

Structured Questions: Paper 2

20.2 Synthetic Routes

20.2.1 Synthesis

Easy (4 questions)	/42
Medium (5 questions)	/50
Hard (4 questions)	/40
Total Marks	/132

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Easy Questions

1 (a) Propan-1-ol can be synthesised from alkene P in the following synthetic route:



i) State the identity of halogenoalkane Q. [1]

ii) Give the reagents and conditions needed for Step 2. [2]

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.....

(3 marks)

(b) Give the name and structure of alkene P.

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.....

(2 marks)

(c) Give a reagent that could be used to convert P to Q and outline why this synthesis of propan-1-ol might not be very efficient.

.....

.....

(3 marks)

(d) This question is about alkene P and Step 1.

i) Give the empirical formula of P.

[1]

ii) Give the reagents and conditions needed for Step 1.

[2]

iii) State the type of reaction mechanism.

[1]

.....

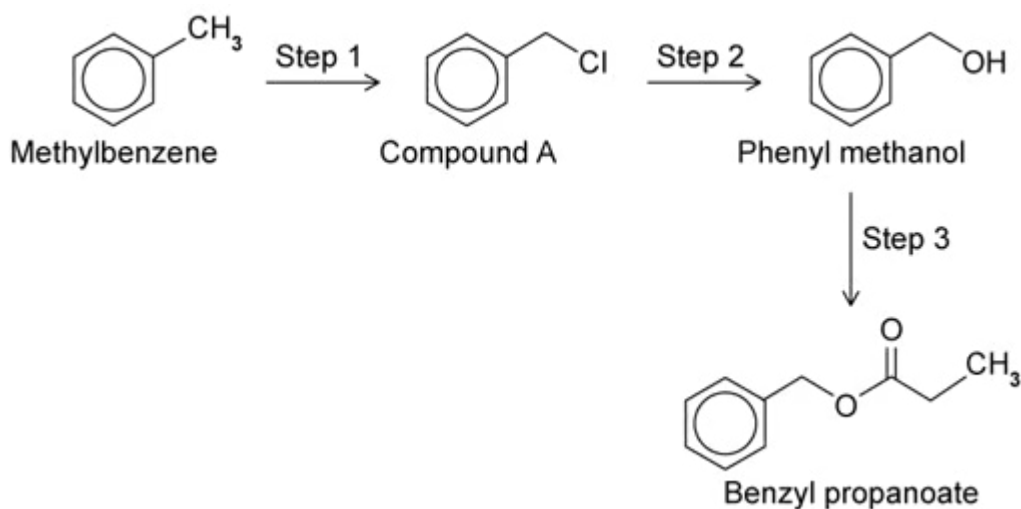
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(4 marks)

2 (a) A three step synthesis of benzyl propanoate is shown below:



i) Give the reagents and conditions needed for Step 1.

[2]

ii) Name the type of reaction mechanism taking place in Step 1.

[1]

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(3 marks)

(b) This question is about Step 2.

i) Give the reagents and conditions needed for Step 2.

[2]

ii) Name the type of mechanism taking place.

[1]

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(3 marks)

(c) This question is about Step 3.

i) Give the reagents and conditions needed.

[2]

ii) Name the type of reaction taking place.

[1]

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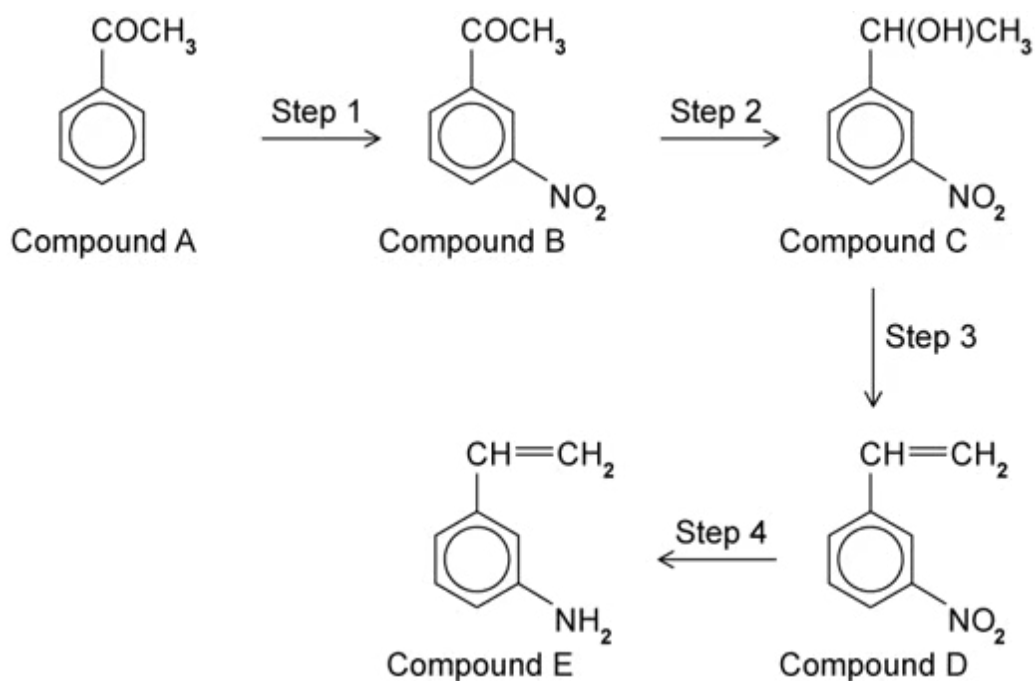
(3 marks)

(d) State the molecular formula of benzyl propanoate.

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(1 mark)

3 (a) The synthesis of 3-aminostyrene is shown below:



i) Give the reagent needed in Step 1.

[1]

ii) State the name of the functional groups in Compound B.

[2]

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(3 marks)

(b) This question is about Step 2.

i) Give the reagent needed.

[1]

ii) Name the type of reaction taking place.

[1]

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(2 marks)

- (c) Step 3 is a dehydration reaction. Outline a chemical test that could distinguish between Compound C and the product of Step 3, Compound D.

(2 marks)

- (d) This question is about Step 4.

i) State the name of the reagent(s) and conditions needed in Step 4.

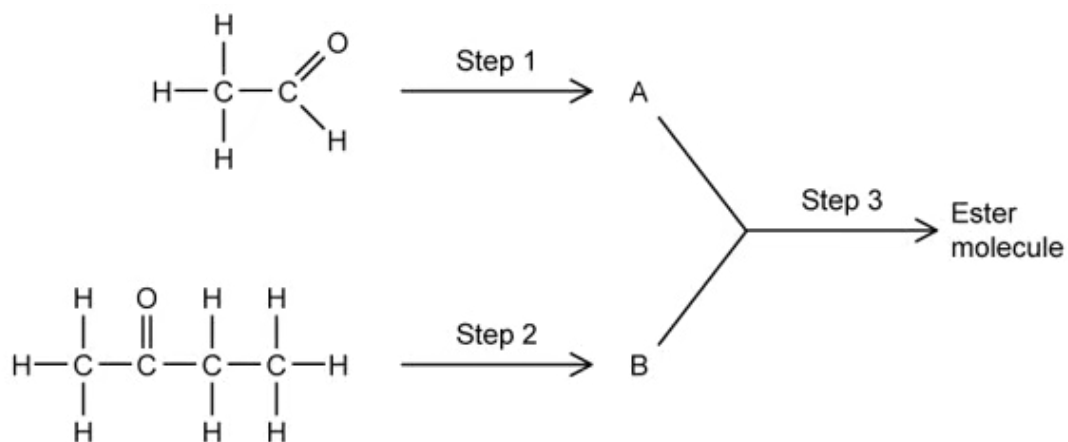
[2]

ii) Identify the type of reaction taking place.

[1]

(3 marks)

4 (a) This question is about the synthesis of an ester.



Identify the class of compound produced in Steps 1 and 2.

.....

.....

(2 marks)

(b) This question is about Step 1.

i) Give the reagent(s) and conditions needed to carry out Step 1. [2]

ii) Identify the type of reaction taking place. [1]

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(3 marks)

(c) This question is about Step 2.

i) Give the reagent(s) needed to carry out Step 2.

[1]

ii) Identify the type of reaction taking place.

[1]

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(2 marks)

(d) Give the names of A and B and write the equation for the reaction in Step 3.

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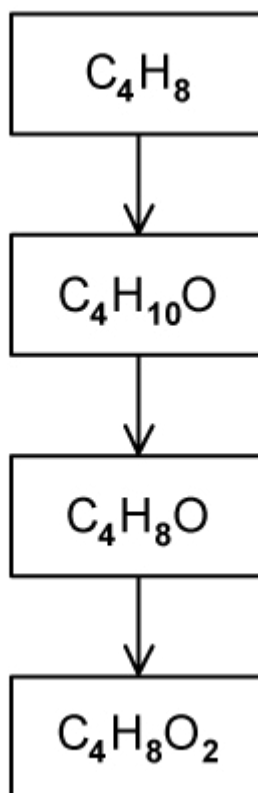
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(3 marks)

Medium Questions

1 (a) An organic reaction sequence is shown below.



State the IUPAC names of the four substances in the sequence.

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(4 marks)

(b) Classify the reactions in (a) and give the names of the reagents in each step.

(6 marks)

(c) Give the reaction conditions for step 3 in (a)

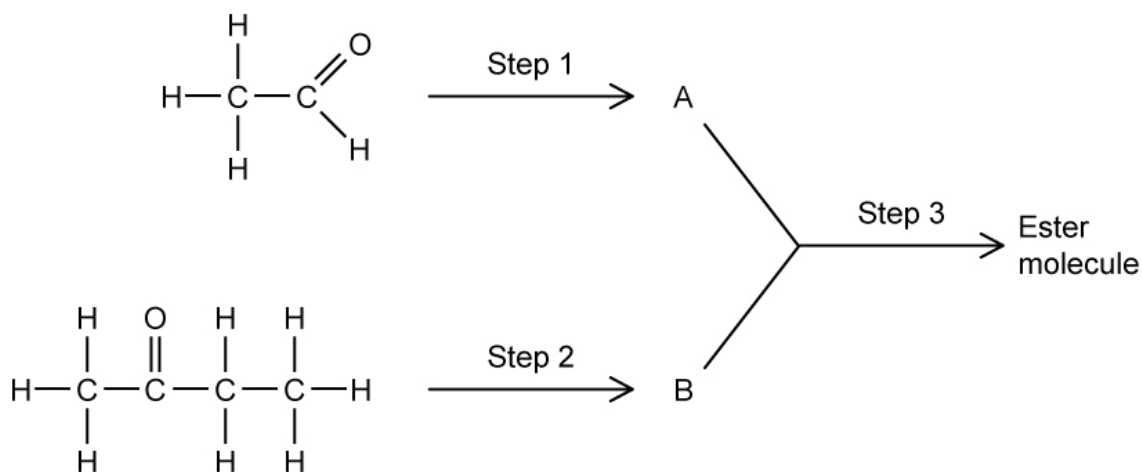
(1 mark)

(d) Draw a displayed formula of an isomer of $C_4H_{10}O$ that gives two signals in an 1H NMR spectrum.

(1 mark)

2 (a) The following reaction pathway is used to produce Compounds **A** and **B**, which when reacted together, form a branched ester molecule, Compound **C**.

Suggest suitable reagents and conditions for the synthesis of Compound **A** via Step 1 and give the name for this type of reaction.



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(3 marks)

(b) In order for the ester to be produced, the ketone in part (a) must be converted to another compound, **B**.

- Name and draw the structure of the molecule that is produced from Step 2.
- Give the name of the type of reaction that is involved in Step 2 and suggest suitable reagents and conditions for the process.

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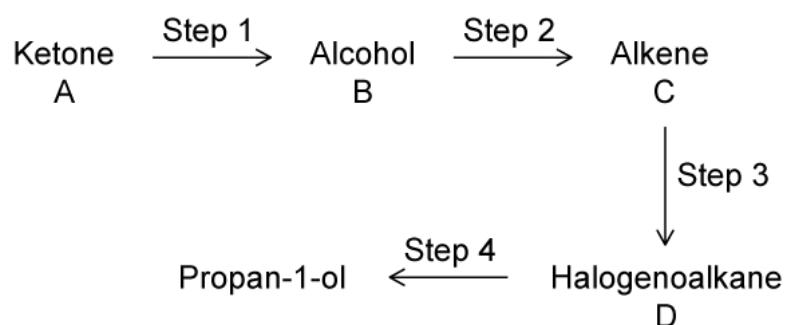
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(4 marks)

- (c) Outline how ethanol can be synthesised from ethane in two steps. State the reaction conditions and reagents and name the type of reaction taking place.

(6 marks)

- (d) The four step synthesis to form propan-1-ol from a ketone is outlined below.

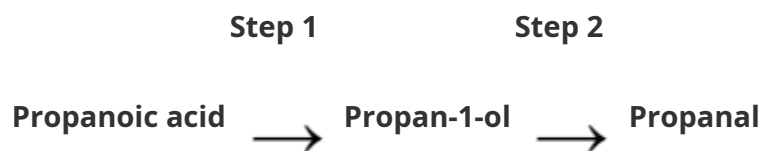


- i) Give the names of four possible substances **A** to **D**
- ii) Give the reagents and conditions for Step 4.

(3 marks)

- 3 (a)** Propanal is a versatile organic building block used in the synthesis of plastics and rubber chemicals.

Propanal can be produced from propanoic acid in the following two-step reaction.



State the reaction type, including suitable reagents, for Steps 1 and 2.

.....

.....

(2 marks)

- (b)** Suggest why it is not possible to convert propanoic acid directly to propanal using the reagent you identified for Step 1 in (a).

.....

(1 mark)

- (c)** Explain why Step 2, in (a), is completed by distillation.

.....

(1 mark)

- (d)** Identify, explain your reasoning, which of the three organic compounds, from the reaction scheme in (a), would be distilled first.

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(2 marks)

4 (a) State **four** factors that should be considered when designing a reaction scheme for the synthesis of a target molecule in industry.

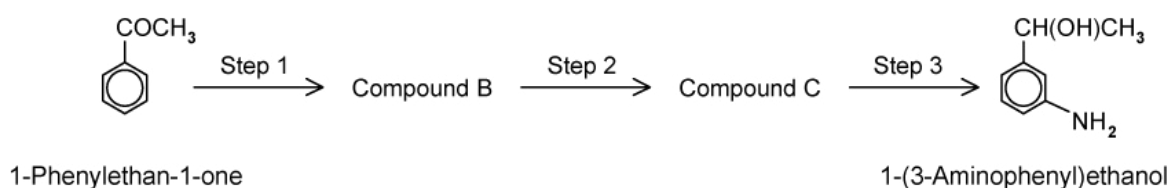
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(3 marks)

(b) 1-(3-Aminophenyl)ethanol can be synthesised according to the following three-step reaction scheme.



Step 1 involves a reaction at position 3 of the benzene ring of 1-phenylethan-1-one.

State the reaction type, including suitable reagents, for Step 1.

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(2 marks)

(c) State a suitable reagent for Step 2, in (b).

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(1 mark)

(d) In Step 3 of the reaction scheme from (b), compound **C** is heated with hydrochloric acid in the presence of a tin catalyst to form the final product, 1-(3-aminophenyl)ethanol.

Explain why Step 3 is a reduction reaction.

(2 marks)

- 5 (a) Suggest a reaction scheme, using displayed formulae, that could be used to prepare a sample of propyl propanoate.

Conditions and reagents are not required.

.....

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(2 marks)

- (b) One of the intermediates in the reaction scheme, from (a), has a molecular mass of 74.09 g mol^{-1} .

- i) State suitable reagents and conditions required to form this intermediate.
- ii) Describe how you could test that this intermediate has been formed.

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(2 marks)

- (c) Propanal and the intermediate ($M_r = 74.09$) in the reaction scheme, from (a), are to be separated by distillation.

Explain which chemical will distil first.

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(2 marks)

- (d) One of the intermediates in the reaction scheme, from (a), has a molecular mass of 60.09 g mol^{-1} .

- i) State suitable reagents and conditions required to form this intermediate.
- ii) Using Section 26 of the Data Booklet, describe how you could prove that this intermediate has been formed **without** reversing the reaction.

(2 marks)

Hard Questions

1 (a) A student is asked to prepare a sample of propyl propanoate using propanal.

Suggest a reaction scheme, using displayed formulae, that the student could use to prepare their sample of propyl propanoate.

Conditions and reagents are not required.

(2 marks)

(b) Use your answer from part (a) to help answer this question.

One of the intermediates in the reaction scheme, from part (a), has a molecular mass of 74.0 g mol^{-1} .

Give the reagents and conditions required to form this intermediate.

(1 mark)

(c) Propanal and the other intermediate ($M_r = 60.0$) in the reaction scheme, from part (a), are to be separated by distillation.

Explain which chemical will distil first.

(2 marks)

(d) Use your answer from part (a) to help answer this question.

Consider the intermediate in the reaction scheme, from part(a), which has a molecular mass of 60.0 g mol^{-1} .

i) Give the reagents and conditions required to form this intermediate. [3]

ii) Describe how you could prove that this intermediate has been formed **without** reversing the reaction using section 26 of the data booklet. [1]

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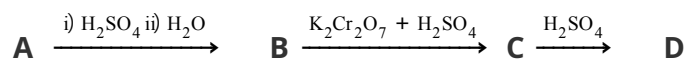
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(4 marks)

2 (a) The following three step synthesis route was carried out:



Reactant **A** is a hydrocarbon containing 85.71% carbon and shows 4 peaks in a ^1H NMR spectrum. Deduce the identity of A.

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(2 marks)

(b) Intermediate **B** shows a fragment at m/z 43 in the mass spectrum and has a molecular ion at m/z 74.

Deduce the identity of **B**, giving a reason.

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(2 marks)

(c) The question is about intermediate **C** in the synthesis.

i) Suggest an identity for intermediate **C**.

[1]

ii) State the reaction conditions for the conversion of **B** to **C**.

[1]

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(2 marks)

(d) Deduce the identity of the reaction product, **D**, and give one piece of spectral data that would support your answer.

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(2 marks)

3 (a) Benzene and cyclohexene are two hydrocarbons that are able to react with bromine. State the type of reactions in each case.

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(2 marks)

(b) Benzene can be converted into nitrobenzene in a one step reaction. State the names of the reagents needed for the reaction and the formula of the electrophile in the reaction.

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(2 marks)

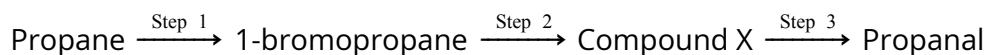
(c) Outline the mechanism of the reaction between benzene and the electrophile in part c)

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(4 marks)

(d) Aniline is useful precursor for making synthetic dyes. It can be made from nitrobenzene in a two step synthesis. Give the reagents and conditions for the reaction.

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(3 marks)

4 (a) For the reaction profile outlined in the reaction profile below, state the mechanism or type of reaction for steps 1 and 2.



Step 1

Step 2

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(2 marks)

(b) Outline the mechanism for step 2.

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(3 marks)

(c) Compound **X** can be oxidised by the reaction with acidified potassium dichromate to give propanal. Compound **X** will oxidise to propanoic acid if allowed to fully oxidise. Explain how full oxidation can be prevented.

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(3 marks)

(d) State the following for step 1.

Reagents and conditions

Mechanism

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(4 marks)