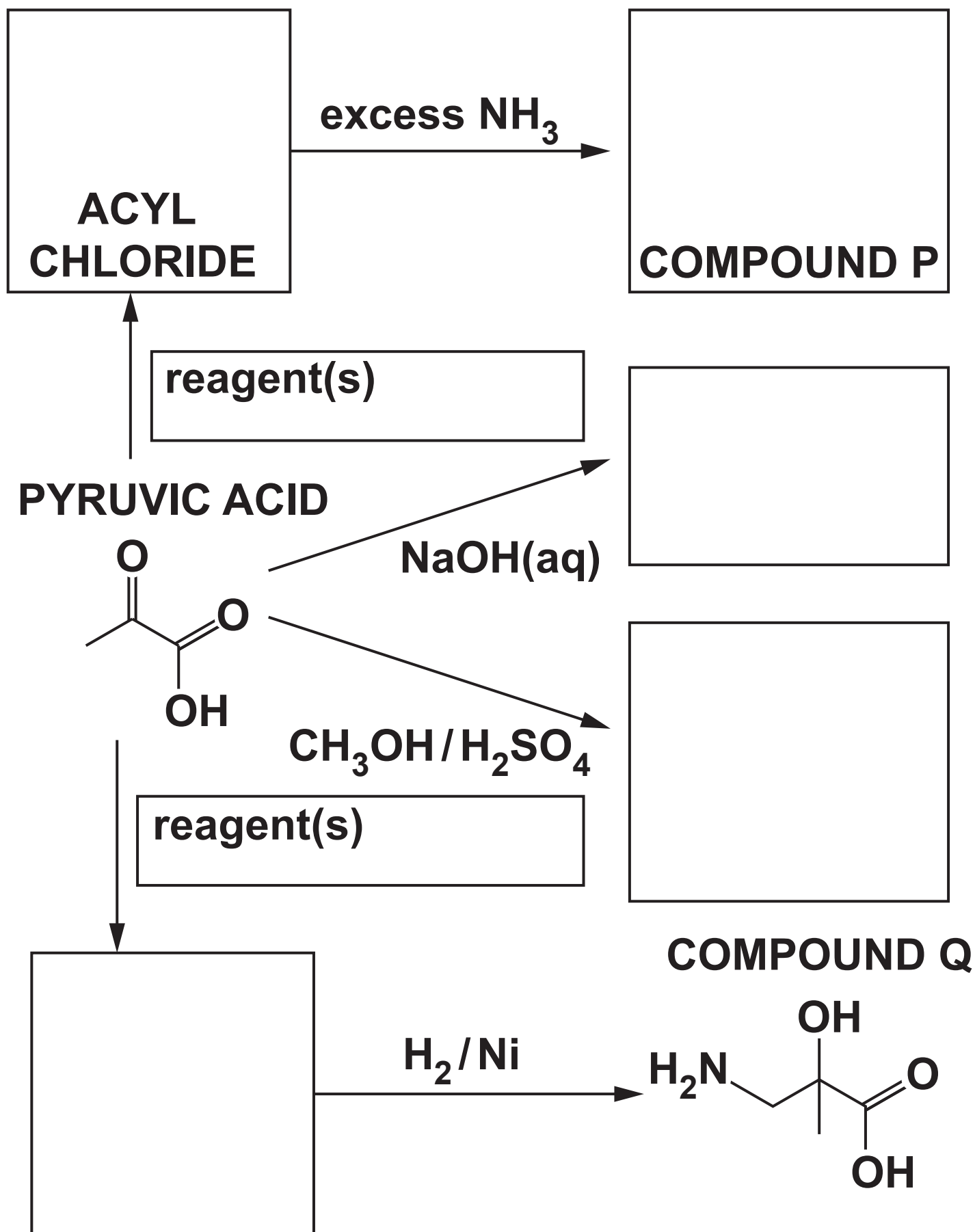
(d) Pyruvic acid reacts with NaBH_4 .

Outline the mechanism for the reaction of pyruvic acid with NaBH_4 .

Include curly arrows and relevant dipoles. [4]



(e) Complete the flowchart for the reactions of pyruvic acid. [7]



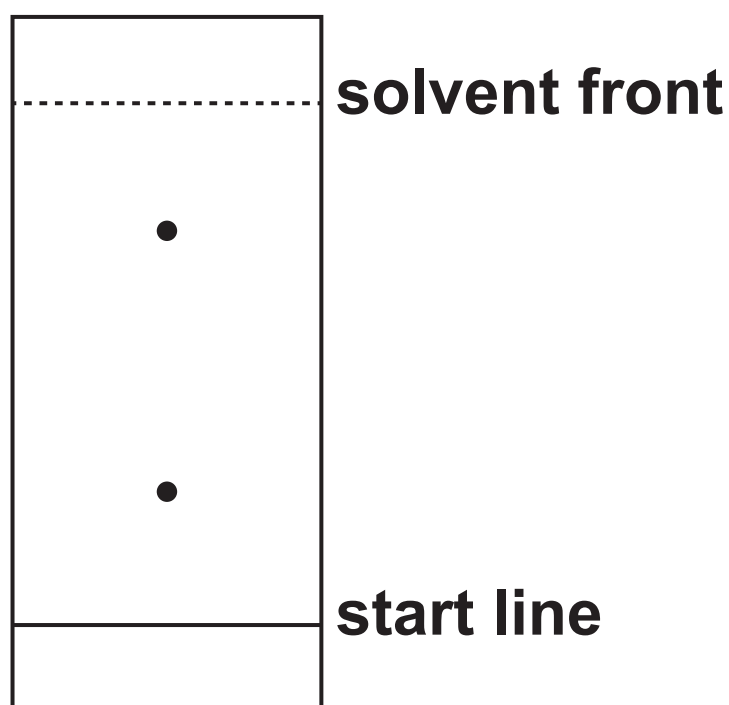
22 This question is about organic acids.

α -Amino acids have the general formula $\text{RCH}(\text{NH}_2)\text{COOH}$.

- (a) Compound S is made of two α -amino acids bonded together.

Compound S is hydrolysed into its component α -amino acids.

The resulting mixture is analysed using TLC to produce a chromatogram:



The R group and the R_f value is shown for some α -amino acids.

R group	R_f value
$-\text{H}$	0.18
$-\text{CH}_3$	0.25
$-\text{CH}_2\text{CH}(\text{CH}_3)_2$	0.64
$-\text{CH}(\text{CH}_3)_2$	0.77

- (i) Determine the R_f values of the TWO α -amino acids in the chromatogram. [1]

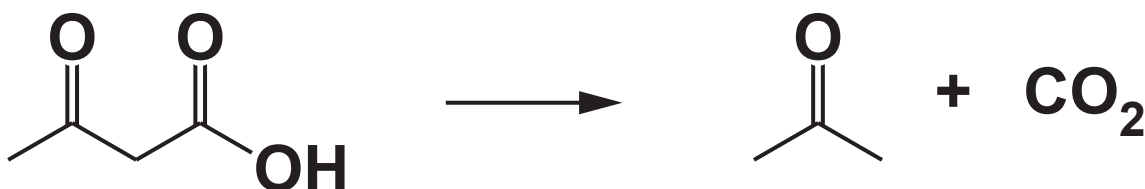
(ii) Compound S has TWO possible structures.

Draw both of these structures. [2]

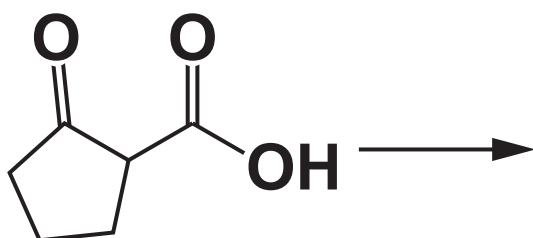
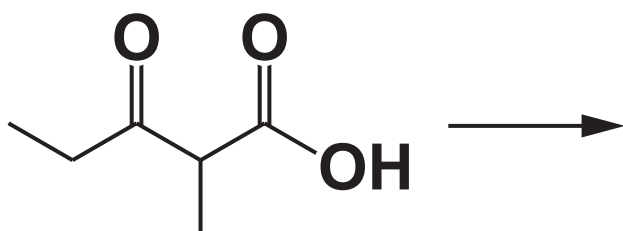
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- (b) This part is about compounds called β -keto acids.**

The equation shows the decomposition of a β -keto acid.



- (i) Draw the structures of the organic products you would expect from the decomposition of the TWO other β -keto acids below. [2]**



- (ii) α -Amino acids have the NH_2 group bonded to the carbon atom adjacent to the carboxylic acid group.

Suggest the difference between an α -keto acid and a β -keto acid.

[1]

23 This question is about spectral analysis.

- (a) Compound K, $\text{C}_4\text{H}_{10}\text{O}$, is refluxed with H_2SO_4 to form a mixture of compound L and compound M.**

The infrared spectrum of compound K is shown on page 3 of the INSERT.

Compound L and compound M are analysed using ^{13}C NMR spectroscopy.

The ^{13}C NMR spectrum of compound L has 4 peaks.

The ^{13}C NMR spectrum of compound M has 2 peaks.

Suggest the functional group in compound K, showing your reasoning, and suggest possible structures for compound K, compound L and compound M.

Functional group _____

Reasoning _____

	Possible structure
K	
L	
M	

[4]

(b)* An unknown organic compound N is analysed and produces the following results shown on pages 4 and 5 of the INSERT.

Elemental analysis by mass

C, 62.07%; H, 10.34%; O, 27.59%

The numbers by the peaks on the proton NMR spectrum are the relative peak areas.

Determine the structure of the compound N, showing ALL your reasoning. [6]

Extra answer space if required.

END OF QUESTION PAPER

EXTRA ANSWER SPACE

If you need extra space use these lined pages. You must write the question numbers clearly in the margin.

[illegible]

[illegible]

[illegible]



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