A2 CHEMISTRY

TOPIC 4.1.1 ARENES

TOPIC 4.1.2 CARBONYL COMPOUNDS

TOPIC 4.1.3 CARBOXYLIC ACIDS AND ESTERS

BOOKLET OF PAST EXAMINATION QUESTIONS

PART II

TOTAL 80 MARKS

3 **(a)** Esters are well known as compounds providing the flavour in many fruits and the scent of some flowers. The ester $CH_3(CH_2)_2COOCH_3$ contributes to the aroma of apples.

(i) Name the ester $CH_3(CH_2)_2COOCH_3$.

..... [1]

(ii) State the reagents and conditions for the hydrolysis of this ester in the laboratory.

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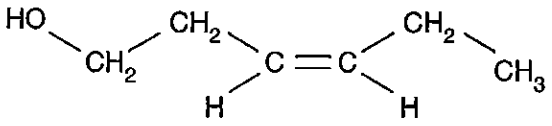
..... [3]

(b) Leaf alcohol, **B**, is a stereoisomer that can form when insects eat leaves.



B

(i) Draw the skeletal formula of **B**.

[1]

(ii) Draw the geometric isomer of **B**.

[1]

(iii) Draw a structure for the ester expected when **B** reacts with ethanoic acid in the presence of an acid catalyst. Show **all** the bonds in the ester group.

[2]

(c) A chemist analysed a sample of **B** and determined its M_r value

(i) Deduce the M_r value that the chemist would expect for leaf alcohol.

expected M_r ..... [1]

(ii) What technique could the chemist have used to determined the M_r for leaf alcohol?

..... [1]

(iii) A chemist reacted **B** to form a product **C** with an M_r 18 units less than that of **B**.

Suggest a structrure for **C** and deduce the type of reaction that took place.

structure of ***C***

type of reaction ..... [2]

[Total : 12]

6 Like esters, carbonyl compounds can contribute to the smell of plants and food. The carbonyl compounds **D** and **E** are structural isomers.

D CH_3COCH_3 **E** CH_3CH_2CHO

(a) Name compounds **D** and **E**.

(i) **D** .....

(ii) **E** .....
[2]

(b) State the reagents you would use and the observations you would make for a simple chemical test

(i) in which **D** and **E** behave in the same way;

reagent(s) .....

observation ..... [2]

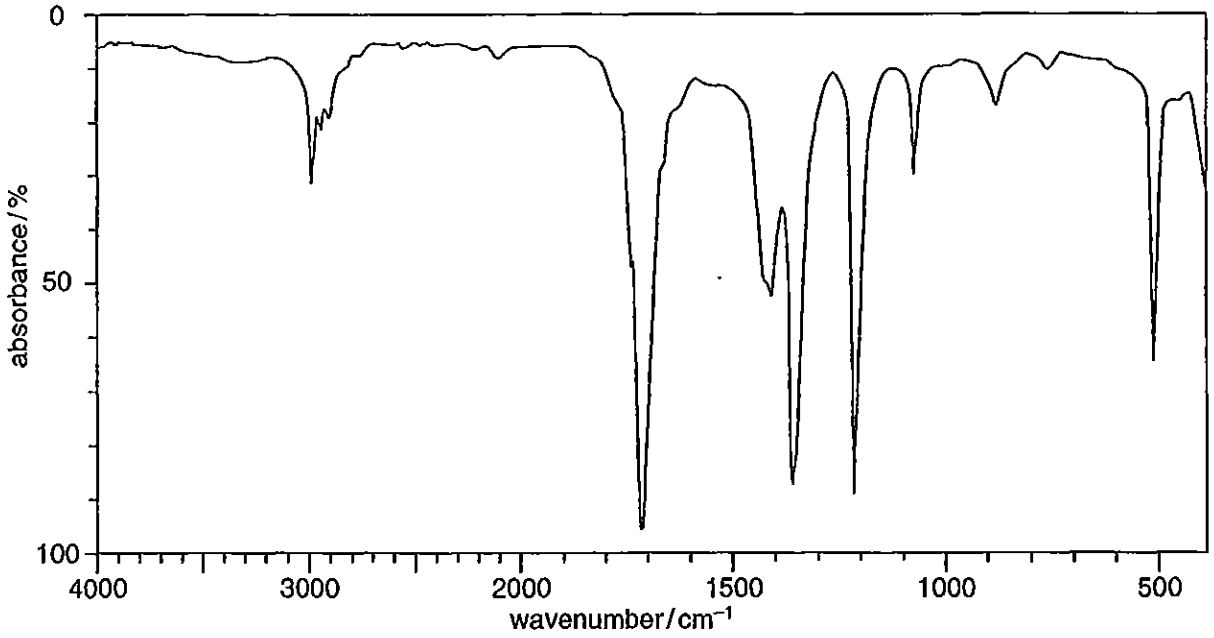
(ii) which can be used to distinguish between **D** and **E**.

reagent(s) .....

observation for **D** .....

observation for **E** ..... [3]

(c) The infrared spectrum of **D** is shown below.



(i) On the spectrum above, mark with a cross the absorption peak that identifies the functional group. Explain how you made your choice. (Use the *Data Sheet* provided to answer this question.)

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..... [2]

(ii) Reduction of compound **D** with $NaBH_4$ produces a compound with the molecular formula C_3H_8O.

How would the infrared spectrum of this product be different from that of **D**?

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..... [2]

3 A commercial synthesis of the ester **G** is shown below.

$$C_6H_5CH_2Cl \xrightarrow[\text{stage I}]{} C_6H_5CH_2OH \xrightarrow[\text{stage II}]{CH_3COOH,\ \text{conc. } H_2SO_4} C_6H_5CH_2COOCH_3$$

E **F** **G**

(a) Stage I:

(i) Suggest a suitable reagent.

..... [1]

(ii) State the type of reaction occurring.

..... [2]

(iii) Write the equation for this reaction.

..... [1]

(b) Stage II:

(i) Draw the displayed formula for the ester **G**.

[1]

(ii) Write the equation.

..... [1]

(iii) Suggest a general use for esters such as **G**.

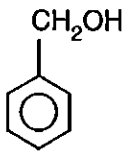
..... [1]

(iv) **G** can also be made directly from **E** by reaction with $CH_3COO^-Na^+$. Suggest a possible mechanism for this reaction.

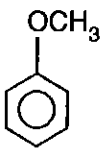
[3]

[Total : 10]

6 Compounds **K** and **L** are structural isomers.



K



L

(a) **(i)** What is the molecular formula of these isomers?

..... [1]

(ii) Calculate the mass:charge ratio, m/e, you expect for the molecular ion peak in the mass spectrum of **K**, showing your working.

Answer ..... [1]

(iii) A sample of **L** is sent for analysis to determine its percentage by mass of carbon and hydrogen. Calculate the expected results.

%C

%H

[2]

(b) Explain how infra-red spectra would allow you to distinguish between samples of **K** and **L**.

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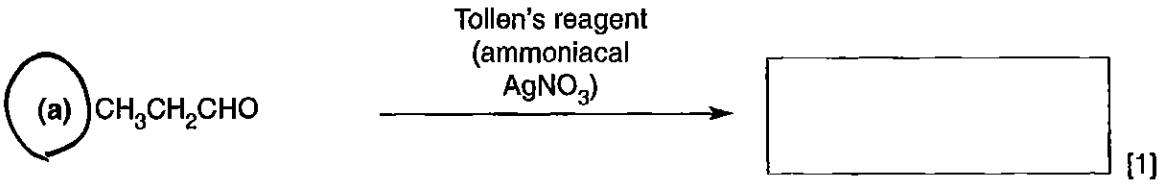
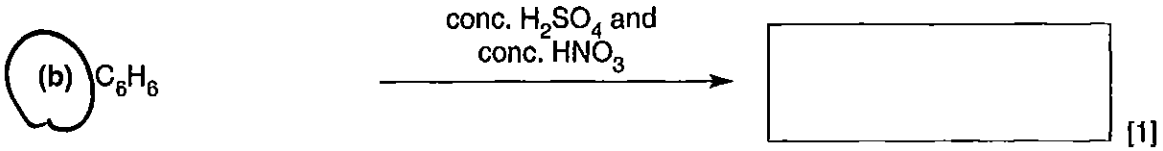
..... [3]

For Examiner's Use

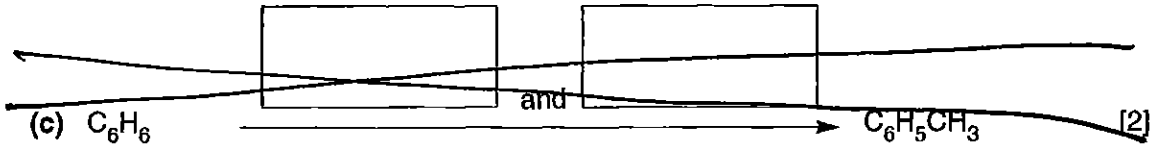
7 Complete the reaction schemes below. Draw the structural formula of an appropriate organic compound, or give a suitable reagent, in each of the boxes provided.



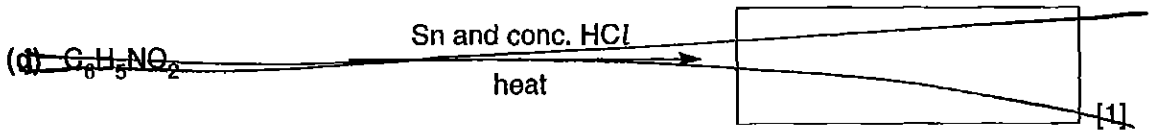
[1]



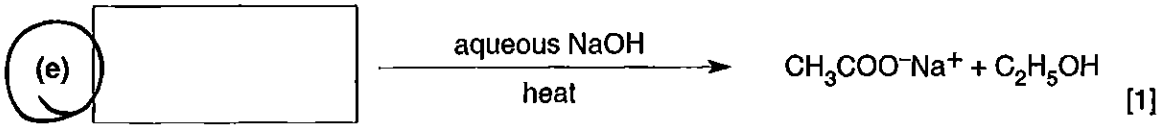
[1]



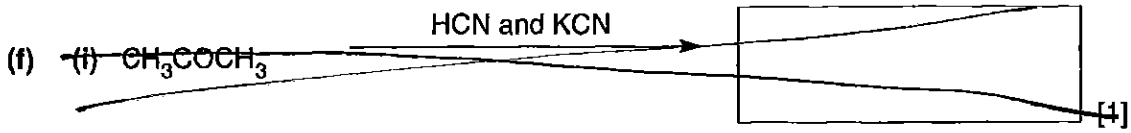
[2]



[1]



[1]



[1]

(ii) Describe the mechanism for the reaction in (f)(i) above. State the name for this type of mechanism.

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..... [5]

[Total : 10]

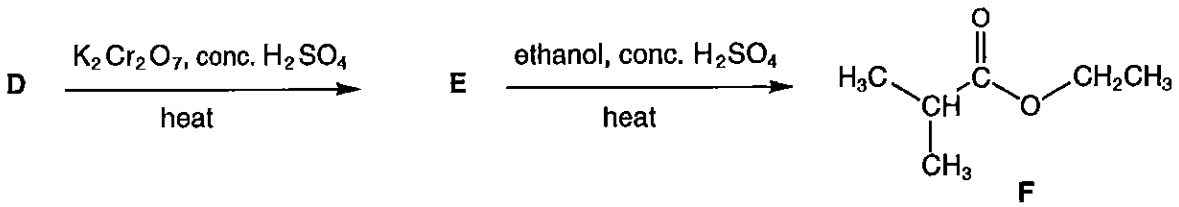
5 Compounds with the formula C_4H_9OH are alcohols.

(a) Draw formulae to show the four structural isomers of alcohols with the molecular formula $C_4H_{10}O$.

[4]

(b) One of the isomers in **(a)**, compound **D**, reacts with $K_2Cr_2O_7$ in the presence of H_2SO_4, to give **E**.

When **E** is heated with ethanol in the presence of concentrated H_2SO_4, compound **F** is formed.



F

(i) In this question, one mark is available for the quality of written communication.

State the reaction, if any, of **each** of your alcohols in **(a)** with acidified $K_2Cr_2O_7$. Use this information and the reactions above to identify **D** and **E**. Give your reasoning.

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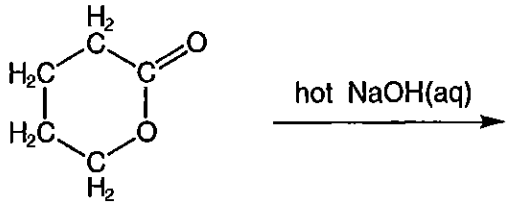
.....[5]

Quality of Written Communication [1]

(ii) Write the equation for the formation of **F** from **E**.

.....[1]

(c) Compound **F** and compound **G** (shown below) are both esters. Draw the structure of the product of the reaction of **G** with hot, aqueous NaOH.



hot NaOH(aq) →

G

[2]

[Total: 13]

For Examiner's Use

(b) 2-Hydroxypropanoic acid was dissolved in D_2O and an n.m.r. spectrum of the solution was taken. Predict, with reasons, the **splitting patterns** observed in this spectrum.

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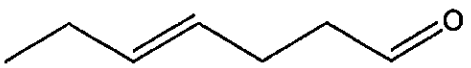
.....[2]

(c) Hept-4-enal, **H**, is also present in milk.



H

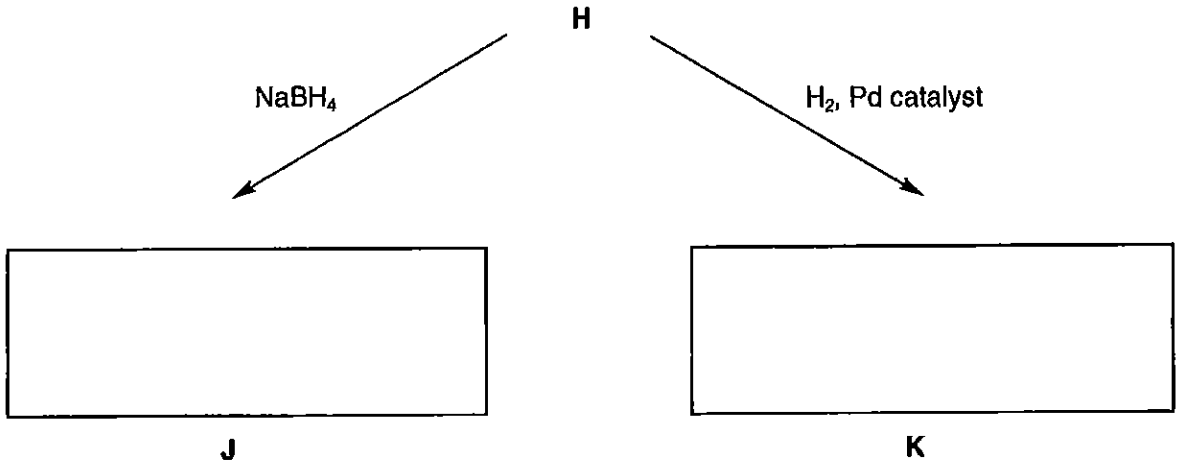
(i) Deduce the molecular formula of **H**.

.....[1]

(ii) Draw the skeletal formula of a stereoisomer of **H**.

[1]

(iii) **J** and **K** can be made from **H**.
Draw skeletal formulae for **J** and **K** in the boxes provided.



[2]

[Total: 13]

[Turn over

For Examiner's Use

8 In this question, one mark is available for the quality of written communication.

Ketones of different chain lengths are important to the flavour of dairy foods.
You are given a sample of an unknown ketone isolated from cheese.

Describe how you would

- detect the presence of a carbonyl group in your compound,
- confirm that it is a ketone and not an aldehyde,
- use a chemical method to identify which ketone you have.

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.....[8]

Quality of Written Communication [1]

[Total: 9]

For Examiner's Use

Answer **all** the questions.

1 **(a)** **(i)** Name the compound CH_3CHO.

.....[1]

(ii) Name the functional group of CH_3CHO.

.....[1]

(iii) Draw structural formulae for the **organic** products of the reactions below.

$CH_3CHO \xrightarrow{NaBH_4}$ [ ]

$CH_3CHO \xrightarrow[\text{(Tollens' reagent)}]{\text{ammoniacal } AgNO_3}$ [ ]

[2]

(b) **(i)** Describe what is meant by *nucleophilic addition*. Use the mechanism of the reaction of CH_3CHO with HCN in the presence of KCN in your answer.

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[5]

For Examiner's Use

5 Benzene and phenylethene are aromatic hydrocarbons. Phenylethene also has an alkene group in its side chain, and shows reactions typical of both arenes and alkenes.

(a) In this question, one mark is available for the quality of written communication.

Describe the bonding in **benzene**. Include in your answer the model used for the arrangement of electrons.

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.....[5]

Quality of Written Communication [1]

(b) Phenylethene, $C_6H_5CH=CH_2$, reacts readily with bromine in an inert solvent. Benzene reacts with bromine only in the presence of a catalyst.

(i) Draw the structural formula of the organic product obtained when phenylethene reacts with bromine in an inert solvent.

[1]

(ii) Explain why benzene reacts less readily than phenylethene with bromine.

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.....[4]

(c) State **one** major use for phenylethene.

.....[1]

[Total: 12]

6 Compound **B** is a secondary iodoalkane, C_4H_9I.

(a) Deduce the mass:charge ratio (m/e) of the molecular ion in the mass spectrum of **B**.

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.....[1]

(b) When **B**, C_4H_9I, is reacted with hot ethanolic sodium hydroxide, HI is eliminated and three isomeric alkenes **C, D** and **E** are formed. **C, D** and **E** form the same compound, **F**, when reacted with hydrogen in the presence of a palladium catalyst.

(i) Suggest structural formulae for **B, C, D, E** and **F**. Give your reasoning.

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.....[8]

(ii) Classify the type of reaction in which **C, D** or **E** is converted into **F** using hydrogen and a palladium catalyst.

.....[1]

[Total: 10]